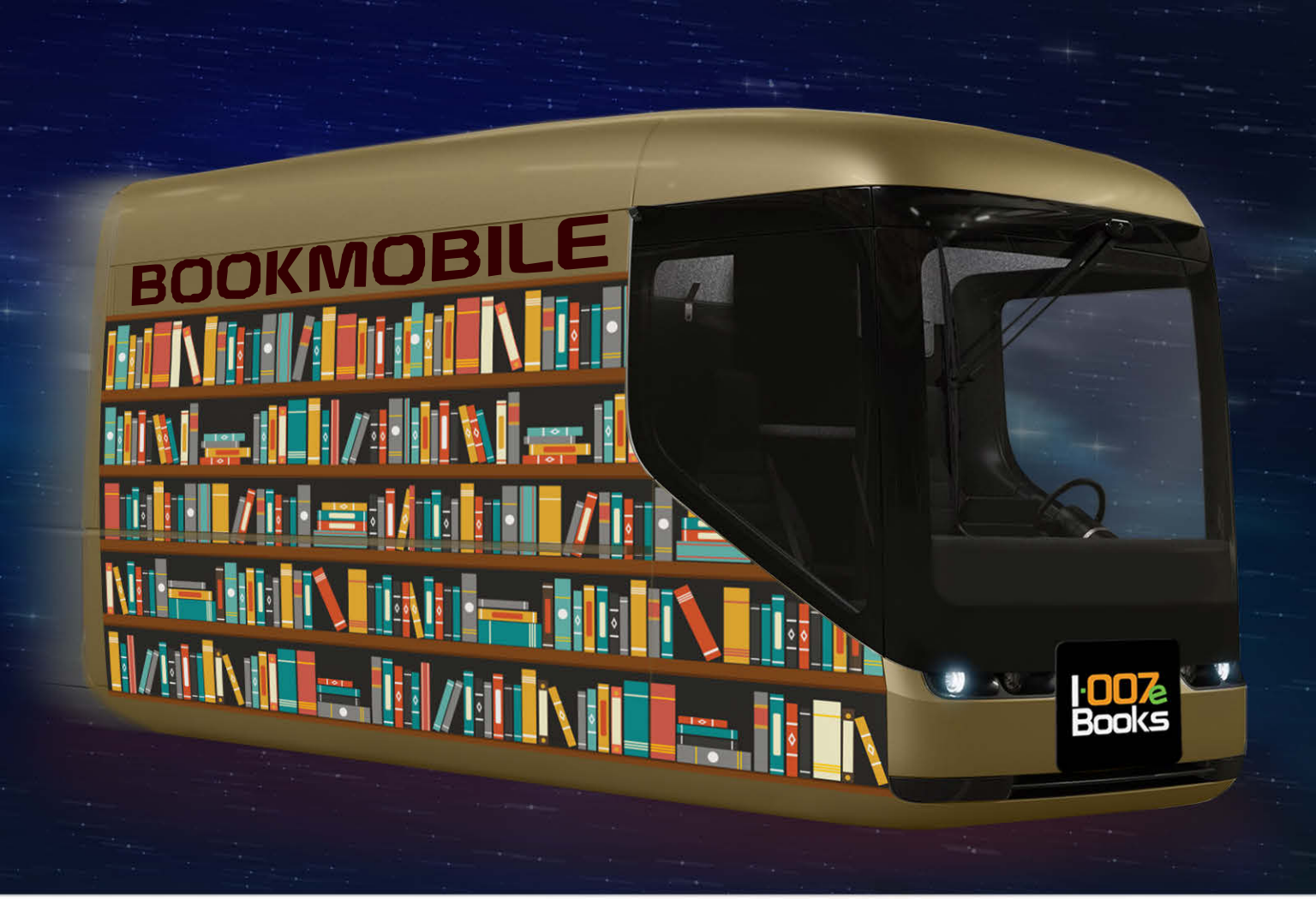
OCTOBER 2018

I-Connect007

PCB007 MAGAZINE

GreenSource Fabrication: Redefining Automation



Our library is the bookmobile for the 21st century.

Registered members of **my I-Connect007** have access to our ever-growing library of eBooks, which now includes a wide range of topics from DFM to thermal management.

Instead of waiting for the bookmobile, though, our users download new titles with the click of a mouse. It's pretty awesome!

View our eBook library

my I-Connect007
GOOD FOR THE INDUSTRY

I-007e Books

“Mark does an outstanding job detailing what needs to be included in the handoff from designer to fabricator. This book should be required reading for every designer.

Douglas Brooks, Ph.D.
BS/MS EE

Most of the design data packages that a fabricator receives contain inaccurate or incomplete data.

Don't be a data violator!

DOWNLOAD NOW

I-007e Books

I-007eBooks.com/data

PCB007 MAGAZINE

GreenSource Fabrication: Redefining Automation

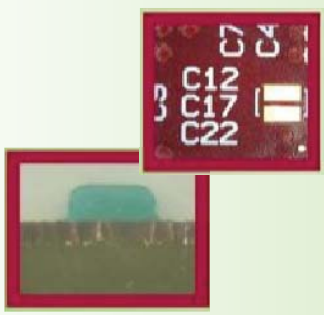
GreenSource Fabrication, a New Hampshire division of Whelen Engineering, is rolling out an expanded facility that can claim to be the most advanced automated PCB facility in North America. It's also zero waste and zero effluent. Take a detailed tour of the facility as we talk to the designers, staff, and equipment suppliers collaborating to make this factory a reality.

MivaTek Global

MIVA TECHNOLOGIES

LED Direct Imagers

Most flexible system
Most diverse customer base



- **Inner Layer:** 10, 25, and 50µ features
- **Outer Layer:** Incredible scale accuracy
- **Soldermask:** 2 mil solder dams, MDP capable
- **Legend Ink:** Excellent resolution for inkjet backup

- **Photoresists:** Any available on the market
- **Soldermasks:** Any available color

- **Factory Support:** Throughout North America

MIVA: LED DIRECT IMAGING

NEW PRODUCTS NOW AVAILABLE

3000LS Large Area Direct Imager

- 30" x 60" standard imaging area
- 1 mil registration accuracy (A/B)
- Up to 3 light engines for high throughput
- Small footprint for the imaging area
- 10, 25 and 50µ feature systems available
- Images all materials resist and soldermask

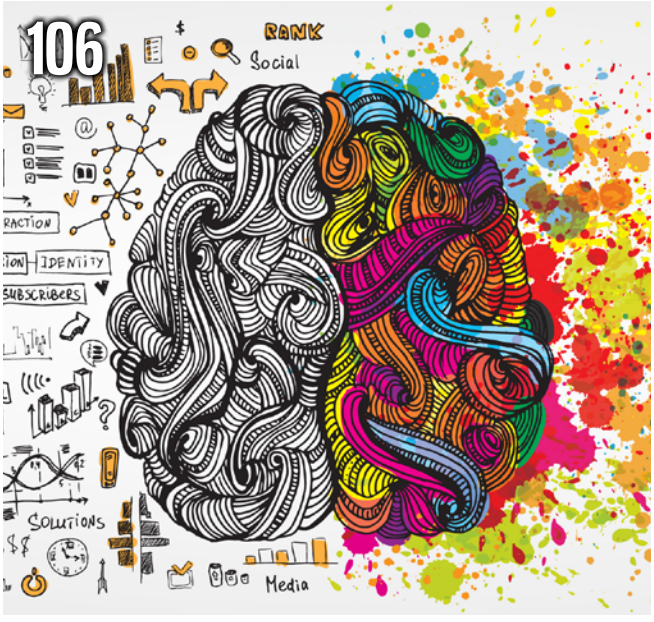
2400L Dual Tray Direct Imager

- Simultaneous panel loading and imaging
- Automation available from third party sources
- High efficiency systems for all applications
- World class Miva Direct Imaging technology
- 10, 25 and 50µ feature systems available
- Configurations for 30 to 120 panels per hour

NEW PRODUCTS

MivaTek Global, 6 Dickinson Drive, Suite 215, Chadds Ford, PA 19317
Eastern US: Brendan F. Hogan, M (610) 620-3795, B.Hogan@MivaTek.Global
Western US: Kurt Weber, M (714) 767-6367, Kurt@MivaTek.Global

PCB007 MAGAZINE



ADVANCED ENGINEERING

NEXT GENERATION AUTOMATION SOLUTIONS FOR PCB MANUFACTURING

Advanced Engineering has been the industry leader in automatic Dry Film Peeling since the early 1990's, when it introduced the model PM01 Mylar Peeler.
With an installed base of over 1200 machines in Europe and Asia and partnered with Hakuto (Japan), AE is returning to North America with its industry leading Panel Handling technology. See the new and impressive technical advances in their machine offerings, now available in North America.

650 Servant Loader/Unloader

Standard Features

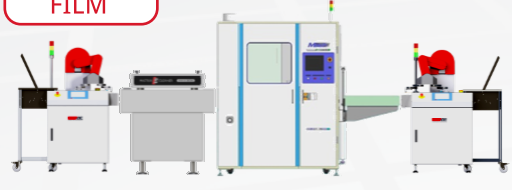
- **Modularity:** All devices share the same basic components
- **Simple Operation:** Using one standard computer
- **User Friendly and Safe:** Robot will stop on touch
- **Compact Footprint:** Smallest footprint in the industry, 3' x 4'
- **Flexibility:** Devices can be used for multiple PCB users
- **Very Low Energy Consumption:** Lowest in the industry
- **Robot Replacement Program:** After 1M panels

Special Features

- Double Sheet Detection
- Copper Thickness Detection
- Interleaf Sheet Handling

Other Automation Equipment and Combinations

LAMINATE FILM



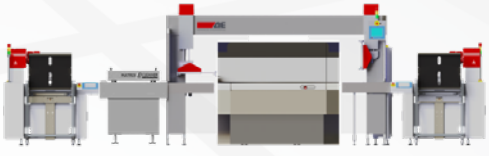
PEEL DES

EC24 "No Touch"
Electrostatic Cleaner

Hakuto 6630NP
Dry Film Lamination

SAP650
Mylar Peeler

CLEAN EXPOSE



Sales • Installation • Training • Warranty • Parts • After Warranty Service

MATRIX
CIRCUIT BOARD MATERIALS

1-800-668-5447 • www.matrixusa.us

TORONTO • SANTA ANA • SANTA CLARA • CHICAGO

GreenSource: The Future

Nolan's Notes

by Nolan Johnson, I-CONNECT007

This is my first issue as managing editor of *PCB007 Magazine*. As I start this journey, I want to thank my predecessor, Patty Goldman, for gifting me with such a strong, vibrant magazine. Patty has guided this magazine expertly and is taking her skills and talents to I-Connect007's quarterly *Flex007 Magazine*. It's a humbling honor to find myself filling her editorial shoes.

This issue is a special one. We devote the entire magazine to a detailed look at GreenSource Fabrication (a division of Whelen Engineering) and its brand new, fully automated HDI facility in New Hampshire. GreenSource is arguably the most advanced and automated fabrication facility in North America today. To achieve this, Alex Stepinski, vice president of GreenSource and process architect, had to approach every step with fresh thinking.

Under Stepinski's vision and planning—and in collaboration with equipment designers at Atotech, AWP, Schmoll/Burkle, InduBond, CIMS, and others—the GreenSource facility has stitched together a series of automation ideas and processes that result in 1) a zero-waste PCB shop that 2) delivers much tighter

Figure 1: One year in one minute! The I-Connect007 team placed a time-lapse camera in the GreenSource Fabrication facility to capture ongoing construction of the second phase of this unique automated facility. Click to watch the video.

tolerances with 3) an any-panel-count capability, all while operating with 4) less energy, 5) fewer chemicals, and 6) delivering fabricated product in about an hour with 7) a 99.9% expected yield.

Those are a LOT of challenging objectives to achieve all at the same time.

We'll take you through the plant, talk to the staff, and bring you technical details from each of the leading equipment suppliers who worked as a team with Stepinski to create this step forward in North American fabrication. You'll also meet the new generation of twenty-somethings who are innovating PCB fabrication operations. GreenSource shows us what 21st-century printed circuit fabrication will look like.

We lead off this issue with a walking tour of the entire facility. Stepinski and Barry Matties discuss the processes and the equipment. As they do, the conversation always comes back around to planning for the future.

Next, Happy Holden takes us deeper into the modernized methods at GreenSource, and exactly how they contribute to "Lean" as well as "green" with an assessment of the manufacturing efficiencies.

Atotech is one of the key equipment suppliers we showcase in this issue. The lively, technically rich conversation with the Atotech support team dives into all the Atotech processes, environmental innovations, and chemistry online at GreenSource.

Drills and laser processing equipment play a vital role at GreenSource. In our next article, Patty Goldman explores all the Schmoll and Burkle equipment with Burkle's David Howard. If you've only ever thought of drills as a mechanical fabrication step, you need to read this interview.

The staff play a critical part in the operation of any manufacturing facility. I gathered all the employee interviews we conducted on site and spotted some common themes and objectives that GreenSource is employing to build a world-class, sustainable staff.

Next, we track back to the equipment with an exposé on InduBond and their innovative lamination technology. InduBond's use of electrical induction to laminate multilayers provides significant cost savings and efficiency, making this conversation between Víctor Lázaro and the I-Connect007 editorial team a must-read.

In the automated optical inspection (AOI) department, GreenSource worked with CIMS. We talk with David Ravino about the CIMS installation, metrology, and integration into the factory's automation database.

Jim Brown, GreenSource account manager, sat down with Patty Goldman during our visit. They discuss precisely how GreenSource will sell to its customers. For a factory this advanced and this automated, the sales and support roles are dramatically different, making this article an insightful read.

Turning back once again to the strategic equipment vendors, we showcase AWP, who fill a crucial role in the handling of board panels to automate the process. AWP has dozens of pieces of board-handling equipment in the automated line; the complexity of the design, engineering, testing, and delivery must have been quite an undertaking. I-Connect007 gets the story from Jochen Zeller, AWP founder and vice president.

Next, we talk with Bob Lazarra, president at Circuit Connect in Nashua, New Hampshire. Lazarra shares about the environmental culture around electronics production in New Hampshire, and Circuit Connect's long history with green manufacturing.

Closing out the discussion, Patty Goldman explores chemistry lab details with GreenSource's Mark Chassé, including the new role of the lab in monitoring and maintaining an automated facility.

As if that weren't enough, columnists John Mitchell and Mike Carano file their latest. **PCB007**

Nolan Johnson is managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing.
To contact Johnson, click here.

GreenSource Fabrication: Looking to the Future

Alex Stepinski, GreenSource Fabrication vice president and facility designer.

Feature interview by Barry Matties

GreenSource Fabrication VP and factory architect Alex Stepinski took Barry Matties on a walkthrough tour of the GreenSource Fabrication facility. Alex and Barry discuss processes, equipment, facility design, typical manufacturing methods in the United States, and a myriad of other topics. A common theme highlights Alex's constant attention to the needs of the future for GreenSource and his customers. In this interview, we present some key excerpts from that conversation where Alex shares his vision for the future, and how this influenced the GreenSource facility's new methods.

Barry Matties: Alex, thanks for the tour today. GreenSource will be arguably the most automated and advanced high-density interconnect (HDI) fabrication facilities in North America. It's also zero discharge, zero waste, and capable of single-panel lot sizes. Let's start by discussing how far forward into the future you chose to aim your factory design efforts.

Alex Stepinski: The whole factory is designed for 10 years out. We're years ahead of others in developing this technology because there is no push for it from other U.S. fabricators. For example, we are years ahead of everybody in this part of the world with plating. The equipment investment was a big deal but building a whole factory to take advantage of it is another level entirely. Anybody can buy a horizontal plater, but how do you take advantage of the capability? One thing we did was build everything in this factory around plating. Plating is usually an afterthought, except that plating is the most complex thing you will do in a board shop. For everything else, there's a solution. You can buy a laser drill or an imager; there are 10 different suppliers for those things. Plating is always what destroys circuit board shops.

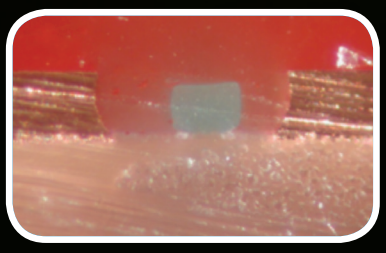
Matties: When we ask people in our surveys what the greatest challenge is, wet process plating is among the top. But with the age of computer control, you're starting fresh, while a company built in the '80s or '90s could be stuck in a rut. How do they get out of it?

Stepinski: I don't think it's that hard. The key is to invest money in research: travel, visit other facilities and vendors, and find ideas. If you're a small shop, you can build a small plating line that does what ours does, and it doesn't cost that much money. Meanwhile, there's no reason larger companies can't have all this. This

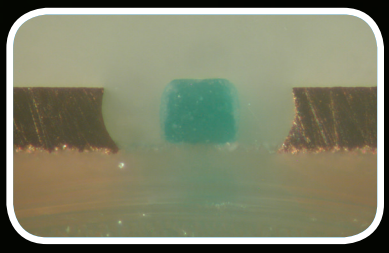
LIQUID PHOTOIMAGEABLE SOLDER MASK

PSR-4000 BW01DI, PSR-4000 BN HF DI, PSR-4000 HFX DI & PSR-4000 MP DI

- DIRECT IMAGING
- GREEN GLOSSY FINISH
- FINE DAM RESOLUTION
- HALOGEN-FREE
- EXTREMELY FAST PHOTO SPEED, < 100 mJ
- WITHSTANDS ENIG & IMMERSION TIN
- COMPATIBLE WITH LEAD-FREE PROCESSING



PSR-4000 BW01 DI



PSR-4000 BN HF DI

TAIYO AMERICA
Your Ultimate Solution

Phone [775] 885-9959 • www.taiyo-america.com • info@taiyo-america.com

equipment is already in Asia, but the U.S. market has never considered it. Everybody is stuck in what they already do.

Another factor is turnover. Larger companies have a lot of turnover, and when you have a lot of turnover, you can't do projects like this. This GreenSource buildout is a multi-year project. You can't have five people leave in the middle of the project or you'll never finish it. You also can't change your management structure or move people around all the time because you'll never finish a thought. The multi-year approach of a private company is a huge advantage for projects like this.

Matties: Tell us about your electroless.

Stepinski: We do plating with very thin electroless, the newest formulation and highest reliability on the market. We're not stuck using 30-year-old electroless formulations due to being locked in by our customers. Since we're a brand-new shop, we're using the latest stuff. The equipment does everything with high reliability and throwing power. You can put a thin layer on and then do electroplating two minutes later. It doesn't even have a chance to oxidize.

Matties: You just move it along.

Stepinski: Yes, it's all in-line.

Matties: That's a huge advantage.

Stepinski: Nobody else has this. Other fabs need to put the work into baskets, take it out, and etch it again.

Matties: You have one more plating line in the shop, right?

Stepinski: This is our Ludy line over here with the crazy-looking vertical plater. It's robotically loaded and unloaded.

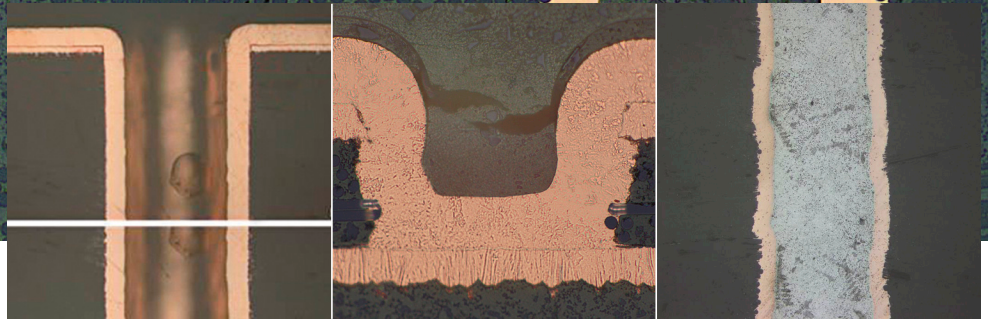
Figure 2: Very thin electroless plating processes from Atotech installed at GreenSource Fabrication.

Cupracid® TP3

Advanced solution for conformal copper plating in vertical hoist type systems

ATOTECH

Convincing processing advantages



80% throwing power and no corner flattening at 2.5 A/dm², AR 8:1

BMV with >80% throwing power at 2.2 A/dm²

Excellent compatibility with direct plating

Cupracid® TP3 provides excellent throwing power and minimum corner flattening over high working range. By this outstanding throwing power even at high current densities less copper needs to be plated on the surface, enabling higher productivity for conventional hoist type equipment.

The plated deposits with Cupracid® TP3 exhibit uniform crystal structure resulting in excellent ductility and tensile stress.

The anode film created by use of Cupracid® TP3 is very robust and therefore ensures stable production conditions and additive consumption.

Atotech Group
+49 30 349850
info@atotech.com

Figure 3: The Ludy vertical line at GreenSource shown here is nearing completion. Once operational, it is expected to be capable of microvia aspect ratios up to 40:1 and beyond. Click to watch flyover drone video.

Matties: Where is Ludy based?

Stepinski: Pirmasens, Germany. We use a different concept; we do the regular free-plate process here, and then all copper cells are down there. Over here, we have the option for nickel and gold plating, and we do the resist stripping in the line. We're doing vertical resist stripping and vertical differential etching for SAP products. As a result, the parts come out fully circuitized. That's a unique feature. Also, every tank has eight pumps. Do you see all of the controls?

Matties: Yes, so you can really dial it in?

Stepinski: Absolutely. Initially, we have six active tanks. They each hold eight panels, so 48 panels can be plated at one time. It's a big line. It's the most advanced vertical line anyone has ever done in North America from our understanding.

Matties: When will this be operational?

Stepinski: August. We're going to start plating the first two chemistries, which are the high aspect ratio electrolyte and a semi-additive plate that does blind via fill at the same time—both from Atotech. The intention is to have one cell for very high aspect ratios up to 40:1 or 50:1, and the SAP process for the very fine line and space and microvias—substrate-like PCB (SLP) stuff. In the other cell, we'll have a bath that only does thick panel microvias. Because the horizontal equipment only goes up to 2.4 mm, we'll have one cell configured for higher thicknesses.

Matties: Your approach to etching is different.

Stepinski: Our etch process is different. Everybody else tries to do vacuum etching with some weird programming stuff on the top side. Instead, we etch everything from the bottom.

Matties: Makes sense.

Stepinski: It's 40% faster from the bottom with no puddling at all. We see about 20% of the variation you'd normally get from top-side etching. There are no moving parts—everything is fixed in place—so nothing can fail.

SigmaPlat Line®

Made in Germany

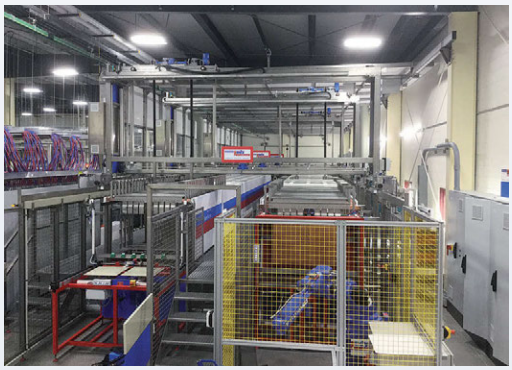
Ludy® Galvanosysteme GmbH

An innovative printed circuit board system made by the German company Ludy Galvanosysteme® GmbH.

At the system's core are copper cells with an **innovative three-dimensional agitation frame.**
The **tunable movement** of the **agitation frame** with **adjustable anode positions** guarantees **optimum coating result.**

Plant for electroplating printed circuit boards, made by Ludy Galvanosysteme® GmbH for GreenSource Fabrication LLC in Charlestown.

Older, small LUDY plant



With this **Plating Center Concept**, all galvanic processes of active baths (cleaning / activating / galvanic copper / galvanic tinning / demetallization of the clamp and frames) can be combined in their sequence, intensity and duration according to the respective requirements.

State-of-the-art switchgear in interacting with a well thought-through hardware system ensure smooth and effective operation of all processes in the electroplating plant.

The plant is equipped with wide maintenance walkways from which the valves and other fittings can be easily reached and handled.

Other significant features of the SigmaPlat Line® are:

- Automatic loading and unloading of the flightbars by means of robots
- Power transmission to the hoists without trailing cable
- System configuration / sequence is optimized by the software
- Automatic dosing devices
- Automatic analysis system for all active baths
- Filter with 5 µm candles / Filter pumps and flow meters
- Activated carbon filter
- Waste water recycling plant

Plating Center

the plant is installed at

GREENSOURCE FABRICATION

Figure 4: Wet-etch processes utilize bottom-side etching for greater efficiencies.

Matties: Why aren't more shops across North America following this path?

Stepinski: It is a function of the whole dynamic in the U.S. market. I think most people in the U.S. market are predominately from the '90s. Thus, board shops and equipment are still from the '90s, and the only things they replace are the drills, testers, and imagers. All the wet stuff is ancient.

Matties: The first thing you notice about this shop is that there's no odor. Sometimes you walk into shops and can smell the chemistry from the lobby.

Stepinski: Yes, you don't smell anything here. For example, the acid etching is recycled through kerosene. We extract the copper and bring it back to a sulfate. I found the technology in Sweden.

Matties: It works?

Stepinski: It seems to work. We use some strange solutions here-and-there to keep it all "green," but at the end of the day, the green stuff doesn't increase the operating cost. Whenever you go green, your operating costs tend to be lower—that is, if you did it the right way. There's the capital investment, and then there's the return. For example, with etching, return on investment (ROI) comes in a year or two.

Matties: Building a factory like this and delivering a lot size of one, there are different rates that you're dealing with here. How difficult was it to build a synchronized line?

Stepinski: It's not that hard. This whole factory is the first any-piece flow PCB shop in the world. Everything is designed for a lot size of one core.

Matties: Wow. A lot of people would think that's the big challenge. We've talked about lot size of one before for many years, and they didn't adopt it for that reason.

Stepinski: We had to get a lot of new equipment that hasn't been built before, but the concept is not difficult. It's just that—if you want to buy it off-the-shelf, it's not available.

Matties: I think it's like you said, you have to think it through.

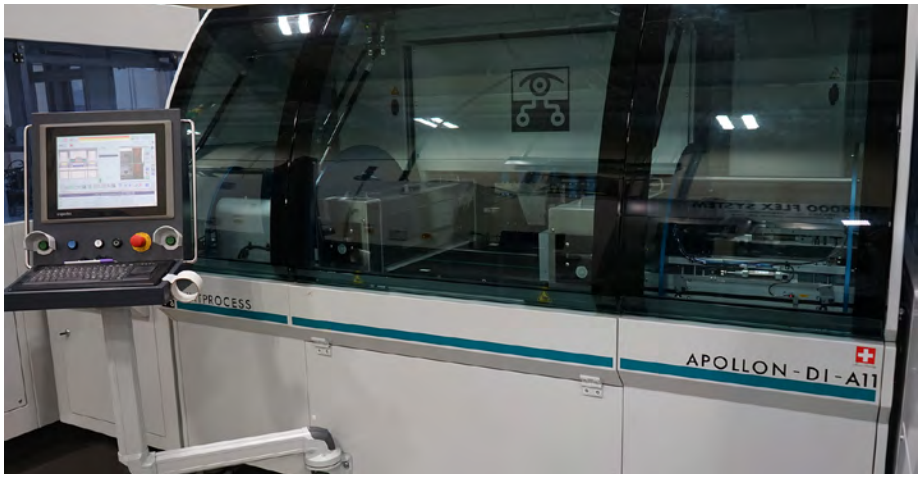
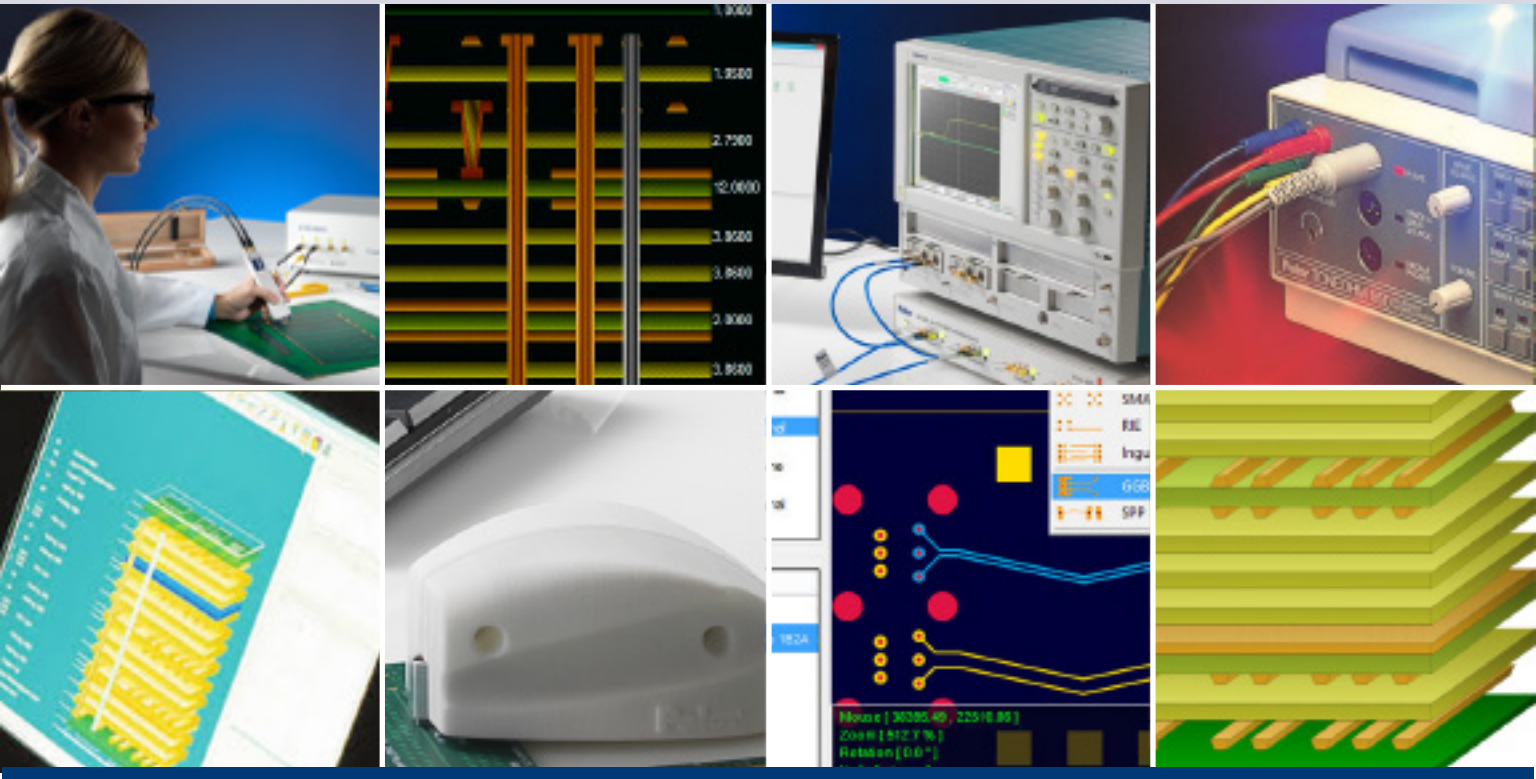


Figure 5: Apollon digital direct imaging system, auto-reverse inline.

Leading the industry with innovative tools for automated PCB layer stackup design and documentation.



"Polar congratulates GreenSource on their achievements, and we are proud to be their suppliers of PCB stackup design and signal integrity tools."

Martyn Gaudion
Managing Director, Polar Instruments Ltd.

Polar

polarinstruments.com

Stepinski: We're willing to step back and think about it. If you look at the machine that manages in-between processes, it's not an outlandish machine. It has a couple of readers built in it—nothing special—but people can't figure it out for some reason that you have to put a code on that you can read all the way through the build process. How do we do this? Just think it through. What is this step going to do to the code? Maybe I should change it a little bit. Then, what kind of reader do I need? Next, call the company that makes the readers and test them all to determine which you want. I might need a different read on two machines because it doesn't work on them.

Ours was the first request of this kind. We found that, in a lot of cases, other fabs weren't even trying to do things like this. You need to determine what is important for the process. How do I track it on this machine? How do I do it on my own as much as I can? Then, it's not very expensive at all. It's very cost effective to do these things.

Matties: Earlier, in your office, we were talking about data. You have overwhelming amounts of data, which means you have to be smart about the data that you decide you need.

Stepinski: Yes, we only collect what is essential.

Matties: How do you determine that?

Stepinski: Talk to your suppliers and customers and identify all of the critical variables. Then make a first pass: "Here are the things that I want to collect." As you go along and find something else that you want to add to the control, add it. Maybe you'll want to take something away, but usually, you add. It's that simple. You don't need to qualify every variable as if no one has ever built a PCB before. Use existing expertise. That is what I did when I designed this facility. I traveled the world for months and talked to dozens of board shops and suppliers all over the world to find all of the best ideas. It's all consolidated in this one site.

Matties: It's definitely a showcase, and you're transitioning from a captive shop to a job shop. What was the motivation to do that?

Stepinski: The return on investment from the original shop, plus the response we received from potential outside customers. We decided to open up the shop based on a lot of research showing that moving forward into advanced

Figure 5: One unique piece of equipment in the line is this film peeler Alex sourced out of China.

Figure 6: The planning and layout of the service walks show the same attention to detail and functional access as elsewhere at GreenSource.

HDI could be our niche. There is no other advanced HDI supplier in the U.S. market that does this advanced level of work professionally with all of the latest equipment. The other shops use older equipment. Their processes are more manual and horizontal. Ours is an automated vertical process. On top of that, it's all green. This line doesn't make one drop of waste; it's all contained in the line.

Matties: For such a new facility, what's it like in the quoting process?

Stepinski: We are going through our quoting exercises right now with multiple clients. We already have a couple that we are starting with and everything is lining up with our original plan.

Matties: Because this is a real data-driven factory, the data that you would get from your customers might not necessarily align. How do you build that bridge?

Stepinski: We have to talk to the customers a lot. There's an established process in North America. Everybody basically uses almost the same process—pattern plating, ammonia etch, and HDI. We're pursuing panel plate almost exclusively. We do either panel plate subtractive etch, or SAP—that's it. We offer a modified SAP and an advanced modified or straight-up SAP. We don't have regular alkaline etching with traditional pattern plating. Pattern plating results in 40% to 50% or more copper thickness variation on the surface. With panel plating, we are down less than 5%. Thus, when you look at microvias made at GreenSource, you will see every layer of copper is exactly the same thickness. You can't discern it with the human eye.

If you look at the rest of the U.S. market, every layer is a different thickness. This is a major contributor to the microvia reliability failures that are present in the industry, among many other things. The GreenSource team reviewed the top 10 items that we—and experts around the world—believe contribute to reliability failures. We also looked at cases where there are no reliability failures, like the cellphone market. We've combined all of these ideas into our facility plan and process selec-

tion, and we're well underway to getting everything qualified.

This is our pitch—complex HDI, one to two days, full traceability, green factory. It has a lot of pluses.

Matties: Tell us about finding the right skillsets for the team that you need here.

Stepinski: The challenge in New Hampshire is that the population to choose from is small. Instead, we'll try to make as many positions as possible into work-at-home jobs so that we can attract people from across the country. We designed the process for the future. It won't be about running around and touching the panels; instead, it's about collecting and analyzing the data, then deciding what to do.

Matties: As it should be in any facility.

Stepinski: True. We're enabling that here and minimizing the amount of physical interaction that needs to occur beyond the automation we already have. In the future, you're not going to have people on the floor touching panels.

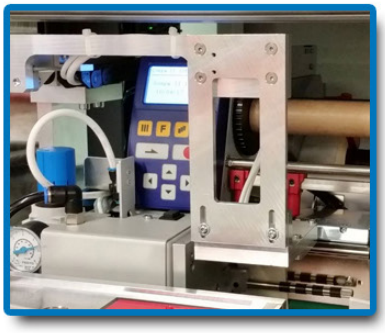
Matties: We hear all the concern that robots are taking jobs away, and what you're saying is that the jobs are here if people want them, but they don't want these kinds of jobs, so you have to bring in automation.

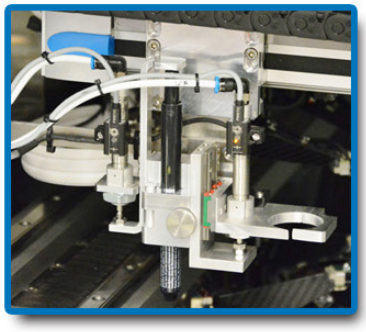
Stepinski: Young people grew up on computers, and they don't want to give them up. We will participate in that job market and reduce the people on site down to equipment maintenance and hands-on engineering. Honestly, you don't need that much hands-on engineering nowadays. I found you can be much more productive on complex technical tasks at home than you can while sitting at a machine. When do you need to be next to the machine? When there is something wrong with it, and you have to stare at it for a while—that's when you need to be at the machine. If you have all of the best equipment, though, you don't have to do that very often—you pay somebody to do that for you. Then, spend your time automating and thinking through how this connects to that, or how is this going to work? How do I predict what tests I am going to run when I receive a new design?

Figure 7: The GreenSource facility, located on the manufacturing campus of Whelen Engineering near Charlestown, New Hampshire.

Unrivaled Test Speed with Full Automation

Introducing the newly designed atg A8a with 8 test probes and a new high speed “lights out” automation for unrivaled throughput.





Highlights:

- Small footprint (6 square meters)
- Dual shuttle pick & place automation
- High accuracy combined with high test speed
- Pen or label marking option

Watch video

Get more info

atg

LUTHER & MAELZER

an Xcerra company

atg Luther & Maelzer GmbH
Zum Schlag 3 • 97877 Wertheim • Germany
Phone +49-9342-291-0 • Fax +49-9342-395 10
sales@atg-lm.com • www.atg-lm.com

These are all things where you don't need to be on site.

Matties: Do the customers care so much about being green or are they primarily driven by the technology?

Stepinski: They care about the whole thing. Some are much more interested in the technology, while others are interested in the automation or in being green.

Matties: But in the end, it is probably about the technology.

Stepinski: We have a couple of original equipment manufacturers (OEMs) who are very interested in the green side.

Matties: Let's talk about the test equipment in your process.

Stepinski: We chose CIMS as our key supplier for testing. We have two scanners with two types of confocal microscopy built into them. We can check the top and bottom of the transmit and the height of the copper. All the checks are recorded. If a customer asks, "How are we going to look for a line width control on this design?" our engineers release a core from their desk onto the line, and an hour and 15 minutes later, the test core has been measured wherever measurement was specified, and it just kicks out the side. "Here's your mini tab and histogram. Is this okay?"

Matties: Your approach to automated optical inspection (AOI) is different as well?

Stepinski: Our AOI inspection needs to be thorough for the types of boards we build. We found that when fabs check line width, it's not with AOI machines. They typically have some small system at the end of the DS line where they use white light microscopy. On 3-mm lines, 10% impedance is usually going to hold about 5% on line-width control. If you do that, it gauges more than 100% of the area; it's not capable of resolving it accurately. The gauge R&R of this test is horrid.

Matties: Do you include your drills in the inspection/test loop as well?

Stepinski: We do. Our concept is most people have a coupon for signal integrity that checks a few nets for impedance. We're going a step further. Our drills are from Schmoll, which are 3D back-drilling boxes attached to half of our drills. Wherever we check the nets or imped-

Figure 8: This bank of Schmoll Modul series drilling machines are outfitted with 3D back-drillings boxes.

Productive Fabrication Equipment

MDI-DT

WorkCell²

CombiDrill

schmoll optronics

BÜRKLE PROCESS TECHNOLOGIES

schmoll optronics

MDI Micromirror-Digital-Imaging

- Cost-efficient & high-quality DDI
- High-power UV-LEDs & DMD-technology
- Operator-friendly concept w/compact footprint
- Modular machine concept & field upgradable
- Flexible number of heads and head distances for shortest exposure times
- Multiple wavelength concept

Vacuum Lamination System

- Even pressure across the platen surface
- State-of-the-art heating system
- All-steel construction
- Modular machine concept & field upgradable
- User-friendly visualization system
- Affordable initial investment

Hybrid Laser Drilling/Cutting System

- Microvia drilling 50-300µm diameter
- Space saving compact design
- Best power/size ratio in market
- Pulse Stabilizer
- European technology center and USA support center

Bürkle North America supplies a full complement of productive equipment for fabricating printed wiring boards. From imaging through metrology inspection, Bürkle North America's equipment offering sets the standard in the industry for Imaging, Registration, Lamination, Mechanical or Laser Drill/Routing and Feature Metrology Inspection.

BÜRKLE NORTH AMERICA, INC.
11105 Knott Ave., Cypress, CA 90630

Contact Dave Howard for more details.

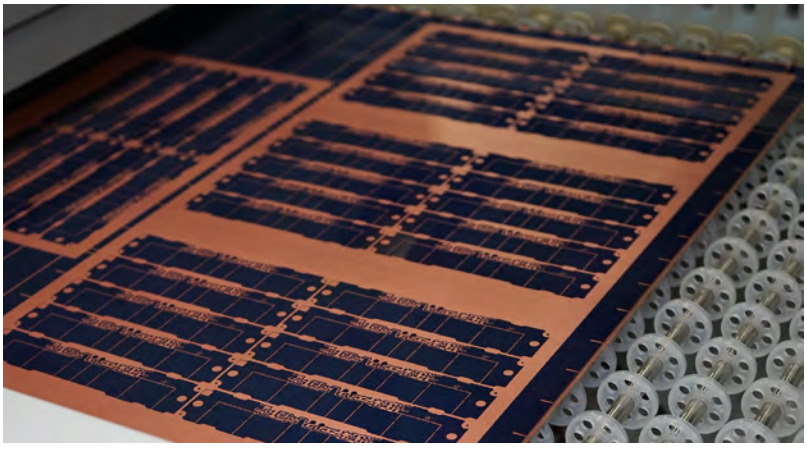


Figure 9: A panel moves through the automated wet-etch line at GreenSource.

ance, we also check at the core level—the trace level—before we put mask over them or anything with confocal technology. Then we replace the model numbers in the database with the measured numbers. We answer the question, "How far off are we?" Then, the drills detect the location of every single copper inner layer in the build within a couple microns.

The drills give us the dielectric thickness as measured at all of these points. We replace all of those numbers in the database, too, and we can tell you the distribution of impedance at this point in the manufacture. When we get the actual impedance readings, you can take those readings, leverage this or that information, and provide a whole profile of the panel. People usually spend a lot of money to have this done by an expert in a lab, and it takes them months to get it all tuned in; ours is fully automatic. We can give you a whole profile. We use it for customers and our own process development.

Matties: With all of the control and on-the-fly adjustments that you do, yield expectation must be incredibly high.

Stepinski: It is. We expect to have total yield or total failure and not much in between.

Matties: You're not leaving much room for error.

Stepinski: Usually when we have a problem, it's because we have such a burden on the front-end part that it will be a total failure. You're not going to have a marginal condition. That's good. You don't want to have processes that are spitting out marginal product.

Matties: It appears the investment you're making on this phase compared to the first phase is substantially more.

Stepinski: Yes, I can't tell you the exact number, but it's larger.

Matties: Where do you expect the ROI on that investment to fall?

Stepinski: The same.

Matties: Really? Because you had a quick ROI on the first phase.

Stepinski: We originally said five to seven years, but it took less time. We're targeting the same this time; it's the same concept.

Matties: Congratulations, Alex. It looks like you're living a dream here.

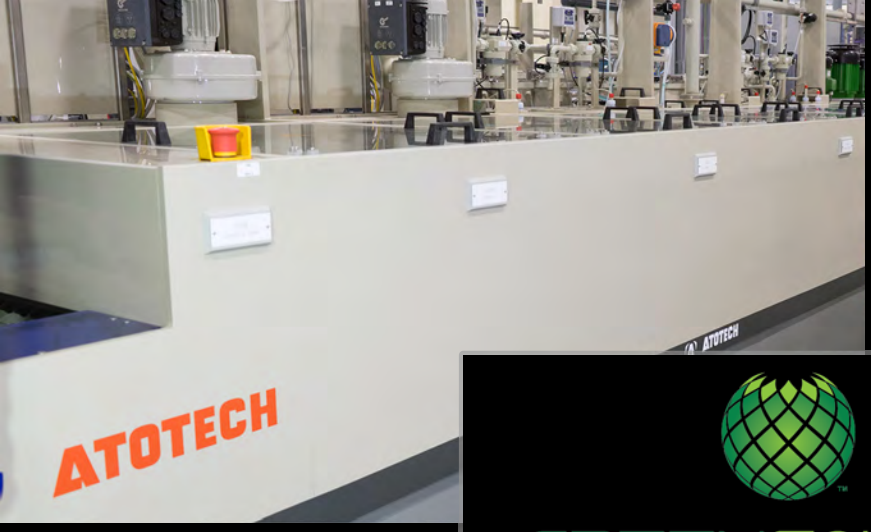
Stepinski: It's a very smart company. The Whelen family thinks 10 years ahead on everything and so does this factory.

Matties: I talked to Mr. Whelen at the EIPC Conference. I asked about their future and how they grow the business and this was a big part of it—being a job shop. They've been captive, building their own products for many years. He had nothing but high regard and confidence in you.

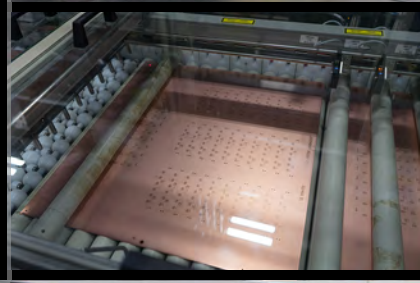
Stepinski: That's good. It's a big line. You don't see lines this size in North America anymore.

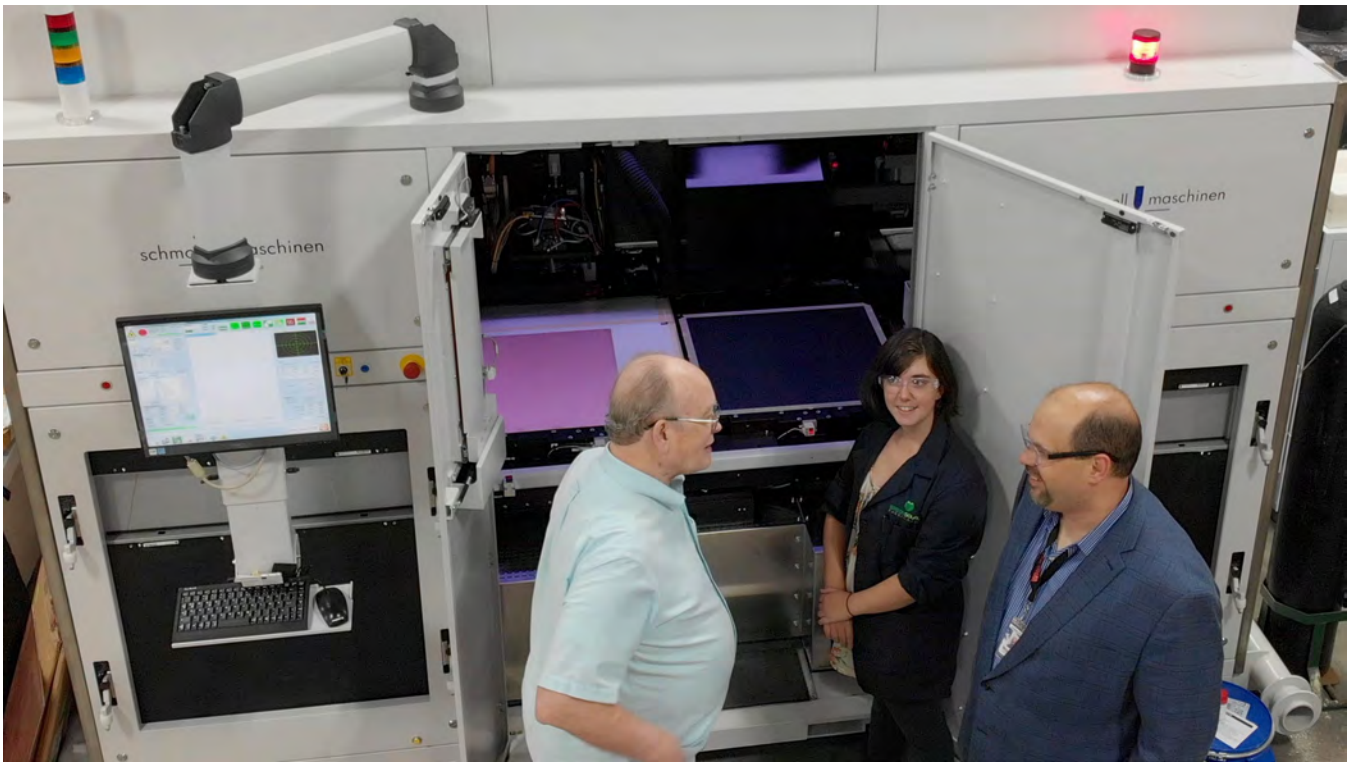
Matties: Thank you for your time. This was a great overview.

Stepinski: You're welcome. PCB007



GREENSOURCE
FABRICATION





Innovative PCB Processes are Lean and Green

Feature by Happy Holden
I-CONNECT007

Not much has changed in printed circuit multilayer manufacturing in the last 50 years except that the equipment is more mechanized and streamlined, the processes much more stable, and high-volume PCB manufacturing has moved to China.

But now, an OEM has finally found a way to build PCBs in the United States for less than buying them from Asia. Whelen Engineering Company of Connecticut is a worldwide supplier of aviation and automotive emergency lighting. Whelen was buying all of its circuit boards from China, while every other part of their manufacturing is done in-house. The supply pipeline duration and intellectual property (IP) concerns continually upset their schedules. Further, costs were increasing in China. Whelen managers decided to take another look at the old PCB manufacturing process and apply what they knew about Six Sigma and Lean manufacturing.

Thus, Whelen Engineering Company concluded that printed circuit manufacturing processes based in the U.S. could be significantly improved, and offer higher quality, lower costs, and rapid delivery on finished PCBs.

Lean and Green

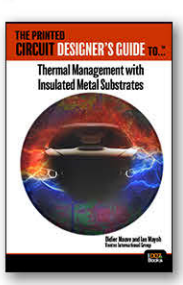
The new PCB factory, GreenSource Fabrication, in Charlestown, New Hampshire, is an excellent example of Lean principles. In the process of automating the PCB flow and eliminating waste, they produced a facility with zero effluents, thus, also becoming an excellent example of a green fabrication facility. "Lean and green" went hand-in-hand.

The over-riding strategy of Lean and green (zero discharge) has not changed, but the technology, focus on customers, and equipment have. The growth in inner layer production to support multilayers up to 36 layers—whereas multilayer made up 1% of the original captive facility—is significant. One should also note the commitment to substrate-like PCBs (SLPs) and high-density interconnect (HDI) features

Flexible, reliable Supply Chain Solutions
high quality copper clad laminates & prepreg bonding materials

ventec
INTERNATIONAL GROUP
騰輝電子

Ventec International Group is a world leader in the production of high quality and high performance copper clad laminates and prepregs, with full R&D and product development capabilities. Our global distribution means we can readily supply our products to all markets in all geographic areas.



Get your free copy of *The Printed Circuit Designer's Guide to...Thermal Management with Insulated Metal Substrates*.

DOWNLOAD NOW

Ventec - wherever technology takes you, we deliver

Ventec International Group
179 Ward Hill Ave,
Ward Hill, MA 01835,
United States
T: 978-521-9700
E: ordersCA@ventec-usa.com
Follow @VentecLaminates

www.**venteclaminates**.com

with advanced automated equipment, including processes, software, and equipment for:

- No-touch automation and material handling
- HDI with sequential lamination
- Laser drilling with the latest generation UV/CO_2 laser
- SLP geometries with light-emitting diode (LED) digital micro-mirror device (DMD) direct exposure
- Precise etching control with continuous regeneration and copper recovery
- Material handling for panels from 0.025 mm to 6 mm or more
- Innovative software for automated optical inspection (AOI) and cameras to improve registration for imaging, lamination, and drilling
- Plating capability to fill blind vias and through-holes

The GreenSource facility does not require waste permits because there are no water emissions. All water is recycled, as are many of the chemicals, which reduces costs. The completely automated process requires only seven technicians to monitor the machinery and a total of 17 for the entire multilayer facility. The bulk of the chemical PCB processing is conducted in one long U-shaped automated line.

Automation and Material Handling

Automating the Lean manufacturing and computer-aided design (CAD) and computer-aided manufacturing (CAM) systems have cut the processing time for multilayers down to just two days compared to the typical three or four weeks. This also offers the flexibility to do prototype runs mixed alongside high-volume production runs even when the product mix may include multilayer, two-sided, and metal-backed thermal boards. Different final finishes do not affect throughput or turnaround time.

The CAD/CAM automation utilizes direct imaging in several innovative processes, such as inkjet printing of pattern-plating resist and etch resist, as well as inkjet printing of solder

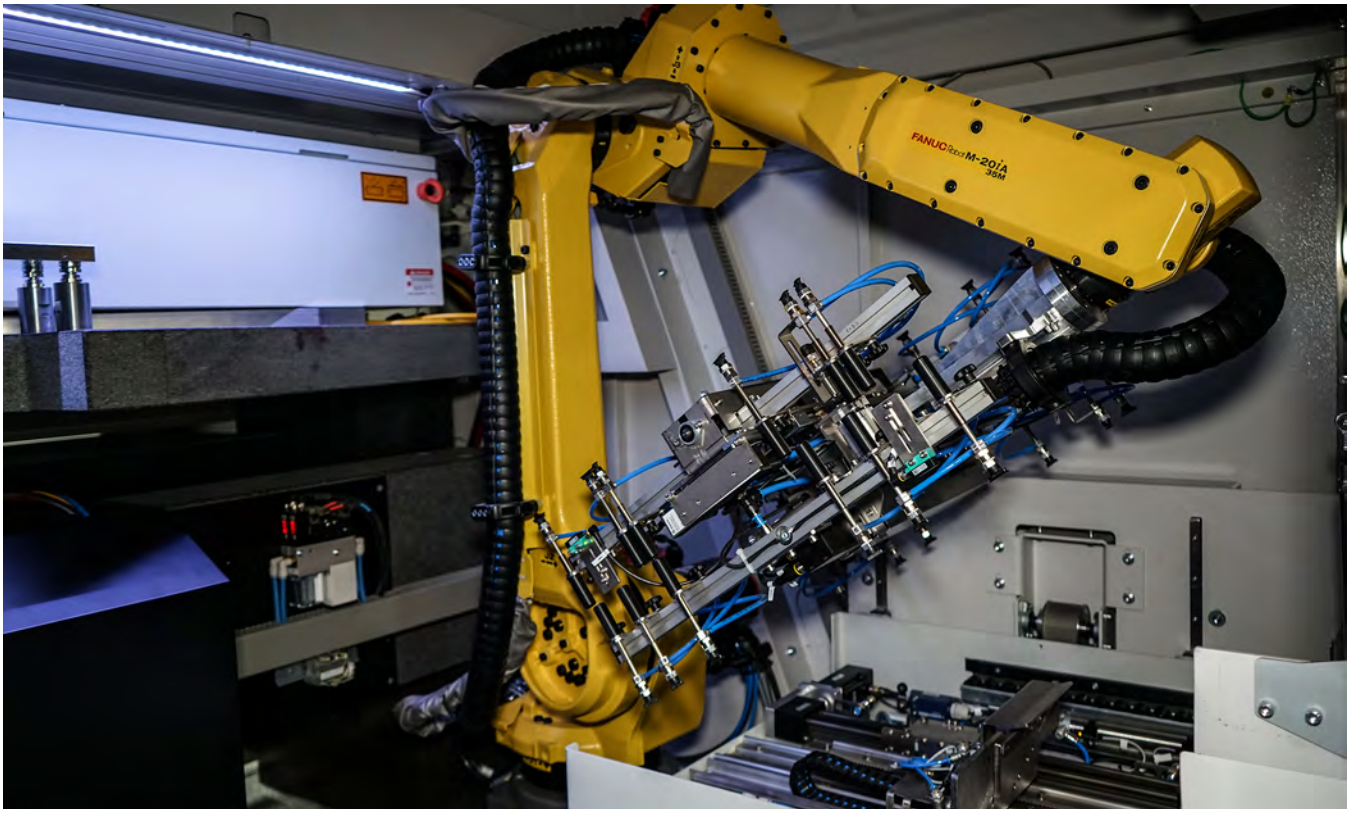


Figure 1: Custom-built Schmoll Maschinen Laser Master is outfitted with dual robotic arms that automatically flip panels over.

mask and legends. For fine-line and high-density circuits, digital direct exposure is used, thus eliminating all artwork, inspection, handling, and storage.

The main high-volume PCB processes are automated on one conveyorized system from the CNC drill through the final solder mask and fabrication.

For high-frequency and controlled-impedance multilayer jobs, ultra-precision direct imaging and continuous conveyorized copper pulse-plating with 56 insoluble anodes yield a maximum of only 3% copper thickness variations across a panel. The metal-backed boards also have the capability of cavities.

Lower Costs by Eliminating Waste

Simplifying the multilayer PCB manufacturing process (Tables 1–6) eliminated 74 steps, including the need for pre-clean and micro-etch. Additional waste was reduced by implementing 17 actions (Table 7).

Delivery as Soon as Needed

Automation eliminates queues, waits, and delays, resulting in a just-in-time (JIT) flow process with a total of 38 steps. As seen in Tables 1–4, there are numerous queues (waits, then move) in the standard multilayer fabrication processes with a total of 112 steps. By eliminating 66% of the process steps, the GreenSource method for outer layers takes only 105 minutes from drill to final fabrication instead of weeks. Standardizing processes from image to etch combines the automation of these steps into one continuous process for both inner and outer layers.

The material handling equipment was all supplied by AWP Group, a European PCB specialist in equipment and material handling. They supplied nearly 100 special panel code readers and radio-frequency identification (RFID) readers to instruct the automated equipment about panel ID to download a specific recipe. These new processes have innova-

7 continuous steps versus 30

GREENSOURCE PROCESS SEQUENCE (inner layer)	
0	CAM
5	In Line Load/unload
6	Pre-clean /R
8	Inkjet Primary Image
15	Etch / R
16	Resist Strip (Print&Etch) /R
17	In Line Load/unload - Move

20 minute I/L print & etch

Table 1: The GreenSource single- and double-layer process removes 23 manufacturing steps.

11 steps versus 19

GREENSOURCE PROCESS SEQUENCE (multilayer)	
1	In Line Load
2	Pinless stackup of layers / PP
3	Cu foil / prepreg
4	Vacuum lamination/cooling
5	Stack breakdown
6	X-ray drill tooling
7	AutoLoad / unload
8	Trim flash / Drill
9	Auto Load / unload – Move
10	Plasma desmear
11	Move

R = rinse

Table 2: GreenSource multilayer process flow.

STANDARD INNER LAYER PROCESS SEQUENCE	
1	CAM
2	Film Plotting
3	Film processing
4	Film inspection
5	Film punching
6	Load
7	Clean / R
8	Microetch /R
9	Unload
10	Load
11	Resist application
12	Hold (cooling)
13	Exposure
14	Unload
15	Hold (polymerization)
16	Load / mylar removal
17	Develop / R
18	Etch / R
19	Strip / R
20	Unload
21	Load
22	AOI
23	Unload
24	Load
25	Lamination hole punch
26	Unload - Move
27	Load
28	Clean / R
29	Oxide / R
30	Unload

Table 3: Standard process single- and double-sided process flow.

STANDARD MULTILAYER PROCESS SEQUENCE	
1	Load
2	Stackup layers (pap-rel-Cu-PP-Layers-PP-Cu-rel-paper)
3	Vacuum lamination / cooling
4	Stack breakdown
5	Trim flash
6	X-ray drill tooling
7	Load
8	Clean caul plates
9	Unload
10	Load
11	Drill
12	Unload
13	Inspect - Move
14	Load
15	Clean / R
16	Organic swell / R
17	Permanganate desmear
18	Permanganate recovery / R
19	Unload - Move

R = rinse

Table 4: Standard multilayer process flow.

	GREENSOURCE PROCESS SEQUENCE (outer layer)
	Loader
1	Debur
	In Line Load/unload
2	Conductive Polymer-Horizontal Cu Plate
	In Line Load/unload
3	Pre-clean
	30 Panel Buffer(FIFO)
4	Inkjet Primary Image
	In Line Load/unload
	30 Panel Buffer (FIFO)
5	Tin Plate
	FIFO Buffer
6	Resist Strip (Plate&Etch)
	90 Degree Turn
7	Etch
8	Resist Strip(Print&Etch)
	In Line Load/unload
9	Tin Strip
	In Line Load/unload

	GREENSOURCE PROCESS SEQUENCE (outer layer) continued
	UnLoad
	90 Degree Turn
20	HASL Post-clean
19	L/F HASL
18	HASL Pre-clean)
	90 Degree Turn
	In Line Load/unload
17	Final Cure
	In Line Load/unload
16	Legend Inkjet x2 with Robot
	In Line Load/unload
15	Solder Mask Develop
14	LDI with Robot
	In Line Load/unload
13	Solder Mask Tack Oven
12	Solder Mask Screen Coat
	In Line Load/unload
11	Oxide-Post-Dip
	In Line Load/unload
10	Oxide – S Mask Pre-clean

105 minute O/L plate & etch

R = rinse

Table 5: The GreenSource outer layer manufacturing flow contains an optimized 39 process steps.

tion rinse systems for minimizing water and solution dragout.

What makes the material handling so special is its capability from 0.025-mm inner layers (rigid or flex) to finished panels of 6 mm or more. This includes an automated storage and retrieval system (AS/RS), or a refrigerated warehouse, that can pull a complete set of materials for multilayer layup and place them in a sealed tray with its own RFID to control lamination.

Precise Etching Control

Another significant change is the switch from the alkaline copper ammonium sulfate etchant to acid cupric chloride. This is due to the cupric chloride having a controller that greatly improves the etch rate control and a new regeneration and copper recovery unit that reconditions the etchant and electrowins the copper as a solid plate from Sigma Engineering in Sweden. For more precise control of finished traces, GreenSource only etches from the bottom with a panel-flipper between the two etch modules. The etchers are significantly improved to allow foil thicknesses from ½-oz. to 2-oz. copper without sacrificing throughput. This control is important for the copper thinning etching after

	STANDARD PROCESS SEQUENCE (outer layer)
a	CAM
b	Film Plotting
c	Film processing
d	Film inspection
e	Film punching
1	Load
2	Debur
3	Unload
4	Load
5	Clean / R
6	Microetch / R
7	Catalyst
8	Accelerator / R
9	Electroless Copper
10	Copper dragout / R
11	Dry
12	Unload –Move
13	Load
14	Resist application
15	Hold (cooling)
16	Exposure
17	Unload
18	Hold (polymerization)
19	Load / mylar removal
20	Develop / R
21	Unload – Move
22	Load
23	AOI
24	Unload – Move
25	Rack
26	Clean / R
27	Microetch / R

	STANDARD PROCESS SEQUENCE (outer layer)move
28	Acid prep
29	Copper plate
30	Dragout rinse / R
31	Acid Prep
32	Tin Plate
33	Dragout rinse / R
34	Unrack-Move
35	Load
36	Resist Strip (Plate&Etch)
37	Rinse
38	Etch
39	Etch recovery / R
40	Tin Strip
41	Tin recovery / R
42	Unload – Move
43	Load
44	Solder mask clean
45	Solder mask coat
46	Solder mask cure
47	Unload
48	Load
49	Solder mask exposure
50	Unload – Move
51	Load
52	Solder mask develop
53	Unload
54	Load
55	Legend print
56	Unload – move
57	Legend cure
58	Unload
59	Load
60	HASL pre-clean
61	HASL
62	HASL post-clean
63	Unload

R = rinse

Table 6: The standard outer layer process comprises 60 steps; 11 steps more than the optimized GreenSource process flow.

lamination to control the surface build-up from HDI sequential laminations.

Innovative Software

What is not observable, but could be the most important innovation, is the dedication to continuous measurement of every panel. Since each piece of material is barcoded and every panel goes through AOI, the AOI from CIMS has the capability to make precision measurements and store these in a unique database supplied by XACT PCB of the UK. The software takes data from cameras, AOI, coordinate measuring machines (Impex ProX3), and X-ray to improve registration for imaging, lamination, and drilling. The X-ray drill data can be transformed into scaling, offset, and rotation data that can be used to convert the NC program to fit the measured panels.

Waste Reduction Actions	Impact
Reduce lot size to increase flexibility, lower inventory	Utilized single-spindle autoloaded drills/routers for lots of three panels
Auto optical pinless layup for lamination	Eliminated pins, depinning, and caul plate cleaning to reduce labor
Inkjet for primary imaging	Eliminated precleans, developer, tin plate cleaner, microetch, predip, and strip chemicals
Eliminate cleaners, microetches, predips, antitarnishes	Decreased wastewater system and chemical costs
Inkjet for legends	Eliminated screening or photo processes
LDI for solder mask	Eliminated artwork, increased registration
Conductive polymer metallization	Eliminated formaldehyde from metallization of copper
Closed loop resist strip process	Saved >$20,000 in annually from chemical usage and treatment
Horizontal copper pulse plating w/ insoluble anodes	Significantly reduced waste and improved thickness tolerancing & control of roughness allowed elimination of microetching for adhesion
Rotary oxygen plasma etch	Eliminated need for chemical desmear with solvents/permanganate or plasma with toxic gases
Closed-loop copper recovery system	Eliminated chemical costs for etching and yielded a positive cash flow from recovered 99.99% pure copper, stabilized etch rate to ±2%, eliminated venting of ammonia to scrubber, and recovered etch rinse dragout back to etcher
Convert all first rinses to static dragouts & increase flow rate of cascade rinses to compensate for less cascade	Decreased IX regeneration by 70%, increased concentrate waste dumps by 25%, reduced in total concentrate waste volume by 30%
Increase temperatures of process baths if possible, and replenish evaporated loss from dragouts	Decreased concentrate waste volume by 25%
Closed loop F006 precursor rinse recovery process	Reduced F006 hazardous waste by 95%
Zero liquid discharge waste treatment	Eliminated permits, saved water
Eliminate fume scrubbing and vapor emissions	Resulted in hermetically sealed tanks with negative pressure, packed columns on ducts
Reduce the number and amount of chemicals used in processes & eliminate chemical handling and any safety issues	Monitored and replenished chemicals continuously, used reservoirs as shipped from vendors

Table 7: Seventeen specific cost reduction actions (Lean) and their impact.

Plating Capability

In addition to the original Uniplate horizontal copper plating, GreenSource has added two horizontal Uniplate platers for copper via fill, the modified semi-additive process (mSAP) for blind vias and the THF2 for thicker panels. A new vertical copper plater from Ludy is in construction that features X, Y, and Z cathode agitation, all with unique insoluble anode eductors that use a liquid electrolyte from Atotech. Like the Uniplate horizontal plating systems, direct current (DC) power can be pulsed as well as side-to-side current controls. This unit is for blind vias (aspect ratio [AR] > 3:1) and through-holes (AR > 30:1).

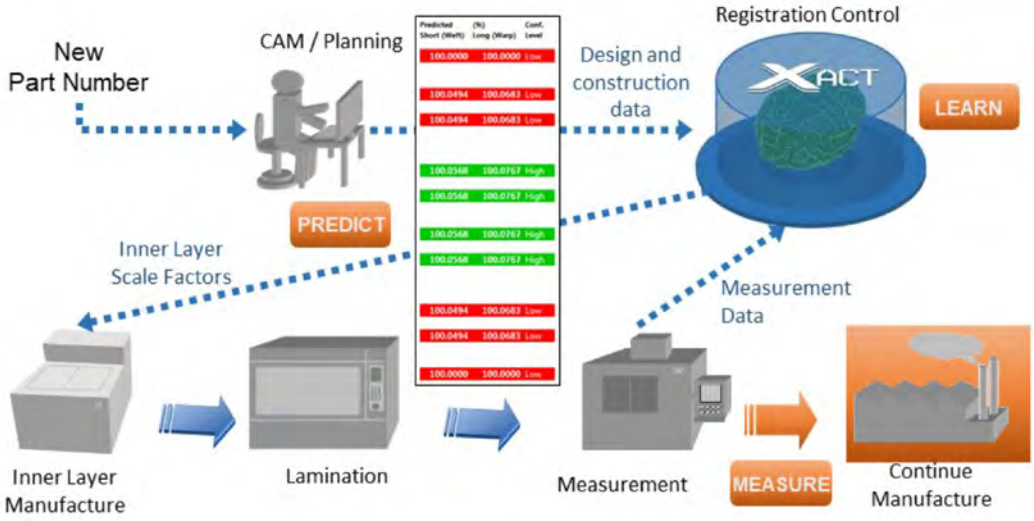


Figure 2: In registration control, we see how these steps are applied to the manufacturing process.

Process Bath	Recovery Method	Recovered Product	Capital ROI
Alkaline etchant	Oxidation/galvanic Cu	Fresh etchant & Cu metal	6–14 months
Acid etchants	Oxidation/galvanic Cu	Fresh etchant & Cu metal	6–14 months
Plating electrolytes	Organic destruction	Electrolyte minus organic	2–3 months
Tin strippers	Galvanic cell	Etch resist & fresh stripper	4–6 months
Microetches	Galvanic cell	Fresh microetch & Cu metal	4–6 months
Oxide alternatives	Organic destruction	Fresh chemical minus organic	2–3 months
Resist strippers	Membrane	Fresh stripper & contaminated brine	2–3 months

Table 8: Methods of chemical recovery to regenerate chemicals, minimize waste treatment, and the ROI for such systems.

Six Sigma Quality Goals and Continuous Improvements

This high degree of automation eliminated handling and other opportunities for defects as well as oxide growth and contaminations. The resulting process has an astoundingly high yield with very low labor. Lean waste in the form of water treatment is shown in Table 8 along with the return on investments (ROI).

Summary

Whelen Engineering's GreenSource Fabrication facility shows how Lean principles can go together with green principles. Seventeen new innovations in PCB manufacturing provide this advantage. The results are lower costs (⅓ to ½ the cost compared to what Whelen was paying for boards from China), decreased lead times (from 4 weeks to 2 days), prototype flexibility on high-volume product lines, and improved quality with no final inspection needed. ROI for the entire project was only three years while only utilizing 50% of the capacity of the systems, allowing sizable growth opportunities and future cost reductions. **PCB007**

Further Reading

1. Lean Definitions, www.lean.org/search/
2. Matties, B., & Bernas, B. Whelen Engineering Reduces Cycle Time by Building a New Automated PCB Factory, *The PCB Magazine*, October 2015.
3. Stepinski, A. The 21st Century PCB Factory—Designed to Eliminate Offshore Cost Advantages, *The PCB Magazine*, June 2016.

Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa/Westwood, Merix, Foxconn and Gentex. He is currently a contributing technical editor with I-Connect007. To read past columns or to contact Holden, click here.

Supplier Highlights

Rogers Achieves IATF 16949:2016 Certification ▶

Rogers Corporation announced that its Advanced Connectivity Solutions (ACS) business has achieved IATF 16949: 2016 certification, the highest international quality standard for the automotive industry. The certification covers the company's Chandler, Arizona, Rogers, Connecticut, Suzhou China and Belgium manufacturing and R&D facilities.

Atotech on Challenges and Opportunities in PCB Manufacturing ▶

Abel Ruivo, Atotech Deputy Business Director of Electronics for Greater China, and Daniel Schmidt, head of Global Marketing for Electronics at Atotech Group, spoke with I-Connect007 about the various challenges of PCB manufacturing in China, as well as about the opportunities in the sector.

Trouble in Your Tank: A Tale of Zinc Tails ▶

It is a given that the zinc tail can have a negative impact on PTH thermal reliability. Therefore, it is best to understand how to minimize its formation, or at least provide a means to mitigate the negative effects of the zinc tail.

Ventec Keeps 'Shaking Things Up' with tec-speed 20.0 ▶

At the EIPC summer conference, I-Connect007 Publisher Barry Matties caught up with Ventec Europe & Americas COO Mark Goodwin, who provided an update on Ventec's new products, the current state of the company, and how Ventec is shaking things up in the materials marketplace.

PCBs Are Moisture-Sensitive Devices ▶

Research by SMT & Hybrid GmbH (now SMT Elektronik) was conducted just prior to the original publication of IPC-1601, which now provides detailed guidelines for the packaging and storage of PCBs, both from the PCB manufacturer and at the assembler's manufacturing floor.

Atotech Launches Next Revolution in Electroless Copper for Advanced FPCB ▶

Atotech introduces a new horizontal electroless copper process specifically developed to ensure a blister-free electroless copper deposition and shiny surface appearance after electrolytic copper plating.

Frontline Releases InPlan 5.5 ▶

According to Frontline, InPlan combines sophisticated engineering know-how with state-of-the-art pre-production planning tools to design the optimal manufacturing process for PCB jobs in a rapidly changing manufacturing environment.

Isola Names Troy Ruhrer Chief Financial Officer ▶

Isola Group has promoted Troy Ruhrer, formerly vice president of finance to the role of chief financial officer and member of the executive leadership team.

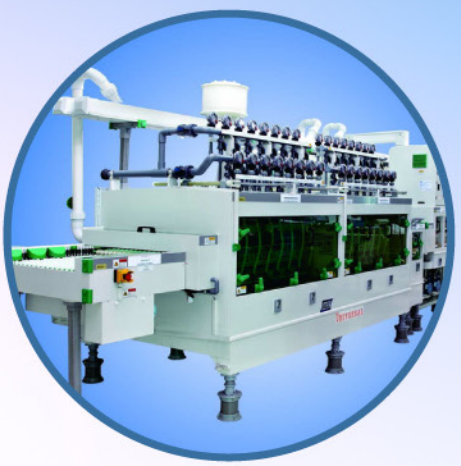
Insulectro Hires Michael King as DuPont Product Manager ▶

Insulectro, the largest distributor of materials for use in printed circuits boards (PCB) and printed electronics manufacturing, has hired Michael King as product manager its DuPont product offerings.

UCE WET PROCESS LINE

Etchers

Scrubbers



Developers

PTH

Oxide Replacement

THIN CORE HANDLING • PC CONTROL • RELIABLE • LOW COST

CLICK TO VIEW OUR UCE WET PROCESS LINE

The leading European PCB Equipment and Parts Supplier

www.vikingtest.com
sales@vikingtest.com

Viking

Atotech Brings World-Class AHDI to the U.S.

Feature interview by the I-Connect007 Editorial Team

During I-Connect007's initial walk-through of the GreenSource facility with Alex Stepinski, GreenSource VP, Stepinski started the conversation on surface preparation and plating by saying, "We have Atotech horizontal production technology in place here. We've been running Atotech turnkey solutions for a while. All of the equipment and chemistry are from Germany. They come here and configure everything for us. Our three biggest suppliers are Atotech, Schmoll, and AWP. With Atotech, we have direct support from Germany on a regular basis here. We're doing real technology development with Atotech."

The Atotech equipment is central to the operation of GreenSource Fabrication. Over the course of the week, we took a deeper dive into Atotech's installations there. We had several conversations with four Atotech representatives on site to oversee the installation: Moody Dreiza, business director for electronics in North America; Daniel Schmidt, global director for marketing electronics and corporate technology training; Kuldip Johal, global original equipment manufacturer (OEM) director for new technology/pathfinding; and John Foley, systems engineer for the GreenSource facility. Our conversations explored the specifics for each Atotech line in the GreenSource facility. We discussed production equipment, chemistry, capabilities, and unique innovations specifically developed to realize Stepinski's vision of highest production flexibility.

Barry Matties: Could you give us an overview of the Atotech equipment installed here at GreenSource?

Daniel Schmidt: Today, GreenSource has eight Atotech production lines installed, including three copper platers, two electroless cop-

Figure 1: Alex Stepinski, GreenSource VP (right) with the Atotech team.

Integrate QA Solution

Because everyone's QA needs are just a little bit different.

Integrate is a fully customized solution, and no two contracts are exactly the same. No matter what size customer you are, we can tailor AOI, testing, final inspection, or a combination of all three services to fit you. And you only pay for the product that actually passes quality assurance, not on panels produced or tested.

Find out if our Integrate solution is right for you!
www.gardien.com/why-integrate

GLOBAL FOOTPRINT
WITH A LOCAL PRESENCE

30+ YEARS
EXPERIENCE

30 YEARS OF PCB
INDUSTRY EXPERIENCE

Figure 2: Atotech's horizontal production lines installed at GreenSource Fabrication (left: electroless copper line; right: oxide replacement line).

per lines, two surface treatment lines, and a direct metallization line. GreenSource also uses a variety of different Atotech wet chemistry processes, such as our high-throw electroless copper (Printoganth T1), blind microvia filling process (Inpulse 2HF), electrolyte for through-hole, BMV and conformal plating (Inpulse 2THF), electrolyte for conformal or flash plating (Inpulse 2HT), as well as laser direct drilling pretreatment (BondFilm LDD SR), higher copper loading bonding enhancement (BondFilm HC), and our ENIG process (Aurotech DC).

Matties: How do you comply with GreenSource's need for system-to-software integration?

Schmidt: Our solution comes with a fully integrated communication interface that translates Atotech hardware and process data and securely exchanges this data via multiple platforms, such as SEMI equipment communications standard (SECS), generic equipment model (GEM), or open platform communications (OPC) to the host manufacturing execution system (MES) software in real time. This enables factory integration of multiple toolsets for optimized productivity and yield improvements. We meet the customer requirements and run the equipment at low chemistry, water, and energy consumptions. At the same time, we can assure minimum waste (e.g., wastewater or dragout chemistry), which—in the case of GreenSource—was exactly what Alex wanted.

Matties: What was new in the equipment that has never been done before?

Schmidt: GreenSource had a special request to install a new rinsing system to allow the high flow of a rinsing solution, which would then be used several times. Instead of fresh water for the rinsing system, we operate with recycled water. For this prerequisite, we installed new devices to the system to avoid particles due to algae generation in the rinses. Algae generation is an issue when using re-circulating water.

One has to understand that when panels leave a chemical process tank, there will be chemical dragout on the panel. There are at least three reasons why this needs to be removed: to stop the chemical reaction, prepare the panel for the next process step (panel must be clean), and avoid contamination of the proceeding process step.

The roller configuration used in our lines and the mechanical design in the outlet area of each module allows us to reduce the solution level above the panel to a minimum with the result that less chemistry will be dragged out. We use anti-dragout and dam rollers to minimize dragout. However, chemistry will always remain in the drilled holes, on the surface along the outer edges, and as a very thin liquid film on the surface of the panel. In general, process chemistries are highly sensitive to contaminations. Hence, dilution factors must be very high to achieve long bath life and process reliability as required by the industry today. In the case of an electroless copper process for advanced high-density interconnect (HDI) products, the dilution factor must

be 1:10,000. In the case of horizontal systems, triple or quadruple rinses equipped with advanced fluid devices must be used to achieve a proper solution exchange in drilled holes and on the panel surfaces.

The concept at GreenSource with conductivity controlled high-flow concentrate rinses, combined with pH and conductivity controlled triple rinses, helps achieve these targets. By using a simple rinsing concept, this can only be achieved by using plenty of water. For plating, we installed our Uniplate advanced IP2 platers, which are considered leading-edge in Asian markets. Today, we look at hundreds of installations worldwide. The installations at GreenSource are the first advanced IP2 platers in the Americas.

Matties: What else is new?

Moody Dreiza: GreenSource is the first customer to use different chemistries for one plater, meaning that we fill the plater, use it for production, pump the solution back to the holding tank, and then come back with a new solution to make the same line suitable for another product and process. That is a unique setting in the market today, and it was a great achievement for us to engineer and provide a system set offering this high degree of process flexibility to one of our customers.

Figure 3: The Atotech electroless copper line (Uniplate LB) and copper plater (Uniplate IP2) on site at GreenSource Fabrication.

Matties: John, you are the account manager. Could you explain all the Atotech equipment installed by the exact production sequence here at GreenSource?

John Foley: We have several different systems, from inner layer, all the way through what we consider to be outer layer. We have multiple versions of our BondFilm products, featuring our alternative oxide process. One line is the high copper load, which is the first in the U.S. of this type, and the other is a BondFilm LDD SR, which is a flash reducer after laser drilling. For desmear, which is the third system we have there, we run our Securiganth P chemistry.

Happy Holden: Do you execute an alternative oxide before lamination for the inner layer?

Foley: Yes, we do. We count several BondFilm products for that process step. Our product series is world renowned for low edge depth < 1µm, high copper holding capacity, and excellent signal integrity due to lower surface roughing.

Holden: What is the next process step in the line?

Foley: We have two different electroless copper lines at GreenSource. One line is designed for thicker panels (the standalone electroless line), and the other line is designed for thinner panels (the LBCu6 line). Each uses a different conveyor system, but the chemistry is the same in both—all horizontal.

Schmidt: For example, our UTS-xs concept is designed to process panels of 40 microns in thickness including 2 x 2 microns of copper clad, which I would consider to be very thin and flexible material. Our fluid management is also key. It en-

ables reliable transport in our systems and is supported by many control devices. We control the solution level in the process area of the modules, and the pressure of the solution flow from the pumps through the fluid devices to the panels. With this, we can assure the latest requirements for transport capabilities.

Figure 4: Atotech's world-renowned Uniplate IP2 advanced copper plater.

Foley: Additionally, we implemented fine filtration systems for all lines. This was required because GreenSource also wanted to process fine-line structures on these lines. To allow this, we have a fine filtration concept for all modules—not only active modules—and on rinses and plating modules.

Our horizontal acid copper system comes next in the process sequence. We have several mixes of acid copper there, depending on needs (e.g., conformal plating, microvia fill, or through-hole fill). This adds up to three or four different acid coppers. Finally, we have the electroless nickel immersion gold (ENIG) line, which is currently a surface finishing line but will be electroless nickel electroless palladium immersion gold (ENEPIG).

Holden: Why did GreenSource switch from direct metallization to electroless copper?

Kuldip Johal: The direct metallization production line was designed for simpler double-sided products. However, for HDI products with wide product specifications as required by GreenSource, strong interconnect reliability and BMV coverage are needed—hence the palladium-based electroless copper process is preferred instead of the conductive polymer-based direct plating process. In the case of GreenSource, they planned for the highest flexibility with both capabilities in one manufacturing location.

Dreiza: They also needed throwing power in the finer, smaller vias. The electroless copper, called Printoganth T1, has that name because it has a throwing power of 1. This means the thickness of electroless copper that you get on the surface of the panel versus the bottom of the wedge of the blind microvia is almost the same.

Holden: When the barcoder reads the barcode for jobs as they move through, what parameters are adjusted for differences in the processes, conveyor speed, pressures, etc.?

Foley: The recipe might change temperature, pressures, or dosing frequencies. Panel size is a factor in recipe tuning, too. Depending on copper thickness requirements and panel specifications, the conveyor speed in the plater—as well as current densities and pulse forms—might change too. Our alternative oxide line was originally brought to market as an inner layer bonding system, but Alex is using it twofold; he's using it for solder-mask adhesion and dry-film adhesion. He's roughening up the surface with the BondFilm, which provides better adhesion with the solder mask and dry film.

Holden: Are they also using it for lamination adhesion promotion?

Foley: That's correct.

INTRODUCING THE CapStone™ ADVANTAGE

Double your flex PCB production throughput and reduce processing costs up to 30%.

Leverage new technology for higher quality and yield.

CapStone combines ESI's latest-generation laser control capabilities with market-leading robust laser technology to provide breakthrough performance without sacrificing quality or precision.

Capitalize on your investment.

Now you can extend your processing capabilities and cost-effectively address even the most demanding customer requirements.

esi®

TPCA Show 2018
| EAssembly | Green Tech | PCB | Thermal |

See us at the Taiwan Printed Circuit Association (TPCA) show Booth # I-919
October 24-26th, Taipei

learn more about CapStone at esi.com

Johal: Yes, recipe changes from a technology point of view can add value during processing for the adhesion promoter because the dielectric materials vary. GreenSource can link a specific barcode job to a particular process recipe. In this case, the conveyor speed may be adjusted to provide different etch depths for the selected dielectric and enhance the performance of the adhesion promoter.

Holden: Normally, that sort of adjustment has to be done by humans or by the batch. That's a key thing here—it's all done automatically. The digital recipe changes the actual physics that occur in the line.

Foley: As Kuldip said, it's driven by the etch rate/depth, and several things could change your etch rate: speed, temperature, or chemistry. At the front of the line is a loader followed by an acid cleaner followed by a rinse, an alkaline cleaner followed by a rinse, and then activation for the actual BondFilm. BondFilm is a modified peroxide-sulfuric etch with organics. Finally, the process concludes with a rinse followed by rinsing and drying.

Holden: And for inner layer?

Foley: For inner layer, the etch is unique. A typical problem in a horizontal etch system is puddling on the top of the layer, resulting in a more aggressive etch on one side. It's hard to control top to bottom consistently. To solve this, GreenSource has two etchers. The bottom is etched in the first half, and then it goes through the AWP flipper, which flips the panel and etches what was on the top in the second half of the line. No top etching means no puddling. It's pretty nice.

Patty Goldman: Do all the different acid coppers use the same tank?

Foley: Some have different holding tanks. Depending on what GreenSource is running that day or week, they will pump over whatever acid copper is needed, transfer it back to the holding tanks, and bring the next one over as necessary. They use the same electrolytic tool but different holding tanks.

Dreiza: I'd like to point out the condensers on our desmear line. Any exhaust from the equipment becomes condensed back into the unit, which benefits a considerable reduction in chemistry usage and improves the overall environmental impact of any operations.

Holden: Speaking of which, I notice the venting is pretty minimal coming off these machines.

Dreiza: The condensers significantly reduce the amount of chemistry needed for the line. That's just one example of many features on the line that reduce chemistry consumption.

Matties: There's a lot of thought and planning in these lines.

Johal: Alex has added nuances into the system by planning for tremendous flexibility in each process. He wants to be able to process thick panels and thin HDI panels as well, and that

Figure 5: Supply pipes from above for recycled water. Control devices and sensors.

Figure 6: Back-side view of the Uniplate IP2 advanced copper plater showing frequency-controlled circulation pumps.

is not your typical mixture in most PCB manufacturing sites. What Alex has done is marry the two to gain the maximum flexibility. That's how I would summarize GreenSource's advantage.

Holden: One of the things that Alex pioneered on the first generation was removing the need for cleaners or acid dips because there was no time for oxidation and no handling.

Foley: Alex uses the cleaner on his standard production when it's coming directly from the drill. Before ENIG, they'll remove the solder mask organic contamination with the BondFilm LDD SR equipment.

Holden: Which of the processes have automatic technical control analysis and dosing?

Foley: All of our horizontal systems have automatic dosing; it's standard on our horizontal line except the ENIG line, which is chemically controlled by the laboratory through daily analysis for additions. The electroless copper and reduction chemistry has automatic controllers built into the line doing continuous analysis. The acid copper platers have this as well. Atotech will supply some unique acid coppers to use for the Ludy system, which is vertical equipment, although I'm not 100% sure how that system is set up.

Another difference in all the Atotech lines is that water on/off is done by conductivity control rather than creating a steady flow of a couple liters a minute. This provides water conservation—another one of Alex's green features. If you look, you'll see a motor turning in that plastic casing. That's our patented edge split-filter system (ESF). It's a self-cleaning metal-mesh filtration system. When the permanganate is pumped to the holding tank, it's constantly running through a filtration system while in the unit. You can't do that with standard filters. We're extending the life of the bath and reducing particles that could affect line and space.

Next is the BondFilm LDD SR. The chemistry is peroxide-sulfuric with a different organic. The "SR" part stands for splash reducer, referring to laser drill splash. When you laser drill, you get splash around the area of the hole. The LDD SR reduces that splash and cleans the capture pad for microvia production. In the LDD SR, the panels go through the alkaline cleaner rinse to the BondFilm stage, and then a rinse before it goes into the next line—desmear or offload.

Once it's through desmear, it's ready for electroless copper or a conductive polymer. The next line is what we call the standalone low-build (LB) electroless copper, which would be very little copper and you would strike plate afterward. More accurately, we're putting on a

Figure 7: GreenSource operators control the Atotech lines from service kiosks like this one.

medium build, after which you can either pattern plate, put dry film on it, or go to a copper-strike or full-panel plating.

Johal: This line also has the latest generation of electroless copper specially designed for blind microvias—a direction more customers are pushing us. With current HDI PCB blind microvias, fabricators are paying attention to how much electroless copper is on the surface versus how much is in the bottom of the capture pad of the BMV; this is becoming more critical for blind microvia reliability. Customers are asking to have >80% throw in the blind microvia at a minimum, and that's an absolute thickness measurement—not by weight gain, but by focused ion beam (FIB) cross-sections.

Foley: True values. The name of the electroless copper bath is Printoganth T1.

Holden: Is that T1 bath formaldehyde-free?

Foley: No, it has formaldehyde.

Holden: Do you do anything special to stabilize it, keep it from generating nodules, or extend its life?

Foley: It has stabilizers in it just like any other electroless copper bath, and if you look behind the bath, every fluid head in the bath has filtration on it. Typically, at the end of the production week, the operator will press one button to go into service mode. Service mode performs electroless cleaning. For example, this line was their production line last week. Now they are running the other line, but you can see it's time for a cleanout; there's a little bit of copper plate in the filter pipe. The operator will call up service mode and start the electroless copper clean process. That will automatically pump it from here to the holding tank, bring the etch from the other holding tank in, run a cycle for probably three or four hours at temperature, etch out all the copper, and then it will fill it with water, rinse it, dump it, and it should be ready to bring your electroless back and start again.

Figure 8: Atotech tank transfer plumbing automates chemistry change-over and maintenance.

GET YOUR 20% DISCOUNT!

WHEN YOU REGISTER BY ***12.21.2018***

APEX EXPO® IPC 2019

IPCAPEXEXPO.org
#IPCAPEXEXPO

SAN DIEGO CONVENTION CENTER, CA, USA

MEETINGS AND COURSES: *JANUARY 26–31, 2019*
CONFERENCE AND EXHIBITION: *JANUARY 29–31, 2019*

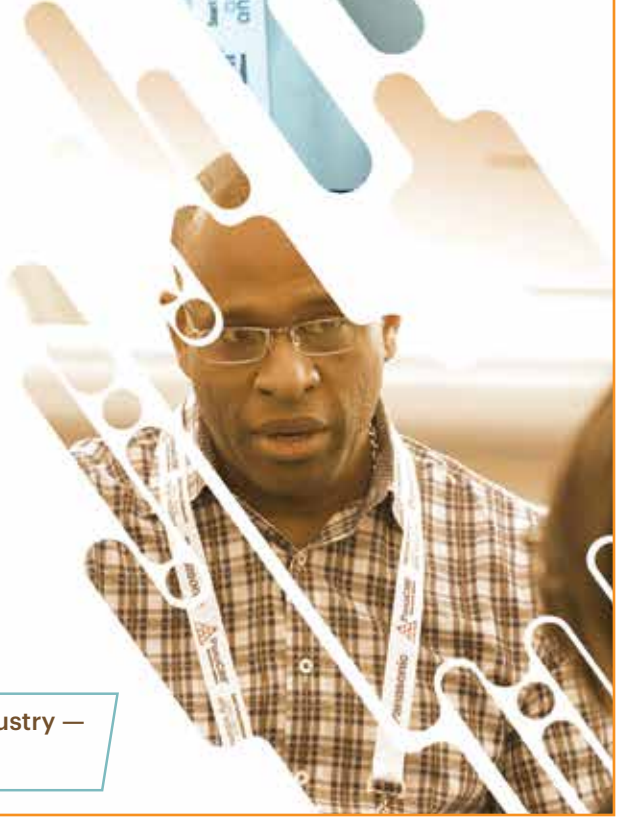
TECHNOLOGY'S FUTURE COMES TOGETHER

THROUGH NETWORKING

Technology's future will literally come together in San Diego at ***IPC APEX EXPO 2019*** on the exhibit show floor, in meetings, sessions and courses, and during networking events. The in-person exchange of ideas and know-how between you and your peers powers the industry's future.

Whether you are established in your career or just starting out, ***IPC APEX EXPO 2019*** will be the event to:

- Network with thousands of electronics industry peers
- Make new connections
- Strengthen existing relationships
- Become a mentor/meet a mentor



Strengthen the opportunities for yourself and the entire industry — register today for IPC APEX EXPO 2019 at ipcapexexpo.org.

Goldman: You must lose some of that electroless copper.

Foley: You would be surprised how little is lost. However, any time you pump it over and back, you're going to lose some.

Holden: What does GreenSource do with the water after dumping it out?

Foley: Generally, the water goes to waste treatment and gets recycled and used again. However, this water might not because it has chemistry in it. The first one right out of each bath is a dead rinse. When that gets drained, it goes to chemical waste—not freshwater waste. The other cascade rinses go back to water and get reused. This one would go to chemical waste.

Dreiza: To help reduce water waste, we reduce dragout. With the horizontal system, we can reduce dragout by 50%, then the quadruple rinse that John described. You're talking about a very low consumption system overall.

Goldman: It's double the savings. You save on replenishment chemistry, and you also save on waste treatment of dragged out and rinsed chemistry.

Foley: On the electroless line and the platers, Atotech moves the solution continually back-and-forth from the bath through the automatic analyzer. The analyzer also controls. That is a nice feature to have—especially in Alex's case where he's using minimum manpower.

Dreiza: This is unique in the industry. Instead of trying to dose the stabilizer based on throughput, you can grab a sample and analyze it. In typical lines, operators spike the stabilizer, and as it decays, they calculate based on throughput when to spike again. With the stabilizer analysis, you can keep a much more controlled stabilizer level, which means that your deposition of electroless copper is more controlled across the process.

Another feature I should point out is that on all these lines is the pumps have frequency

Figure 9: Back-side view of modules with fine particle filtration units.

drives that allow the system to vary the pressure. For microvias, we want to run at high pressure and high frequency. After all, you have to get it down to the bottom of that via.

Holden: We're seeing that there are elements of the recipe and nuances for optimization that haven't been done in the past.

Foley: If you think about it, the U.S. method is all vertical. It's all "dippy dunk." The advantage of the horizontal system with frequency drives on the motors is that you get that solution down to the bottom of the via. In a vertical line, you're dependent on the stroke of the agitation.

Figure 10: Frequency-controlled high-efficiency motors for pumps at all process modules and rinses.

Holden: Let's talk about the chemical dosing portion of the system.

Foley: The back wall has chemical dosing for several different lines. Some of them have fairly large pumps. You could have one pump for dosing and a second for makeup. If we use the same pump for dosing and makeup, some of the makeups would take several hours. Thus, we install a slightly bigger pump for makeups.

Goldman: What is the throughput on this line and does it vary?

Foley: Usually, the low-build electroless copper line is designed to run at one meter per minute. This can be combined with the plater for strike plating at the same speed. However, if full-panel plating is required, then the speed of the plater is reduced and the electroless copper panels are fed into the plater.

At the beginning of the Printoganth TP1 bath, we have a unique roller patented by Atotech. There is a stainless steel roller, an anode, and a cathode. When the panel comes in, it gets a small electrical charge, which kicks off plating as soon as panels enter the bath—even at the first roller. Otherwise, plating starts much later (several feet further down the line). It helps with the thickness if you kick it off right at the beginning; that's another unique thing to Atotech.

On the other line, you'll notice that the rollers are much larger in diameter than the rollers on this line, which are slim rollers. This goes into our pre-dip and palladium activation.

Goldman: What's the target deposit?

Foley: Anywhere from 0.76 to 1.2 microns, depending on what is running. Compared to all the other electroless baths I've worked with over the years, this is a much more stable bath. We've been in production now for close to six months with the same electroless bath. I've yet to see a bath plate out at GreenSource, which is a typical problem in the industry.

When the line shuts down at the end of the day, several spray bars will spray off the conveyor for 30 seconds. The conveyor will run for another 10 minutes cleaning up and returning everything back to the bath. It might dilute the bath a bit, but it keeps the work-

Figure 11: The Atotech team (from L to R: Kuldip Johal, John Foley, Daniel Schmidt, and Moody Dreiza) continues to work with GreenSource on further advances and improvements.

ing area clean. You don't get that buildup of copper.

Another unique thing I should point out—and we only did this because it was Alex's request—is the UV light. In every rinse, the UV light conditions the water and controls algae, bugs, etc.

Holden: Is GreenSource still using panel plate on the Whelen designs versus the new jobs that will be pattern plated?

Foley: Everything that goes through our Atotech line is panel plated. We are developing a horizontal pattern plater called Uniplate IP3—these are all Uniplate IP2s. We're not there yet, but we're getting close to offering this as horizontal process technology too. It's much more difficult with pattern in the plater itself.

Holden: Are any of these modified semi-additive processes (mSAP)?

Foley: GreenSource hasn't run any mSAP PCB designs yet, but these lines are capable to run mSAP.

Holden: Will that be different chemistry or is it a whole new line?

Foley: It would be different chemistry. We have these lines in other parts of the world doing mSAPs daily.

Matties: It's exciting to see such a factory being built. Congratulations for being such a large part of that.

Schmidt: Indeed. Now people from around the world are starting to take notice of what is possible with some of the more advanced systems, which is really the combination of equipment and chemistry. We are pleased to be part of this and will continue to support GreenSource in their future plans. **PCB007**

GreenSource Fabrication Drone Flyover Video Tour ▼

Time-lapse Video: One Year in One Minute! ▼

Schmoll and Burkle Automation Technologies: Lasers and Drills for GreenSource

Feature interview by Patty Goldman
I-CONNECT007

While at GreenSource Fabrication, Burkle Automation Technology's Dave Howard introduced me to the Schmoll equipment as well as other items that Burkle installed at the facility. One unit of great interest was the Impex inspection machine which can do sophisticated non-destructive cross-sections using a very fine fiber probe. We then enjoyed a discussion while touring the line, which is excerpted here. Also present at times and adding to our technical discussion were one Burkle engineer, Evan Howard, and two Schmoll application engineers, Jens Baensch and James Verheul.

Patty Goldman: Dave, tell me a little bit about your background.

Dave Howard: I'm originally from England. Many years ago, I was brought over to the U.S. by the company that I worked for at the time, and I've been here ever since. I am now with Burkle America and in addition to Burkle Lamination Presses we also represent the Schmoll drills and other equipment.

Goldman: We are standing in front of the 16 single-spindle drills lined up in two rows facing each other (Figure 1).

Howard: Yes, these single-spindle drills have lots of bells and whistles on them including linear motors in all axes, high-speed spindles, precision depth control, and automatic loaders.

Figure 1: The double line of Schmoll single-spindle drills at GreenSource Fabrication. Click to watch the video.

IT-170GRA1

IT-170GRA1 Value Proposition

- Halogen Free
- Best in class performance in its space
- Best in class CAF performance
- Very attractive price to performance ratio
- Pass MRT-6 requirements
  - -CAF > 1000 hours
  - -0.65mm pitch equivalent, no thermal issue
- Available with RTF and 2μ copper which provides additional performance on a very solid platform
- Df = 0.0075 @10GHz

Intel Purley Mid-Loss Solution – IT-170GRA1

Futures

Halogen free mid loss, Df < 0.01
Tg 180°C by DSC, low CTE

Applications

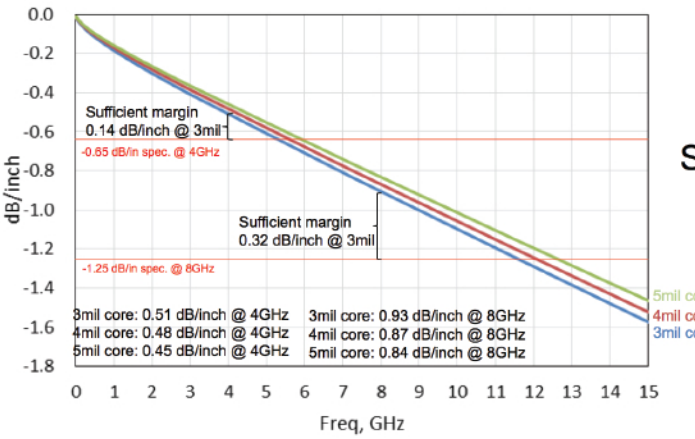
Server/Storage/Switch (10G, 40G)
Backplane, Telecom
Base station

Feature — *Purley Platform Mid-Loss Solution – Hi Tg*

General Properties

Items	Methods	IT-170GRA1
Tg (℃)	DSC	180
T-288 (w/ 1 Oz Cu, min)	TMA	60+
Td-5%(℃)	TGA 5% loss	380
CTE (%), 50-260℃	TMA	2.4
Peel strength (lb/inch)	1 oz	7.0
Water absorption	D-24/23	0.1
Dk: 2-10 GHz	Bereskin	3.96 – 3.99
Df: 2-10 GHz	Bereskin	0.0073 - 0.0075

IT-170GRA1 Insertion Loss



ITEQ

Originally, there was a set of eight that came here about three years ago with the first phase.

Goldman: Have they been replaced, or have they been upgraded?

Howard: GreenSource ordered the second set of eight, so there are 16 now. The original set of eight had individual loading systems that were on the back of each machine of the original line. With this phase, the automation will be taken off the older machines and then they will ultimately be fed by automated, guided vehicles (AGVs).

Goldman: Are those Schmoll AGVs?

Howard: Yes, they're being supplied by Schmoll; they are not yet in-house.

Goldman: Is there any difference between the old and new machines other than the automation?

Howard: Not really. There have been some minor modifications that would have happened because of evolvement, but primarily they're identical systems. Although they are primarily drilling machines, somewhere amongst these 16 are a couple of routing machines.

Goldman: Are they used only for routing?

Howard: I believe so. They all have vision systems associated with them, so they can do vision alignment. These are very sophisticated single-station machines and, from what I hear from GreenSource, they've worked very well.

Goldman: How will the new loading units work?

Howard: Loading will still happen from the back, but it's a different style of loader that will blend better now with the intention of being fully automated. All of these machines have a large capacity tool-change system. It's a little difficult to see, but there's a chain that runs all the way around the machine and it holds 2,200 tools. With an automated system it's very important that you have a lot of tools so that you're not constantly trying to attend the machine just to put additional tools in.

Goldman: Okay, tell me about that very sophisticated panel I am looking at.

Howard: That's the operator control system which offers individual control for each of the 16 units. On the screen here are all functions for this machine including speed (hits per minute), tool management, what options are turned on or off, as well as job information. These units have most of the options and features that Schmoll offers (Figure 2).

Goldman: What's next, then? The laser?

Howard: Yes. This is a two-station pico laser, meaning that it's lasering the material at picoseconds rather than the more traditional nanosecond style laser. One of the characteristics of a pico laser is that it can handle all the different materials.

Goldman: That's an order of magnitude faster, right?

Figure 2: Dave Howard of Burkle North America and I-Connect007's Patty Goldman check out the control system of a Schmoll Modul drill.

Howard: Yes. An order of magnitude. The pico laser also has twin robots, so it's automatically loading the panel on each table. Traditionally, a laser drill has a single station. This is the first machine of its kind for Schmoll and—I believe—for anybody. This has a very powerful laser but then has the beam split, which means two optic paths directed to two different tables.

Figure 3: Optiflex post-etch punch.

Goldman: If there are two tables, do they necessarily have to run the same job?

Howard: You would have to be processing the same job on both tables, yes.

Goldman: That certainly is a powerful laser because you're getting double the throughput on this machine than you would normally get.

Howard: The second laser that is coming is, in fact, a nanosecond laser—the Schmoll Combi-Drill—and it has two types of lasers, both a UV and a CO_2 laser source. It, too, has a split beam approach, to feed two tables. In the case of the Combi-laser you use both lasers simultaneously most of the time. The UV beam is opening the copper and the CO_2 follows behind and removes the substrate.

Jens Baensch: There is a laser source which is inside the cabinet with an optical path of mirrors and lenses that bend and focus the output into two beams, 50% to each table. The difference between this and the other Combi-laser yet to be delivered is that we're having two laser sources. One laser source is UV and is used to open the copper surface; the second laser source is a CO_2 laser, used to cut through resin and the glass and stop at the copper surface. The CO_2 laser cannot cut copper.

Goldman: So that must all happen fairly quickly and automatically?

Baensch: Yes, you have two different optical paths inside the machine. One path is serving the UV laser source directed to the copper surface, and the second optical path is cutting through the resin and the glass and stops at the copper.

Goldman: What is this unit?

Howard: This is the Optiflex, a post-etch punch. This particular unit is an eight-camera system, meaning you're looking at the registration front to back and confirming the accuracy front to back, and then as the name would suggest, you're optimizing the position of the tooling holes based on the cameras that are looking at the visual targets (Figure 3).

Goldman: What goes through here, individual cores? And I presume the Optiflex is reading the panel barcodes that GreenSource puts on every core?

Howard: Correct. Everything in the entire factory is individually identified and tracked through the process.

Goldman: I imagine this doesn't give much trouble as far as failures.

Howard: No, these have been extremely reliable.

James Verheul: So what we'll do is we'll put in a test strip, which is basically an automatic test cycle which just tests every function on the machine. So it's like a dry run, so to speak.

Goldman: Certainly, I know they do everything individually, but surely you must try to put one job in all together. How does that work?

Verheul: I'm not sure with respect to the whole line, but on the Optiflex everything is done with barcodes. Every program will have its own set of requirements; the machine will automatically load a recipe specific to that barcode. So, the thickness of the panel, the formats, everything will be in the recipe, and as it goes through the barcode reader, it will read the barcode, change the format and then punch it.

Goldman: So every individual core has its own barcode.

Verheul: Yes.

Howard: I believe that's true of everything in the shop. Everything through every process is tracked and all relevant data is collected.

Goldman: Then once it becomes a multilayer it must get a new barcode.

Howard: Correct.

Verheul: Yes, it comes in on the left-hand side from the loader, then the system automatically aligns it, the barcode reader will read the code, and if it needs to make any changes, it will make the changes to the format; then it will go through a punch and carry it out. If, for whatever reason, the fiducials cannot be found, or the barcode cannot be read, or there's a problem with the machine and it doesn't know what to do with the board, it doesn't punch it but just passes it through. With the automation, the cores and machines go through a continuous cycle. If there's one panel that is dirty or broken or whatever, it will still run it through.

Video: The Schmoll Maschinen Linear-Z XRI Series X-ray system provides extremely accurate reference hole drilling for multilayer panels. Click to watch the video.

MEPTEC2018

HETEROGENEOUS INTEGRATION: THE PATH FORWARD

REALIZING THE COST AND PERFORMANCE BENEFITS

12.5.2018

WEDNESDAY, DEC. 5, 2018 | SEMI GLOBAL HEADQUARTERS | MILPITAS, CA

SYMPOSIUM 8:00AM - 5:00PM | EXHIBITS 9:30AM - 6:30PM | RECEPTION 5:00PM - 6:30PM

KEYNOTE SPEAKER

Heterogeneous Integration Roadmap and SiP

William "Bill" Chen, ASE Fellow and Senior Technical Advisor, ASE Group

KEYNOTE SPEAKER

Disruption is Coming: Adapt, Change or Be Left Behind

Keith Felton, Product Marketing – IC Packaging, Mentor Graphics Board Systems Division

KEYNOTE SPEAKER

Heterogeneous Integration: Is it Ready for Changing the Packaging Landscape?

Risto Puhakken, President, VLSI

MEPTEC continues to cover leading-edge topics in semiconductor packaging with its Fall 2018 Symposium ***"Heterogeneous Integration: The Path Forward."*** Industry leaders will present the latest updates on technical and business issues related to integration of different types of semiconductor devices. This field has been identified as the next critical area for the semiconductor industry to continue to advance, as progress via Moore's Law scaling becomes increasingly cost-prohibitive or prevented by insurmountable technical challenges. With progress in many areas, cost and performance benefits are finally being realized, and previously impossible combinations of devices are now possible.

Don't miss this unique opportunity to get up to speed at MEPTEC's symposium "Heterogeneous Integration: The Path Forward" on December 5, 2018 in Milpitas, CA.

Sponsorship Opportunities and Exhibit Spaces Available

SPONSORS AND EXHIBITORS

SMART MICROSYSTEMS™

ASE GROUP

Promex Microelectronics Assembly Technologies

Mentor® A Siemens Business

MEDIA SPONSORS

3DInCites.com · Chip Scale Review · GLOBAL SMT & PACKAGING · I-Connect007 GOOD FOR THE INDUSTRY · i-Micronews Powered by Yole Développement · MEMS JOURNAL · semiconductor packaging news a circuitnet publication · Solid State TECHNOLOGY Insights for Electronics Manufacturing · TAP TIMES Test, Assembly & Packaging TIMES

REGISTER ONLINE TODAY AT WWW.MEPTEC.ORG

Figure 4: Burkle Process Technologies' lamination press.

Goldman: Thank you. Now let's move on to the X-ray system. This is a Linear Z technology XRI machine?

Evan Howard: Yes. The X-ray system will measure panels as they come out of the post etch. It scans the panel, checking the accuracy of the post etch. GreenSource will be checking to see if the drill tools are getting dull or if anything is out of alignment. X-ray is the checks-and-balances system before lamination.

The next unit will be checking inner layers and aligning. It will look at the inside of the panel, then drill pinning holes based off where the inside of the panel is, accounting for the little bit of drift from the lamination process. It uses X-ray to look inside the panel, align everything and then drill two holes that will align the panel on the drilling machines when they go into drilling and routing.

Howard: In other words, it's correcting errors that have been introduced during earlier steps.

Goldman: Which hopefully are small.

Howard: Yes. Like everything else here, it's fully automated so it picks panels off a stack, brings them in, does the X-ray analysis and then takes them out.

Goldman: And thee panels came here from from which manufacturing step?

Howard: From the post-etch punch.

E. Howard: The inner layers will come into the post etch, they'll get punched, then they'll come through here to be checked to make sure everything is where it's supposed to be. It then continues on to lay-up.

Goldman: Is that what this next room is going to be, lay-up?

E. Howard: Yes. These carts will load up with inner layers to be transported to the lay-up room.

Goldman: Eventually transport will go straight through the wall, right?

E. Howard: Yes, we already have the pass-through hole, it's just sealed off right now.

Howard: This lay-up equipment here is coming from Burkle. Some of it came with the first phase: a hot press; a cold press; the loading system; and then the interconnecting conveyor together with lay-up and breakdown after the book is pressed.

For the second phase a second hot press was added. The sequence of operation is like this. The loader goes back and forth in front of the machines and will take the load from the hot press, index down, put it in the cold press and then it will receive the next load from the lay-

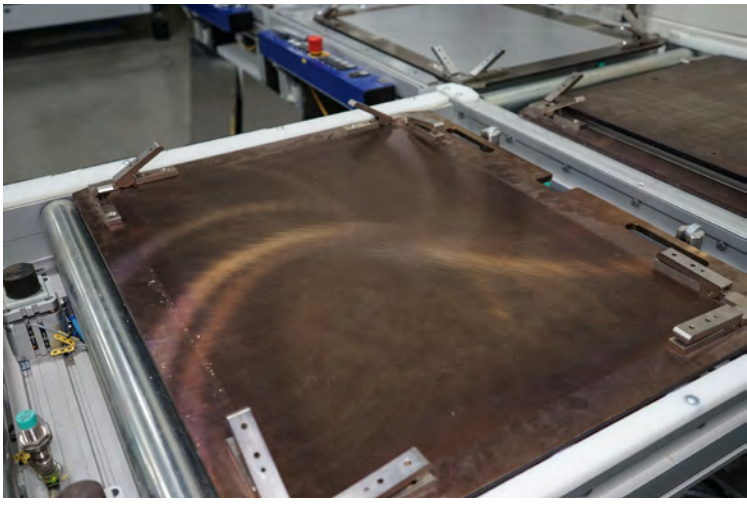


Figure 5: Burkle's pinless lamination fixtures at GreenSource Fabrication.

up room. It will then come in on these conveyors and will be placed in the second hot press while the other one is going through the pressing cycle. While this is going on, the load in the cold press is removed by the carriage and sent to breakdown. Now the cold press is open and available for the next load coming from the hot press. So you pretty much have a continuous operation. I don't know specifically with GreenSource, but on average, a circuit board shop has a hot press cycle time of about 90 minutes. The cold press would be quicker than that. You can obviously empty the cold press before the next load from the hot press is ready, so this is a continuous operation.

Figure 6: The Impex Measuring Solutions proX3 quality inspection and test tool at GreenSource Fabrication.

GreenSource uses a style of pinless lamination. There's a breakdown station here and then inside the room will be the associated layup stations. These press systems are all thermal oil heated as opposed to electric element heating. Thermal oil just tends to give you better uniformity of heating to the platens.

Goldman: Is this the control for one press or both presses?

Howard: The whole system. So that covers most of it: the X-ray, laser drill and the 16 single spindles.

Goldman: Tell about this piece of equipment.

Howard: This is the proX3 from Impex Measuring Solutions, and it's a quality control tool. The proX3 has various measuring techniques from scanning the complete panel quickly, to reporting on the position of every single hole in the panel. It will also report on missing or blocked holes and provide the locations for those. And then there are the proX3's other measuring techniques, like the point-to-point camera system, and also 3D capabilities with which it can literally map the topography of the panel.

Goldman: That's impressive in this one machine. Can it look into the holes?

Howard: There are now techniques where you can plunge into a hole with a very small diameter fiber and it can record the position of every inner layer within the hole.

Goldman: That's really something.

Howard: Yes, it is! This is a very sophisticated machine and I've been very impressed by it.

Goldman: This has been so informational. Thank you, Dave.

Howard: My pleasure. PCB007

Automation Attracts The New Guard to PCB Fabrication

Feature by the I-Connect007 Editorial Team

It only took a few seconds inside the GreenSource Fabrication plant for the I-Connect007 staff to realize just how different the facility is. The look and feel of the place, however, is just one difference; staffing the facility is unique as well.

Of the Charlestown, New Hampshire facility's technology and people, GreenSource Fabrication VP Alex Stepinski said, "You don't see other fabricators replacing plating areas. It just never gets done because it's too hard. And then you have a lack of young people in the industry—everyone is five seconds from retirement, it seems. From what we see, if you go into any board shop, I think the average age is probably 55–60."

Figure 1: GreenSource Fabrication finds ways to build a younger, more sustainable work force at their New Hampshire manufacturing plant. Working virtual is a key part of their staffing strategy, too.

Ask him why that is, and he answers right away.

"They can't get young people to stay there because the places are all scary. If you're a millennial and you walk into some place where there's copper plating dripping everywhere…" Stepinski shakes his head. "Nobody wants to work there."

GreenSource Makes a Choice to Bridge the Gap

GreenSource—like most of the industry—is struggling with an age/expertise gap. In fact, it's more like a gaping chasm. Experienced PCB fabrication techs and engineers are typically over 50, with a much smaller percentage under age 30. In between, there's a huge chunk of the age demographic simply missing from the work force.

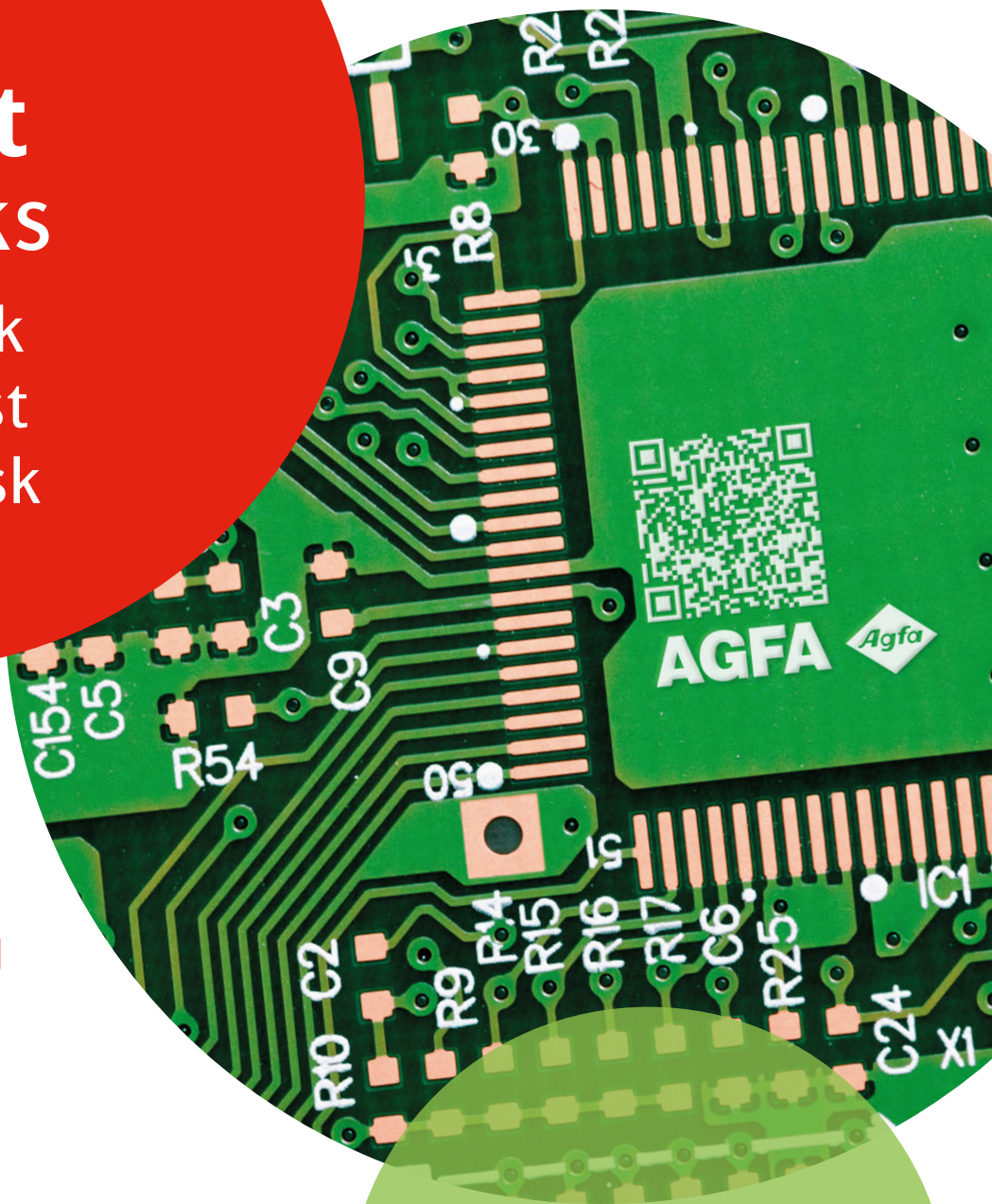
"For every five that retire, they get replaced with one," says Stepinski. Which raises one of the key questions for PCB facility ownership: what good is investing in new equipment if there won't be anyone who can run it?

After a thoughtful pause, Stepinski threw down the gauntlet.

"We see this across the whole market. We're trying to stay ahead of it by making a nice working environment and getting a lot of young people here. We have a good demographic. We have experienced people who have a lot of industry knowledge. Then

DiPaMat
Inkjet Inks

- Legend Ink
- Etch Resist
- Soldermask



- **Variable data printing**
- **Fast**
- **Ecological**
- **Efficient**

BE FLEXIBLE.
GO DIGITAL.

AGFA, your partner for imaging solutions

Traditional Phototooling
and UV Inkjet Inks

industrialimaging@agfa.com

AGFA Agfa

we have a lot of younger people, and we have a bunch of people in the middle," Stepinski explained. "It's a nice bell curve, as it should be. That's going to be our advantage long term. I think 5–10 years from now, you're going to see a lot more shops disappearing simply because there is nobody to run them."

Management Plans

The GreenSource master plan, therefore, does not simply stop with equipment. Expertise is required as well—sustainable expertise. After talking to a number of staff members, the master plan emerged based on five key pillars:

- Invest in cutting edge equipment and processes
- Make this facility cleaner and more capable than any other in the industry
- Staff with high-caliber industry experts and motivate them to teach down
- Select and train local area technical grads
- Avoid industry tradition (what was), and concentrate on current knowledge (what is)

Recruiting Processes

Beautiful and rural as New Hampshire is, Stepinski sees the location as a potential disadvantage. "The local population to choose from is small. What we'll try to do is make as many positions as possible virtual, so we can get talented people from across the country. We designed the process so that it's not about touching the panels; it's about analyzing the data and making a plan."

Asked how he attracts talent to work at the GreenSource facility, he replies, "We recruit locally. The plan is to hire four more young engineers fresh out of school this year. In on-site support, the experienced folks are always near retirement and don't want to move. The burden is on us to take in a group of new grads every year."

To accomplish this goal, Whelen Engineering—and GreenSource Fabrication—work closely with technical programs close to home,

Figure 2: Jacques Jalbert talks with the I-Connect007 team, and shares details on the AWP equipment he maintains at GreenSource Automation. Jalbert is a recent graduate of the University of New Hampshire.

specifically the University of New Hampshire. Process engineers Cassie MacKinnon and Jacques Jalbert both found GreenSource by talking to Whelen reps at a UNH job fair. Jalbert and MacKinnon have degrees in mechanical engineering, and both found the GreenSource facility compelling.

"I came out for a plant tour and I kept thinking, 'Wow, this is really cool!'" shared MacKinnon. "There were so many machines and we toured a bunch of different buildings here on the Whelen campus. The GreenSource facility was the last building we came to. The job was for CNC drilling…and I thought it was just the neatest thing…and that's the job I ended up getting. I was really happy with that."

Jalbert added, "They were looking for people my senior year, mostly for the drills. I got

connected that way. They were looking for younger staff to have on hand, mostly to specialize in areas like automation, drills, lamination…things like that."

Now Jalbert works on automation equipment, "My job is anything AWP-related. That was kind of the route I was aiming for—control systems and robotics. It was a perfect fit."

MacKinnon added, "John Olson [former Whelen CEO] graduated from UNH. The Whelen and Olson families put a lot of money into UNH programs. Whelen always comes to UNH career fairs."

Figure 3: Cassie MacKinnon, GreenSource Fabrication process engineer, runs certifications on the proX3 tester as a part of bringing all systems on-line.

Training

But turning new grads into industry experts requires on-site experience and training—lots of training.

Asked what it's like to work with the industry veterans, Jalbert answers, "I think it's a great opportunity. I like working with people like Mark Chassé, Alex Stepinski, John Burke—people who have a lot of experience in this industry. They know what they're doing, and I can always go to them if I need help with anything."

"I've been in the metallization, plating, and electronics industry for 30 years this summer," said Chassé. "It's been an exciting ride. The regional rep from Atotech worked with me on my first job 30 years ago. He knew that Alex was looking for some talent. It's a really good fit."

Cross-training is a priority as well. Asked if he works exclusively on machinery, Jalbert said, "I do some of the software, too, at least with the automation equipment. I go back and forth. With software, I have an idea what needs to happen, so when I need software fixed, I can go to these companies and say, 'This is what I need done. I've looked at the code; this is what's missing. Please fix it.'"

Ask Chassé his thoughts on passing his knowledge to the next generation and he replies.

"The day I stop learning will be a bad day. These young guys are brilliant. They've been given tools—I'm not quite sure how to explain it—and they approach problems differently just because of when they went through school," said Chassé. "They're taught differently, taught to go through computers. I didn't touch a computer until I was 30 years old," he laughed. "Their mindset and approach to automation is really something. These younger guys are different than me. It's just because of their training and their youth. It's profoundly good. So, I learn from them, and hopefully, I can teach them something."

Crystal LaClair, a quality manager and seven-year employee at Whelen, is in a different place on the learning curve. In her role, she's in charge of creating, documenting, and validating many of the brand-new processes, using brand-new equipment, to get everyone production-ready.

When asked what it's like to work with the older industry veterans, she said, "I pick these guys' brains all the time and they challenge me even more. They come at the younger group and they ask, 'What do you guys think?' because we have a different perspective on things. We ease into technology faster than the previous generation. And the next generation is going to do the same, so I think it's very cohesive for us to work together. Then, at the

same time, we're building the next generation of PCBs. We know what we want to be; we all have high goals here."

On her start in the industry, MacKinnon said, "It was a huge learning experience, and it still is because when I got out of college I didn't know the PCB fab business at all. I'm still learning all the technical process terms, for example. I worked with Henry Brzeski, who is our equipment engineering and facilities manager, and started doing maintenance with him. Henry taught me a so much, and he still teaches me how to troubleshoot the machines, do maintenance, replace parts."

MacKinnon spent about six weeks training on the drill machinery in Rodermark, Germany, at the Schmoll facility.

At this point, 14 months into her tenure at GreenSource, MacKinnon is establishing her growing expertise in both mechanical and laser drilling machinery. During our time on site, we observed MacKinnon working extensively on a CO_2 laser drill machine, with a serial number of one.

Concerning his start at GreenSource, and in the industry, Jalbert said, "I've traveled to Poland, Germany, and Japan training on all this equipment…I've been hands-on since the equipment was delivered."

Chassé explained one of the more intangible parts of working with younger engineers. "Sometimes they don't know the urgency. As one of the veterans I have to lead by example and express the urgency and that, when I need them, I need to trust that they're going to respond. And they have. It's all part of learning. That's what they're learning: how to work in a fast-paced environment. I have to keep my mind open to learn new stuff from them."

Including the Family

MacKinnon and Jalbert have been in a relationship since college. Now they both work at GreenSource. Mark and Chris Chassé are the multi-generational father-son duo in the plant. LaClair is a newlywed—her spouse is also employed by Whelen Engineering.

"There's an excitement for me to work with my son because he's a mechanically adept

Figure 4: GreenSource Fabrication's focus on sustainability includes the facility, the equipment, the people, and the product.

Are you getting to the bottom of your via?

Prevent connection failures in thick PCB substrates with plasma treatment

New **VIA™ Series 2.5** cleans deep, narrow vias where other processes can't go

VIA™ Series 2.5
Plasma System

Contact us now to learn more
+1-925-827-1240 / info@nordsonmarch.com

nordsonmarch.com

Nordson MARCH

person. He's a mechanical engineer. He just thinks differently," Mark Chassé added. "And we just talk about this stuff on the way home. It's exciting for me to be able to talk to somebody at home who understands what I'm doing."

GreenSource's Competitive Advantage

According to Stepinski, "This factory is designed for 10 years out. And 10 years out, we'll still be the only green factory in the U.S. We're years ahead of everybody in developing this technology."

The implication is clear: If it takes the rest of the industry 10 years to retool and catch up, by that time, the staff at GreenSource will have 10 years of practical experience. The GreenSource staff will be masters of the process while everyone else is still learning how to use their new equipment.

And this thinking is trickling down.

MacKinnon wrapped up our conversation, saying, "We just keep evolving. We have tons of opportunities to keep evolving our equipment and our processes. We want to be the leading PCB manufacturer. That's where I see us going."

Jalbert's closing comments echoed Alex's sentiments. As a new hire, Jalbert noted, "It's great to have you all on-site and recognizing what we do here, especially on the environmental side. You go to these other companies and their recycling isn't quite there yet. I'm excited to see the industry really grow into an environmentally friendly atmosphere."

It's not just the leap forward in equipment and design that makes GreenSource competitive, environmentally friendly, and—most of all—sustainable. It's the awareness at GreenSource, with their five-point plan for staff development, to develop their own young experts as well. **PCB007**

Industrial Automation Vendors Consolidate Their Product Portfolios to Generate New Revenue Streams

By offering third-party-enabled Industrial Internet of Things (IIoT)-based products and solutions, industrial automation vendors have evolved to provide proprietary digital platforms via the product-as-a-service (PaaS) business model. The trend of digitalization in end-user industries prompted automation vendors to invest in IIoT technologies across diverse applications, and they are now looking to integrate these technologies to complement conventional automation systems and give end users better control over the systems' functionality.

"The advent of Industry 4.0 is disrupting the partnership ecosystem in industrial automation, with start-ups and independent software vendors (ISVs) partnering with automation vendors to develop digital capabilities and solutions," said Rohit Karthikeyan, Senior Research Analyst, Industrial Automation & Process Control at Frost & Sullivan. "Automation vendors will aim to standardize their portfolios through M&As and partnerships, and drive growth in their respective business segments. The consolidation of their IIoT portfolios will result in the upselling and cross-selling of automation solutions and create fresh revenue streams."

Frost & Sullivan's recent analysis, Global Industrial Automation Market Outlook, 2018, highlights the IIoT platform offerings of major automation companies and compares their products and services. It underlines the role of start-ups with niche capabilities in operational and information technologies in 2017. The analysis also details the market landscape of the key participants in process automation, hybrid automation, and discrete automation markets.

(Source: Frost & Sullivan)

tracqms

THE RIGHT APPROACH CONSULTING LLC

Now is the perfect time for you to take the right approach to quality management.

The single best improvement you can make to your business is to update your QMS. I can help you upgrade to ISO 9001: 2015 or AS9100 Rev D in six months - guaranteed!

LEARN MORE ABOUT MY CERTIFICATION GUARANTEE

tracqms.com

Electronics Industry News and Market Highlights

'Optical Rocket' Created with Intense Laser Light ▶

In a recent experiment at the University of Nebraska–Lincoln, plasma electrons in the paths of intense laser light pulses were almost instantly accelerated close to the speed of light.

Automated Guided Vehicles Market Size at $7.3 Billion by 2025 ▶

The global automated guided vehicles (AGV) market size is expected to reach $7.3 billion by 2025, according to a new report by Grand View Research, Inc., registering a 16.5% CAGR over the forecast period.

Flexible PCB Market to Reach $27.6 Billion by 2023 ▶

Flexible printed circuit board market is expected to increase from $13.5 billion in 2016, to $27.6 billion in 2023, at a CAGR of 10.7% from 2017 to 2023.

3D Print Colloidal Crystals ▶

MIT engineers have united the principles of self-assembly and 3D printing using a new technique, which they highlight today in the journal *Advanced Materials.*

Wearables to See Slower Growth in 2018 Before Ramping Up Again Through 2022 ▶

The worldwide wearables market is forecast to ship 122.6 million units in 2018, up 6.2% from the 115.4 million units shipped in 2017, according to IDC.

3D Printed Electronics Market to Touch $3.915B by 2026 ▶

The global 3D printed electronics market is expected to reach $3.915 billion by 2026. The market is projected to expand at a CAGR of 44.46% during the forecast period from 2018 to 2026.

Medical Electronics–Medicine in a Digital World ▶

The health industry is going through a period of dramatic change. We are seeing more and more digital solutions throughout the patient journey—at every stage from prevention and diagnosis to treatment. Medicine 4.0 can only work on the basis of collaborative efforts at the point where the medical and engineering disciplines overlap.

Semiconductor IP Market to Reach Over $9B by 2026 ▶

The global semiconductor intellectual property market is expected to reach $9.4 billion by 2026, according to a new market research report published by Transparency Market Research titled *Semiconductor Intellectual Property Market—Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2018–2026.*

Global Semiconductor Sales Increase 17.4% Year-to-Year in July ▶

The SIA, representing U.S. leadership in semiconductor manufacturing, design, and research, today announced worldwide sales of semiconductors reached $39.5 billion for the month of July 2018, an increase of 17.4% compared to the July 2017 total of $33.6 billion.

Shrinking Semiconductor Lasers to the Nanoscale ▶

A tiny laser comprising an array of nanoscale semiconductor cylinders has been made by an all-A*STAR team1. This is the first time that lasing has been achieved in non-metallic nanostructures, and it promises to lead to miniature lasers usable in a wide range of optoelectronic devices.

pluritec

Celebrating 50 Years of Service!

50

1968-2018

The Pluritec brands that provide you with tomorrow's technology today !

pluritec

X-ray Optimizer &
Automated flash/Bevel/Corner
rounding panel prep

Drills & Routers
24/7 automation

MORE INFO

ECOspray SYSTEM

Multi-color solder mask
coaters with 15 minute
fast tack oven

MORE INFO

IS INTERNATIONAL SUPPLIES

Wet Process
developers - etchers - strippers
Cobra - MEC Etch
Shadow - ChemClean

Mechanical prep
Debur - Scubbers - Pumice/Oxide
PCB brush & Chemical washing

MORE INFO

www.pluritec.com | info@pluritec.com

InduBond Takes on the Lamination Process at GreenSource Fabrication

Víctor Lázaro, Indubond

Feature interview by the I-Connect007 Editorial Team

In a conference call with the I-Connect007 staff and Víctor Lázaro, chief technical director (CTO) at InduBond, we discussed InduBond's innovative lamination technology currently being installed at GreenSource Fabrication. Though not yet delivered at the time of our visit, we contented ourselves with a long-distance discussion and photos of the equipment.

Patty Goldman: Victor, can you remind our readers about InduBond's history? It's been some time since we last caught up.

Víctor Lázaro: InduBond is the brand name of the company named Chemplate Materials, located just north of Barcelona, Spain. The company was born 30 years ago as a shop in the local PCB market for different parts like consumables on the chemistry side. At that time, Chemplate was also representing several equipment brands for the PCB industry. There were other businesses in the same company for general chemical plating for other industrial fields, such as plating on plastics and the aluminum markets for different kinds of processes.

Back then, the company was very small and owned by five families. The founders are now retired, but some of their sons continue to be involved at the company. I was hired right out of school back in 1996. The idea was to follow up on the business area related to the equipment side for the PCB market. In 1999 or 2000, I first had the idea of applying induction into the PCB manufacturing process. That's a lot of what today's technology is at InduBond—induction bonding of the inner layers together. With this new technology, the industry can move away from the older technology and lamination process.

Induction has many advantages. We not only developed the equipment and technology, but we also developed the process, which was new to the PCB industry. Today, we have around six or seven different patents for this technology.

Once we introduced this technology, the market took three to six years to accept it and to see the benefits compared to the previous well-matured technology in use today, which is hard tooling registration and then lamination with that hard tooling. Together, it is called pin registration and pin lamination. We also introduced the InduBond brand in 2000 to identify our process technology. Then, we continued the development. We did the very first, genuine induction bonding machine. Ten years later, around 2010, we started to go directly to the market. Today, we have a product line that comes from a basic unit to a sophisticated,

Electronics Coatings for the Digital Era

ELECTRA

EMP110 Soldermask

- Reputation for reliability
- Meets or exceeds automotive requirements
- Widely used in the automotive industry

RoHS COMPLIANT

T +44 (0)1732 811118
info@electrapolymers.com
www.electrapolymers.com

fully automated unit for the induction bonding registration machines.

Additionally, we developed another novel product and technology for the next process after the registration and bonding. We created a new system for pressing or laminating the panels. It is also based on the InduBond technology, but that lamination press is called InduBond X-Press.

Nolan Johnson: How did you become connected with GreenSource?

Lázaro: Several years ago, when this new project started at Whelen, Alex visited an InduBond account in Germany that has InduBond inner layer lay-up equipment. That's where we introduced Alex to this technology. And Alex, being a very forward-thinking person, was immediately interested in the pinless lamination.

Alex began asking me about the lamination press technology. We were seated in a meeting room defining how the automation and the induction bonding machine registration would work according to his requirements. By chance, I mentioned that we had another technology that had not yet gone to market. I introduced that technology and its benefits. Because Alex is a fanatic for the state-of-the-art, he asked to come to Barcelona to see the first machine, which had been working for eight years for a local customer. He was very impressed with what he saw, and he wanted us to move in that direction.

InduBond is taking charge of the whole lamination process at GreenSource. Their goal is to produce complex boards and laminate using our new induction bonding press technology. The benefits of our equipment are that you can get even pressures and temperatures—including high temperatures—but the energy performance is also important. Our technology uses just 8–10% of the energy a standard press uses for a similar capacity, which offers huge energy savings.

Barry Matties: When you're talking about the press, the energy savings is a big deal, but also the heat-up and cool-down cycle time. Does that provide substantial savings as well?

Lázaro: Our technology saves a lot of time in the heating, of course, because the energy is directly channeled into the material. It's not heating the big ovens that then must transfer heat into the material. However, the limit to

Figure 1: Induction lamination press.

shorten the cycles is in the resins. To best leverage this, the ramp-ups and heating speed must be inside the limits of resin as set by the manufacturer in their prepreg data sheets.

The chemistry industry has been developing composites to be manufactured in the available technologies in the industries: conventional presses with all their pros and cons. For that reason, the resins, epoxies, and composites are designed to be cured in traditional ovens. Now that we are putting this on the market, I think it may be possible to have faster heating uniformity to shorten the cycle times and cost in a real, effective way.

Matties: You just keyed in on one word—uniformity. Do you expect a greater uniformity with the induction as well?

Lázaro: Yes, we do. Like I said before, we have a prototype and an onsite machine that has been working in production for eight years. Our customers still send regular samples to make sure that the Tg and lamination capabilities are consistent. The reports are always excellent, which means that temperature uniformity is very nice. A key to this is that the sensors in the machine are monitoring the temperature right at the material, not the big heavy platens like in the traditional presses.

Matties: It sounds like you receive the uniform temperature across the entire panel, as well as through the thickness as it transfers. But how do you handle cooling? Is it in the same press or do you move it into a cooling press?

Lázaro: The concept is a bit different. We are going in the direction of flexibility, which means the machine is ready to go the whole time. You don't need to preheat anything. Each press will do the heat profile and then the cool profile without releasing pressure. It's going to enter the stack of the panels, start the cycle and when the press opens it's ready to break down the stack at room temperature. The cooling is also a new and sophisticated system using air flow. Energy is moved from the center towards the edges uniformly.

Matties: Right, because you have that open-air space.

Lázaro: Exactly. The ideal way to cool down a laminated panel is to keep the pressure, open the door of the press, and let the panel cool down to ambient without forcing it. In our case, we are emulating that ideal way to cool down.

Matties: What sort of cool-down cycle time do you expect?

Lázaro: We did test simulations on the computer, plus tests on the machine that is almost ready to go to GreenSource. We can go faster than today's resin sets specify. Normally, they don't want to go faster than three degrees a minute, and we are able to go to 4.5 degrees a minute. Depending on how many panels, we're talking about 30- to 45-minute cooling cycles.

Matties: What you guys are doing is creating a need for the resin manufacturers to upgrade their products as this technology becomes mainstream.

Lázaro: Yes, that's right. There are only two or three manufacturers of epoxy in the world. Ideally, it can be possible to heat up faster and cure faster. I'm sure they can develop faster resins. For the PCB, I think it could be possible to have a horizontal press line. You put a single panel on one side of an inline machine and get a panel laminated on the other side ready to continue to the next process.

Matties: You're ahead of your time. That takes care of the press portion. What about loading? My understanding is this is a completely automated system from lay-up to break down.

Lázaro: Yes, but the lay-up operation of the panel to be laminated stays on the manual side because there are many variables in the process. For instance, there are a lot of different types and thicknesses of prepregs, different thicknesses of copper foils and a lot of variables to handle. There's still going to be manual labor,

but in a lot more ergonomic way—faster and more comfortable for the operators.

The stack is also built up in a faster way because we do pinless lamination, so the registration of the inner layers will already be done on the InduBond bonding and registration side, which means we're going to have a book of cores already registered and bonded that have to be put together with the outer layer copper foils and prepreg. That part of the buildup is going to be easy and fast.

The operator will build the final stack to be laminated on carrier plates, depending on the production needs. For example, they can do three or four panels or the full capacity of a press. Again, our idea is to make modular presses. You will be able to press five panels in one press because you are prototyping and need it fast, let's say, jumping the production line for some reason. But a side press can do 40 production panels in the same cycle. Because we are not going from one general big press, the whole line will be very flexible. It's like modular single-head drilling machines; there can be one machine doing a job, and the next machine is doing a different job. That's the philosophy.

The loading and unloading of the stacks will be done by similar automation as with the standard machines. You will have a transferring automation in front of a line of different presses and a buffer where you store all the carriers or all the stacks waiting to be laminated. According to our general control decision or criteria, this transfer automation system will go to the general buffer, pick up the stack of panels to be laminated, load it inside the available press, close the press, and start the cycle. In the meantime, the system will load or unload another press and deliver to the breakdown table for the operator to separate panels and plates.

Matties: It still requires an operator for separating the panels. Was that something Alex was looking to automate or was he resigned to the need for human intervention there?

Lázaro: This could probably be automated in the near future, but the whole lamination line

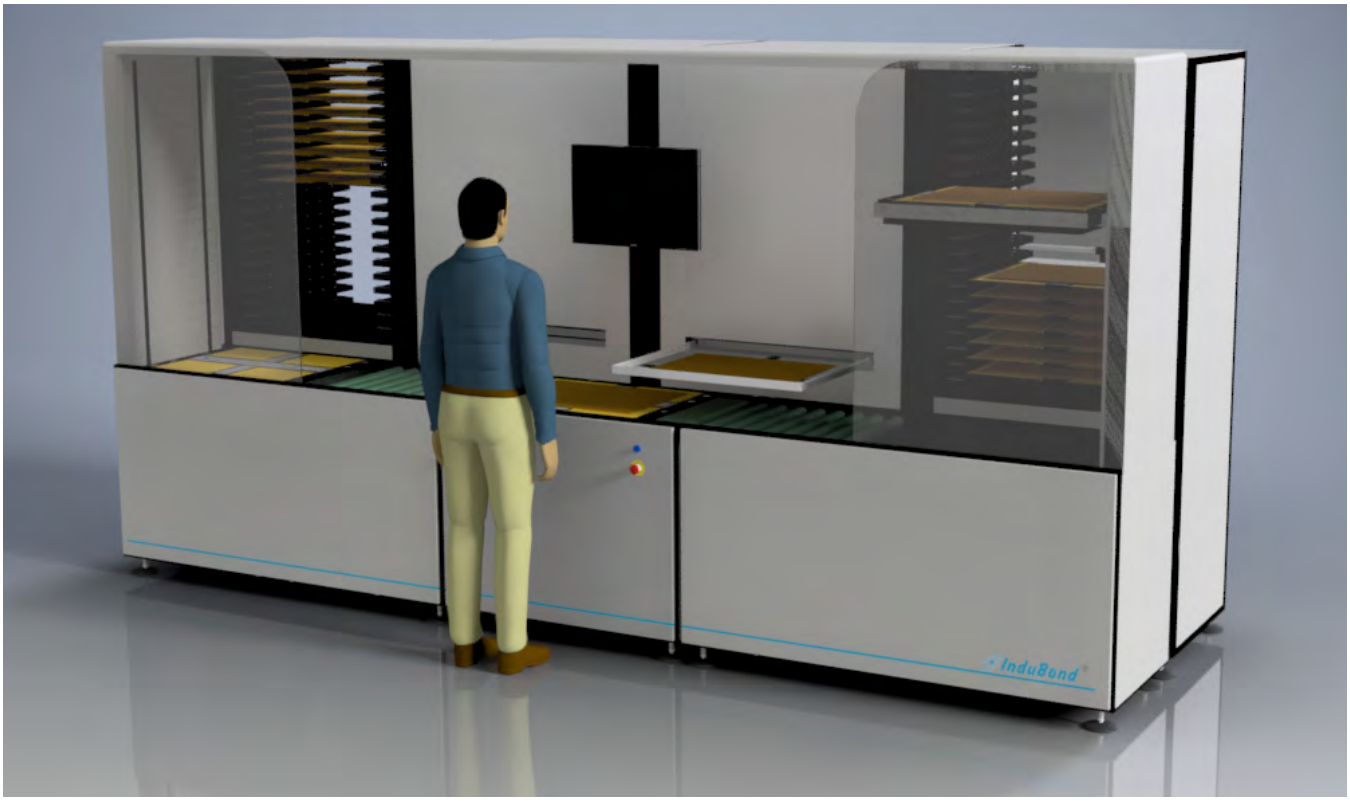


Figure 2: Automatic lay-up station.

Excellon

Manufacturers of precision Micro-Machining Solutions for over 50 Years

COBRA II

Hybrid laser system

689

6-station precision drilling and routing system

HS-1L DS

Single-station, dual spindle high-speed system

136L

High accuracy and speed

154L

Large panel applications

HS-2L

2-station, high-speed

129

Single-station precision system

Move into the future with the latest innovations in Fabrication Technology from the Industry Leader!

www.excellon.com

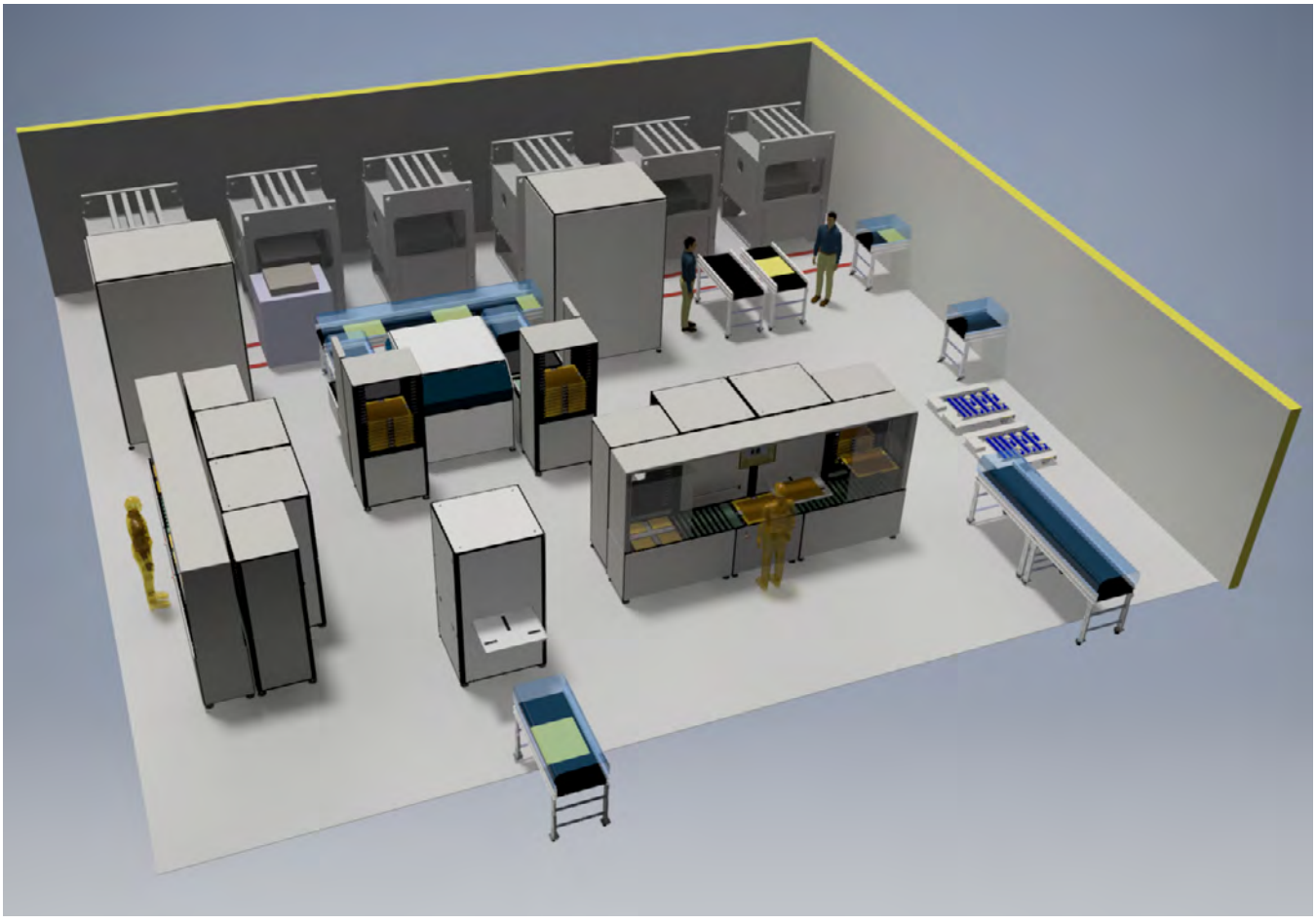


Figure 3: 3D model of GreenSource Fabrication's lamination room.

is going to be altogether new stuff. His wish is to have everything super automated, but he also understands that some parts of the PCB process for multilayer are very difficult to automate for the complexity of the panels he wants to build.

Thus, the breakdown of packages could potentially be automated by robots. This is something we still have as a possibility in the second phase. But for the buildup, we are not thinking of automation now because the prepreg is challenging to pick up in an automated way. The bottom line is if you need an operator to do something at the end, it makes no sense to automate—just leave a little detail for the operator.

Matties: You're right. I would think that the breakdown phase would be the obvious area for automation because you're dealing with the panel at that point.

Lázaro: Yes. That part is when you're just separating materials. You put the plate into the stack that goes to the cleaning machine, and the panels go to a different pile that will be moving to a flash routing area, so, it can be automated easily.

The other thing we developed and have tested is a fast, smart dispenser. It's a new way to automate and reduce human manipulation of the cores or panels. At GreenSource, we will be congregating all the cores at the end of layer inspection or tooling, prior to getting inside the lamination room.

This dispenser is a tower elevator. In the elevator, you have a removable cage with 20 automated drawers. The line where the cores will come from will be talking to this dispenser, which will follow some definite criteria. The loader will load according to the criteria for the cores in the defined drawer. It's a smart storage machine. Then, since the whole 20-drawer

cage is removable from the dispenser machine, a cart or trolley will transfer the whole storage thing to another dispenser in the lay-up station. This defines a faster, cleaning and manipulation-less process.

The automated lay-up station will have another two of those dispensers. We offered to make those trolleys with self-guided or self-driving technology, but there's not much room for having automatic vehicles inside. Instead, we decided to move those trolleys manually. An operator will detach that cage of 20 drawers from the first dispenser and will be loading that cage of 20 drawers into the lay-up station. This lay-up station will have the capability of 40 total drawers, and each drawer can have a capacity of more than 200 cores per drawer, depending on the thickness of the cores. You can have a lot of material inside.

Not only that, but you can also have the prepregs there. While the loader is loading, it's creating a database of the content of each drawer of each cage, so there is an interconnection from the first dispenser to all the other dispensers. Everything is on the database. It will need just one operator on the lay-up station.

Then you have a lay-up table and on the other side of this automated lay-up station, which will have an automated dispenser of our tooling plates. What the operator does is build up panels in an ergonomic and automated way. The only thing the operator does is pick up core or prepreg and lay it down over the tooling plate. That's it.

Matties: Everything GreenSource needs arrives from these cages right when they need it.

Lázaro: Exactly, because these dispensers will be delivering in the correct order the sequence of the stackup of a given job number.

The tooling plates will be stored in racks on this automated lay-up station. The tooling plates are very precise, mechanically speaking, and will have a long life because they are not going to the press; after the bonding process, the panel is removed from that tooling plate because we're talking about pinless lamination. Those tooling plates will always be in the same good condition. They will be also numbered, so every stackup will have some process parameters. This is also new in the industry, tracking registration!

The other feature for the automated lay-up station is that this reduces handling by operators, so no scratches or mistakes, but it also provides control. Each time the operator is laying down a core or the prepreg, there is a system that accurately measures the differential between the previous and the next to quantify the thickness. Because the database knows associated stackup details and the theoretical thickness of each material at the right time, it will be checking to confirm an accurate stackup. If the operator makes a mistake, for example, putting more prepreg sheets than there needs to be, the system will warn. Or if the core is not matching what is expected in terms of copper or substrate thickness, you will get an alarm, and there is a protocol to remove that or put it aside. That is not going to pass through or around stackup.

Matties: That will certainly cut down on the scrap and increase yield because that's a costly step to have a mistake after you have so much invested in the panel.

Lázaro: Yes. Once an operator loads that rack with 20 plates on each side of the InduBond RFX tandem machine, everything that happens afterward is fully automated. Another machine will pick up the plate with the materials and drop it off over at the bonding machine. The bonding machine will scan the barcode to know the bonding recipe and bonding locations for loading the right Gerber file and then the machine will start bonding.

The bonding machine is also a new tandem machine—one table is inside the bonding area, and the other table is outside. While one panel is being bonded, the table on the outside will be unloading the previous one and loading the next one. The automation will be picking up the bonded stackup, which will be dropped off onto a flat conveyor at the exit of the machine. That conveyor will transport the bonded panel

into a general buffer that is going to be right in front of the final buildup station for the press.

Matties: There's going to be a lot of eyes watching this piece of the technology that Alex is putting together. It certainly has a lot of benefit throughout for the industry. When do you expect to have your press delivered and operational?

Lázaro: Yes, we want to thank Alex and GreenSource for giving us this opportunity. I believe we will be ready by mid-October to move the machines.

Matties: With all this equipment and this being a data-driven factory, how are you dealing with the integration with the communication of your equipment into the overall data structure that Alex has in place?

Lázaro: This is a big challenge that will be happening mostly after all the equipment is installed. It's complex and needs an IT team working together and talking to Alex or the engineering management at GreenSource. However, we did prepare the machines in a flexible manner, so we can interface easily and remotely to all they will need when they integrate the general control software to track the data.

To do this, we developed a communication protocol where our machines also create a database with information coming from the QR readers. At some point, it will be easy to integrate this into their system when they are ready.

Lázaro: The lamination portion is very possible, it's just a question of sitting down together with the right people. There's much more of a challenge with the whole factory, though.

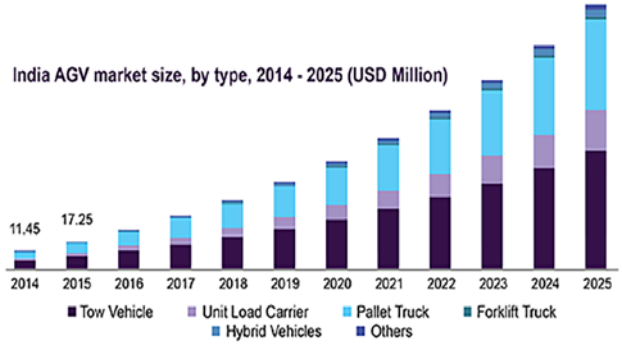
Matties: A lot of moving parts there.

Goldman: Thank you so much for your time.

Lázaro: It is. Thank you. **PCB007**

Automated Guided Vehicles Market Size at $7.3 Billion by 2025

The global automated guided vehicles (AGV) market size is expected to reach $7.3 billion by 2025, according to a new report by Grand View Research, Inc., registering a 16.5% CAGR over the forecast period. AGVs are transforming the way materials can be moved within manufacturing and distribution facilities. In a production environment where several operations are carried out simultaneously, these vehicles can ensure predictable and reliable transfer of raw materials as well as manufactured products from one point to another within the facility, thereby eliminating any potential disruption in production. These vehicles can operate safely around structures, machinery, and employees, as they are equipped with accessories such as camera vision and LiDAR sensors. These can help in detecting junctions, identifying floor signs, and avoiding collisions with obstacles.



Manufacturing plants and warehouses are increasingly deploying material handling equipment for various activities, such as locating stock, picking orders, and moving products and raw materials. Transportation and logistics firms are particularly under pressure to boost the efficiency of their operations in line with growing demand for their services. They are hence heavily investing in such equipment. Increasing demand for material handling equipment is expected to boost the AGV market over the forecast period.

(Source: Grand View Research, Inc.)

INTERNATIONAL PRINTED CIRCUIT & APEX SOUTH CHINA FAIR

HKPCA IPC

2018国际线路板及电子组装华南展览会

Presented by HKPCA & IPC 由HKPCA及IPC联合主办

启迪行业 探索无限

Inspire the Industry. Explore the Infinity.

One of the Global Largest PCB & EA Show for Effective Sourcing and Information Exchange
Additional Hall 6 Opened to Cover More Innovations in the Industry!

- Visit the biggest ever show to see the latest products and solutions from close to **560 exhibitors** and **3,100 booths** across a massive exhibition space of **over 60,000 sq.m.** covering **4 halls**
- Check out more products and technologies of Hong Kong PCB manufacturers at the **"Hong Kong Pavilion"**
- Other onsite events like **International Technical Conference**, **IPC China PCB Design Seminar**, **Golf Tournament** and **Welcome Dinner** provide you with vast educational and networking opportunities

2018 HKPCA & IPC Show

2018.12.5-7

Shenzhen Convention & Exhibition Center, China
Halls 1, 2, 4 & 6

Pre-register now at www.hkpca-ipc-show.org or WeChat for fast admission!

Follow us on WeChat!

Organizers

HKPCA Hong Kong Printed Circuit Association 香港綫路板協會

IPC

Event Manager

BAOBAB TREE 柏堡

Participation Enquiry :

Organizers:

HKPCA
Ms. Manda Wong / Ms. Amanda Li
Tel: (852) 2155 5099 / (86-755) 8624 0033
Fax: (852) 2155 9099 / (86-755) 8624 0022
Email: secretary@hkpca.org / amandali@hkpca.org

IPC
Mr. Chuck Li
Tel: (86-21) 2221 0072
Fax: (86-532) 8099 0700
Email: chuckli@ipc.org

Event Manager

Baobab Tree Event
Hong Kong & Overseas
Ms. Faye Lau
Tel: (852) 3520 3612
Fax: (852) 3520 3618
Email: faye.lau@baobab-tree-event.com

China
Ms. Carmen Feng
Tel: (86) 133 6057 8272
Fax: (86-20) 8765 5805
Email: carmen.feng@baobab-tree-event.com

CIMS AOI Solutions: Truly Creativity In Motion

Feature interview by Barry Matties and Patty Goldman
I-CONNECT007

The company tagline for CIMS is "creativity in motion." Headquartered in Suzhou, China, with offices globally, CIMS provides automated optical inspection (AOI) solutions to enhance production and yield in PCBs, high-density interconnect (HDI) PCBs, and flex and rigid-flex PCBs. Patty Goldman and Barry Matties spoke with David Ravino about the CIMS installations at GreenSource Fabrication, which includes AOI, metrology measurement and analysis, laser inspection, and real-time process data capture. They also discuss the innovations and challenges that this project presented for CIMS.

Patty Goldman: Tell us a little bit about CIMS and what you have going on at GreenSource Fabrication.

Panasonic

For Millimeter-wave Band Antennas
NEW Material replacement of PTFE

Halogen-free
Ultra-low Transmission Loss
Circuit Board Material

R-5515

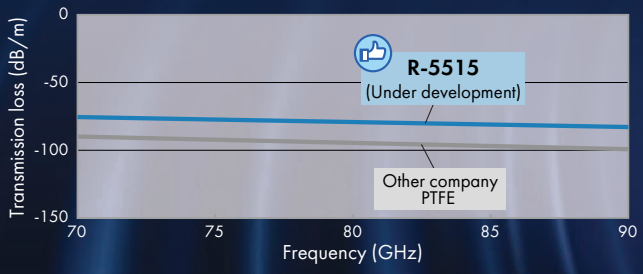
Under Development

Features

- Low transmission loss (Equality or Better than PTFE)
- Dk 3.0 Df 0.0019@10GHz
- Reduce PCB process cost (vs. PTFE)

Transmission Loss

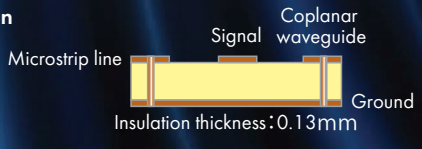
- Frequency dependence by Transmission loss (70-90GHz)



- Transmission loss at 79GHz

Material	Transmission loss (dB/m)	Dk (Design)
R-5515	79	3.22
Other company PTFE	96	3.14

- Construction



Contact us

More information

DISTRIBUTOR IN NORTH AMERICA
MATRIX USA INC.
TORONTO • SANTA ANA • SANTA CLARA • CHICAGO • MINNESOTA
Visit our website at www.matrixusa.us

Partnering to go beyond.

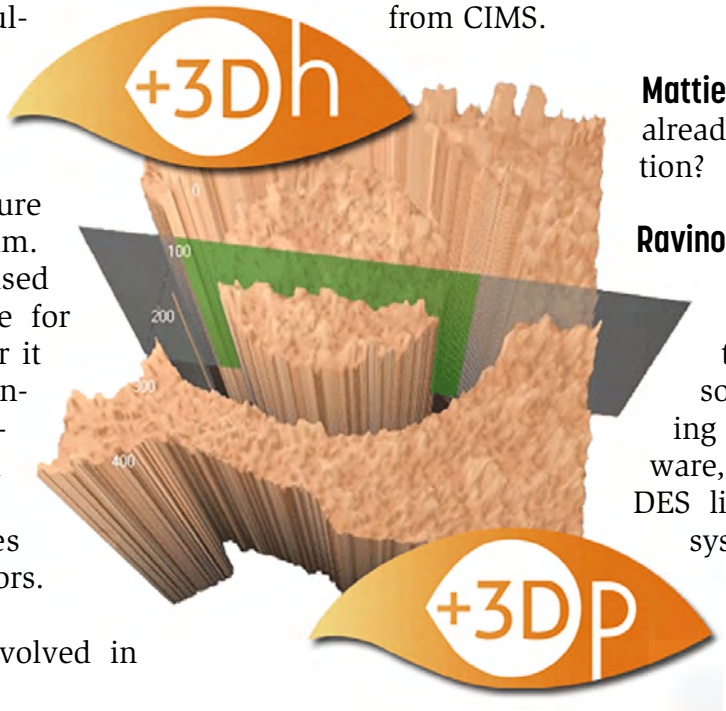
Electronic Materials
Panasonic Corporation

David Ravino: GreenSource is a fully automated PCB shop. They were looking for a solution for AOI that would connect to their automation so that AOI would be part of their inline process. We've been doing this with our current technology for many years. I don't know if you are aware that CIMS is a spinoff of Camtek. We're providing the ability to connect our AOI system to different types of automation. Our technology could be installed as a standalone unit, connected to a loader/unloader, or part of an inline process. It was the perfect fit for GreenSource. Besides conventional inspection, we also offer outer layer inspection. This allows inspection of the finished part—final inspection—which is unique to our AOI system.

Goldman: Are you providing metrology?

Ravino: Our metrology solutions were critical for GreenSource. We deliver 2D measurements in our metrology solution, which measures lines and traces with an accuracy of plus or minus two microns and the actual size of the panel with an accuracy of plus or minus eight microns. We also offer the ability to do a 3D measurement, which measures the height of the trace and laser via depth with submicron accuracy.

The technology for 3D measurement is Fulcrum technology. It's a combination of laser and light. To measure height, we use a laser. To measure depth, we use Fulcrum. Metrology can be used as a tool to measure for impedance control, or it can be thickness controlled. Thus, the metrology option with such a mature technology distinguishes us from our competitors.



Goldman: Are you involved in via inspection, too?

Ravino: Yes, another feature we offer is laser via inspection. Since GreenSource plans to produce HDI PCBs, all the AOI systems we sold them are designed to go down to 15-micron lines and spaces. Again, one of the critical items for GreenSource was not to have the operator involved. The operation of our AOI equipment can be 90% automated. To do this, the equipment reads the barcodes, identifies the layers, automatically loads the job into our AOI system, and completes inspection.

Another key feature GreenSource will use is the ability to verify defects. To give you the idea about the configuration, the machine will be connected to the DES line. Panels will load into the AOI, and one side of the panel will be inspected. Next, the panel will flip and be moved to the next AOI where the second side is inspected. Then, the panel will move to an offline verification station. When the panel reaches the offline verification station, it will be verified remotely by an operator who could be anywhere, including off site.

This is an overview of the configuration we're installing at GreenSource. We're working very closely with AWP, the company that produces and develops the automation software for GreenSource. The ability to integrate so closely with AWP is one of the primary reasons why GreenSource selected the AOI system from CIMS.

Matties: Is your equipment already there and in operation?

Ravino: Yes, the equipment is there, but it's not connected to the automation yet. AWP has had some delays in supplying the automation software, and that affects the DES line. However, all our systems were tested as standalone units; they just aren't connected to the line yet. The plan is to go live

or to be in full production in October of this year.

Aside from machinery, we also provide solutions to collect the data from our systems. GreenSource is using a CDB, a CIMS database. With this, they can obtain all the information from our AOI system—inspection and measurement results, etc.—and create various types of reports and different analyses. The AOI system and the database it drives can be used as a quality control tool.

This also means that GreenSource will be able to monitor the activity on the AOI system, such as how much the system has been used in a period of 24 hours. They will also be able to monitor in real time if the machine is idle. If the machine was in idle, why? And what was the cause of the idle time? They can sit in their office and monitor the productivity and quality of their product, and also the utilization of the system.

Matties: How has your experience been interacting with Alex Stepinski at GreenSource?

Ravino: Alex is a very unique person in this industry. He does things that are entirely out of the box and different from other PCB shops. He's trying to bring the whole PCB fabrication process to the next level. Alex pushed us to improve our AOI systems by defining exactly what he wanted and needed regarding inspection, productivity, and to make his shop fully automated.

Matties: What was the greatest challenge for you in this process?

Ravino: The first challenge was metrology where Alex wanted the ability to measure specific features, and for us to be able to supply the results of the measurement in the manner he wanted. He's going to rely on our system strongly. Again—I want to make it clear—it will be an ongoing project with GreenSource because once the system is connected to the DES line and in full production, I'm sure we'll need to improve certain items and add more features.

The second challenge was the need to connect each machine and be part of an inline process. Even though most PCB shops are somewhat or fully automated, you still have a loader and unloader that isn't connected directly to the DES line. Having the ability to connect the machine to the DES line and synchronize it with the AOI system was another challenge.

Matties: What a great opportunity for you to be a part of the GreenSource project. As you said, it's improving the features and equipment that you're going to offer to your other customers as well.

Ravino: I'm confident that it will open up more opportunities in Asia. GreenSource is a pioneer in how they will be producing PCBs, especially in North America. It will be an excellent marketing tool for us. It will create more opportunities and help us grow as a company.

GreenSource is a pioneer in how they will be producing PCBs, especially in North America. It will be an excellent marketing tool for us. It will create more opportunities and help us grow as a company.

Matties: Since we weren't able to see all of the CIMS solutions in action on the shop floor, I-Connect007 will visit GreenSource in a few months and provide full coverage of the CIMS implementation then.

Ravino: Great. Thank you.

Matties: Thank you. PCB007

How GreenSource is Fine-Tuning the Processes, Right Down to Account Management

Feature interview by Patty Goldman
I-CONNECT007

While on-site at GreenSource Fabrication, Whelen Engineering's zero-discharge PCB fabrication facility, I sat down with Account Manager Jim Brown. He explained the intricacies of the many processes that this ground-breaking company has fine-tuned, including company culture, account management, and chemical processes.

Patty Goldman: Jim, what are you involved in here?

Jim Brown: My official title is account manager. I'm the only salesperson here. I live on the other side of the state, about an hour and 45-minute commute, so I often work remotely.

Goldman: As an account manager, your business isn't so much here as elsewhere, servicing customers.

Brown: Correct. My manager, Don Taylor, and Alex Stepinski and I had the discussion about what the sales team will look like here. At first, we had considered following the conventional wisdom and building out a regional organization, with territories and accounts. As we started to get feedback from customers and looked at the operation that we have, we saw ourselves as being digital because we're so process-driven and our yields are going to be very consistent.

We're either going to have 98% yield or close to zero. So as far as customers go, where do you spend the majority of your time with customers? It's typically fighting fires and doing "damage control." With our processes and equipment, there's a high confidence that we're going to minimize escapes. We have all the automation equipment, so handling damage is going to be minimal. We have a lot of in-situ measurements: line width; holes; copper thicknesses. We're doing virtual cross-sections with the Impex proX3 machine. And with the Schmoll drills, we can map copper layers as we drill.

The Impex will give us a visual representation of a cross-section. The Schmoll drills will show us the cross-section electrically. As we drill into a panel, we can identify the location

Ucamco
Former Barco ETS

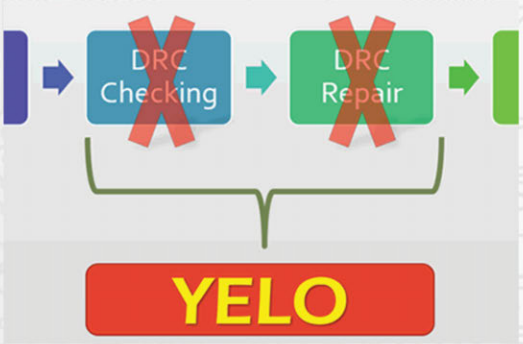
SOFTWARE | PHOTOPLOTTERS | DIRECT IMAGERS | NEWS | SERVICES | COMPANY | DOWNLOADS | CONTACT

Software

YELO

Yield Enhancing Layout Optimizer

- Optimizes board layouts within minutes
- Cuts back CAM cycle time & cost by up to 30%
- Lowers technology class improving manufacturability
- Reduces scrap and delivers a more reliable product
- Return on Investment within the first year



Read more

Need a Gerber Viewer?

Ucamco, caretaker of the Gerber format, presents its new Reference Gerber Viewer. Use this free online tool to view and/or check your generated/received Gerber jobs.

- Reads X2 attributes containing PCB fabrication data
- Imports Excellon and NC drill files

Go ahead and link your site to https://gerber.ucamco.com

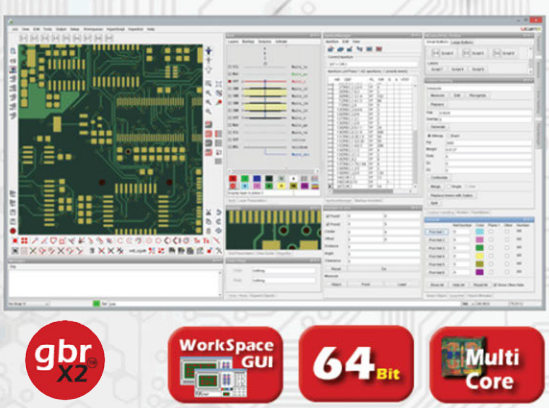
Software

UcamX

New ground-breaking CAM Software

- For Rigid, Flex and HDI PCBs
- New Graphical User Interface with Workspaces
- Optimal performance using Parallel Processing
- Multi Job Processing via load balanced Sessions
- Support for Gerber version 2 (X2) format

Read more



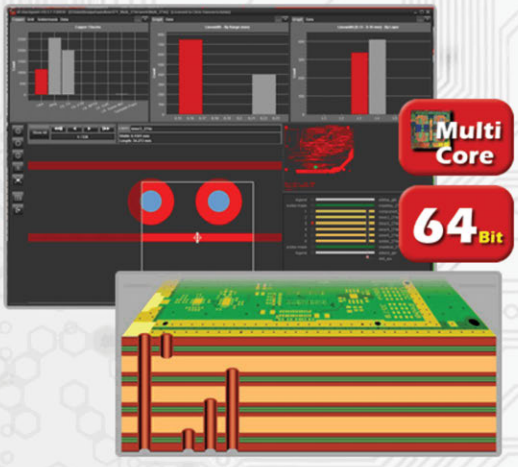
Software

Integr8tor

Automated data entry and design analysis

- Ucamco's 9th Generation Sales & Engineering Tool
- Field proven with more than 300 installations in daily production
- Seamless integration into any environment

Read more



For more information please contact info@ucamco.us,
call (415) 508-5826 or check out our website at www.ucamco.com

of the layer and just by doing the math, we know what the dielectric is. If you know how far apart the copper is, you know what the dielectric is. And of course, we're using that to map the copper layer location in the holes. So, we'll rip a backdrill file from the Schmoll machines because we've identified where every copper layer is in every hole. When we know what (holes) we have to backdrill, we'll just enter it in our backdrill file right from there and it's tuned to the actual board.

With all of these process controls we've put in place, we're confident we are going to minimize escapes. With that aspect of servicing the customer in mind, we're evolving what customer service looks like.

Jim Brown

Because we're still new, we've made the decision that we're going to delay adding sales people until we understand what we need to do to service the customers. Maybe we simply need more people in the front-end because once we tool the job, we're good. We're already learning that front- end engineering is going to be our single largest headcount. The way our process is set up, once you start a board, there's no queue time. There's no need for queue time because it's part of the recipe. As that board gets to the next step in the process, the recipe is already downloaded, and the piece of equipment knows what to do, and it does it. And the next panel that comes right behind it can have a different recipe. Because all those 2D codes and radio-frequency identification (RFID) tracking that we put on up front tell the machine what's there.

Goldman: So you totally depend on what happens up front to get that recipe right.

Brown: The recipe is key and again that's where the human factor comes in, the front-end engineering. We're going to have to do checks and double checks because we're digital; if we make an error there, that error is now part of the recipe. But with our in-situ data collection, it should never get more than two or three steps further in the process before a "flag" pops up. It is possible but unlikely an error could get all the way through to electrical test before finding the problem.

Ultimately, that's our first goal, no escapes.

Goldman: Instead of a first article, you run a first piece to test the recipe.

Brown: Yes, but it's in every operation, that's the cool part. Because when we run cores, they'll get over to automated optical inspection (AOI). And our first piece is checked at AOI. So if we have to make any adjustments, we make the adjustment right there and restart the cores. We don't have to wait until we do a cross-section. If we do a first article inspection, we're going to look at it as more of a validation than an inspection process because of all the in-situ measurements we're doing. We're going to predict what the board is going to look like and then we're simply going to validate it.

Goldman: And, especially early on, you'll learn with every board if things need to be tweaked.

Brown: Correct. All that data is corrected and fed back. We can make "on-the-fly" adjustments for impedance, as an example, and not wait until it gets to E-test.

Goldman: A lot of people try to inspect their quality in, but what they should be doing is using all those steps to fine-tune the process.

Brown: We're not going to inspect it in; we're going to build it in. It's counter to how it's being done because everybody does that. To your point, Patty, with first article inspection, you're kind of sitting there with your fingers crossed. I hope it's good, I hope it's good, I hope it's good. We'll be able to say, we know it's good. Then we just validate it because all of the data that we collected along the way tells us the

cross-section is right, the line widths are right, we know what the impedance will be because we've modeled it. We looked at the copper already, we know the line width, we know the line height, we know the dielectrics.

Goldman: I want to go back to the Impex proX3. I understand there's a fiber that goes down into the holes?

Brown: Yes, it's an 80-micron fiber-optic camera probe that will go down into the hole. We can do a virtual cross-section of a hole.

Goldman: That is very interesting, because as a virtual cross-section, you see the entire circumference of the hole wall plus the length, I presume.

Brown: And you're seeing the hole in the board. Not a "like" hole in a coupon that was located a foot away on the panel from the hole that you're concerned about. Plus, it's nondestructive.

Goldman: And surface inspection?

Brown: With the Schmoll X-ray drill that we have, we can look at the surface. It is so sensitive that we can basically do a vertical section through the X-ray.

Goldman: Between the two of them, you get a lot of non-destructive inspection and verification.

Brown: Correct, and for us, they're all in-process tools. We believe customers are going to find the data we collect to be valuable. Radio-frequency (RF) designers, for example, are very particular about being able to tweak lines because that's how RF works. They're very concerned about line geometries: What's the height of the copper? How trapezoidal is the trace? We can profile that. We can show the actual line plot to them and, if it is of concern, then through the additive manufacturing of SAP processes, we can make that sidewall almost perfectly perpendicular.

Goldman: I'm sure a lot of your customers find that kind of reliability to be unmatched, what with the tools you have here.

Brown: We believe so. Especially on the hole side, and particularly with microvias.

Goldman: And the interesting thing about the coupons is there was always a question as to how representative they are. It's usually on the outside edge of the panel because you can't put it in the middle. But here you can show any number of holes. It ought to give a lot of assurance to customers.

Brown: It's a tool that we can offer to them. To your point, do you want to pick some pattern on your board? We can do every hole depending upon how much data the customer wants to see to assure reliability on their end. If you want to do every hole, we can do every hole.

Goldman: How long does each inspection take?

Brown: It's going to depend on the thickness and number of layers, because you have to go slow enough that the optics can pick up what you're looking for.

Goldman: Is it like a video?

Brown: Yes. We have people that look at cross-sections and they can immediately find the problem and analyze it. The Impex is similar. It's a better representation. It's an amazing tool.

Goldman: That's not all that's unique at GreenSource.

Brown: Right. Then there's the Ludy vertical plating line. We're going to bring that up over the next couple of months. That is another unique piece of equipment.

Goldman: I understand on the Ludy line there's going to be an extra tank for them to play with.

Brown: There's going to be more than one.

Goldman: More than one? So they can get to that 50:1 aspect ratio?

Click to watch short video clip.

Brown: Alex has added in maybe half a dozen tanks because he's also thinking about the next wave of surface finishes on the horizon. You know what I mean, we've got EPIG, EN-EPIG, palladium, what's the next best thing for surface finish?

Goldman: Do you offer immersion tin or are there certain things that you don't offer and don't intend to?

Brown: We have hot air solder leveling (HASL), outside processing (OSP). The Ludy line will have some flexibility, so if somebody comes to us with a good business case, we've got room. Many people are familiar with the name Ludy, but once again, it's something that Alex looked at and said, "You know that's a good machine but if you could just do this..."

Goldman: Constantly asking for just a bit more functionality?

Brown: And he's done exactly that. We have a couple of electrostatic cleaners that are "off the shelf." I tease Alex about it—you couldn't figure out a way to make those better?

Goldman: Right off the shelf, are you sure? (laughs) Surely there's nothing here at GreenSource that's off the shelf.

Brown: We have a wonderful relationship with all our suppliers because they've appreciated the concurrent development work we've done with them. We've become something of a showcase for them as well. The relationships are very deep.

Goldman: Everybody benefits. It's a win-win.

Brown: Absolutely. Atotech has credited us with a number of sales that they've made.

Goldman: You have capability beyond measure here. I understand you started your first commercial outside job this week.

Brown: We are engaged right now with half a dozen "early adopter" customers. We approached them to go through the learning curve with us—it's a concurrent development kind of thing. We're trying to refine our processes and there's nothing like real, live jobs for that. We identified a half-dozen customers that we thought would be good target. We approached them, hoping to get half of them to work with us, Every single one of them said they wanted in. We even had one of them call a friend who called me and said, "I want in too." So, we've got seven customers that we're working with right now. The one we've been working with the longest, we're doing some unique plating services for.

So we got our engineering teams together, working concurrently. They're absolutely thrilled. Their end customers are going to audit us at some point. Naturally, they are thrilled with the opportunity to bring their customers in to see this facility, and we're thrilled because it gives us exposure to some very respectable OEMs.

Goldman: That makes it exciting, doesn't it?

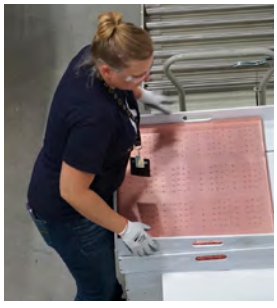
Brown: It sure does! It's great and I love the environment. I'm incredibly excited about the opportunities in front of us. I've been in this industry for 30 years. I've worked in four different board shops, I've worked at a laminate supplier and this is the best job I've ever had.And sometimes we talk about what we can do, and I still shake my head and say "We can do what?!" It's

fun for me when customers come in here with healthy skepticism then leave skipping out the door. It's just cool, and it's contagious.

Goldman: That's fun stuff.

Brown: I'm doing what I want to do right now. That, and I try to get these younger folks here to understand what they've got in front of them.

Goldman: Right, you have such great opportunities in front of you.



Brown: And for the younger staff, this is normal. They don't understand what normal really is in this industry.

Goldman: Jim, earlier you were telling me about the groups that have been hired here who are like family members. Tell me a little bit more about that.

Brown: It is part of the culture and, to me, it's a positive thing because it provides harmony within the company—it mirrors the family relationship. It translates to both places. Husbands and wives, fathers, sons, get to go home at night and talk about work, and they know what each other is talking about.

For the younger employees, this is such a unique place. We have people who have board experience and sometimes that's helpful, but sometimes it's a hindrance. Experienced staff have a preconceived concept of how to build a board, how the operation works. They come here and there's a paradigm shift that they must go through.

Goldman: It's not just the look of the facilty, although that's a huge thing, but the attitude. Like you said, the enthusiasm.

Brown: Right, and that's where we're going to rely on Alex as the visionary. Get him out of the day-to-day stuff and start to look at the roadmap for the next three to five years. Get Alex working with our suppliers, anticipating what the customers are going to be looking for two years or three years out, then start developing it now.

Goldman: Knowing GreenSource and Alex, once he develops a roadmap, the customers may respond with something like, "Okay, so now we know where we want to go."

Brown: Yeah, there is a bit of a catch-22 to that. One of the customers commented, "I can't wait to give your capabilities to our engineers and see what they can do with it." And he went on to tell us that their engineers are limited right now by the capabilities that exist within the industry and shops in North America.

He said, "You're taking it to a whole other level." We're on the edge of semiconductor technology right now. With the semi-additive process (SAP), the line is blurred. PCB technology used to be down here, and semiconductor was up here. We're closing the gap.

That's why a lot of the equipment that we have for in-process checks is semiconductor equipment. That Impex proX3? That's semiconductor-grade equipment. If you look at the equipment that the industry is using right now, the gauge error of the equipment is greater than the tolerance customers are asking us to hold. So how do you validate that you're meeting the customer's requirement when the error in the measuring equipment exceeds the criteria? It's interesting times.

Goldman: It would seem you and your customers are forming the same kind of partnership that you have formed with your suppliers. GreenSource has pulled the suppliers up, now you're pulling your customers up, and then the customers will keep pulling you up. Everybody goes forward and that's great to see and feel.

Brown: We all acknowledge that all boats rise with the tide. It's exciting.

Goldman: It is definitely exciting. Thanks so much for giving me a lift! **PCB007**

AWP Group: Small Company, Big Solutions

Feature interview by the I-Connect007 Editorial Team

As the I-Connect007 team prepared for a tour of the GreenSource Fabrication facility, Publisher Barry Matties and Editors Patty Goldman and Happy Holden spoke with Jochen Zeller, VP and co-founder of AWP Group, about the status of AWP's specialized equipment and flexible capabilities at GreenSource.

Patty Goldman: Jochen, please begin by telling our readers a bit about yourself and AWP Group.

Jochen Zeller: I spent 10 years in PCB manufacturing and then switched to the supplier side, so I have over 25 years of experience in the industry. AWP Group was formed a couple of years ago by several people from various well-known equipment companies in the PCB industry so we can proudly look at a combined know-how of over 150 years. Our engineering and sales headquarters is in Germany for all equipment and our main production site is located in Poland where we manufacture all kinds of handling and wet process equipment. For the support of the Asian market we also have a sales and service office in Suzhou, China as well as in Hong Kong. Our main focus is handling equipment for any process step in the PCB production and the industry 4.0 integration of handling equipment with any process equipment. We also supply horizontal wet processing equipment for all various processes in the PCB industry.

Barry Matties: What is the status of things for AWP at GreenSource?

Zeller: The status on GreenSource right now is that we have three of the wet process lines already installed. The DES line is filled with chemistry and is up and running. The next two lines—pre-clean and copper reduction—are ready to be filled with chemistry. Next, we have two more lines coming in—an OSP line and the solder mask developer. Many pieces

Figure 1: GreenSource Fabrication's automated wet etch uses AWP etching and material handling equipment.

Get HyperLynx DRC for FREE for 12 months

COMPATIBLE WITH ANY PCB LAYOUT TOOL!

www.mentor.com/get-drc

visit us at SMTA International booth 933

Figure 2: AWP's wet etch line installed at GreenSource Fabrication.

of the handling equipment are also installed and up and running. There is still more handling equipment in manufacturing stage or on the way and will be installed over the coming weeks and months.

From the beginning of this project, we focused on having redundancy in the equipment and used standardization as much as possible. This now comes in handy because, as you can imagine, it is a large project to integrate changes along the way. We have a lot of flexibility to move equipment around in the set-up. If GreenSource is testing for another location, we can put them somewhere else in a temporary set-up and move them to the final location later. This provides GreenSource the flexibility to help them shuffle equipment around if things change along the way during the process.

Goldman: Once finalized, how many pieces of AWP equipment will be at GreenSource?

Zeller: In total we will have around 100 pieces of equipment installed at GreenSource when this stage of the project is complete.

Goldman: That's a lot!

Zeller: Yes, this is our biggest installation around the world and a great showroom to show our capabilities. For a company AWP's size, this wasn't an easy task. The major keys to success were the high level of equipment standardization that we implemented early on, along with a combined effort from everybody at AWP. Even equipment that was specially designed for certain functions, still uses components and subgroups from the standard machines where ever possible. This is a huge advantage for maintenance because the spare parts are all the same. The other advantage is that the basic operation of the machines is similar for the operator, so they don't have to constantly learn new things. Early on, Alex told us, "I know I'm trying to feed an elephant to a chicken, but we will get this done in a combined effort." That's how this project started and moved on to success.

Matties: We talked with some of the AOI employees and they said they were waiting for AWP equipment to be installed. How far along are you in the install process?

Zeller: At the beginning of the project we established priorities with GreenSource to have the equipment that needs a longer qualification stage in place first. We are working the priori-

Figure 3: A line of AWP equipment installed at GreenSource Fabrication.

Figure 4: AWP equipment awaiting installation at GreenSource Fabrication. Note the panel cassette in the foreground.

ties as defined and will have equipment arriving at GreenSource on a regular basis.

Happy Holden: Are you supplying the automated guided vehicles (AGVs)?

Zeller: At the moment, there is one AGV to start between our handling units, after the X-ray and the laser drill as well as between the automated stacker and the mechanical drill machines from company Schmoll. This AGV will be supplied by Schmoll but will be fully integrated with our handling units.

Holden: Is the material warehouse in now or will it come in later?

Zeller: The fully automated material warehouse will come in later. That is something we have targeted for the end of the year and will be one of the last pieces to come in.

Matties: What has been the most challenging aspect for you during this whole process?

Zeller: The most challenging aspect has been keeping track of all the changes. It's a big project with a long time-frame, which makes it challenging to maintain the flexibility to move things around and adapt to changes. As I mentioned before, the standardized equipment helped us a lot; otherwise, it would have been more difficult to move things around as easily as we did.

Matties: What are the challenges with regard to software?

Zeller: The equipment software is pretty straightforward because that is what we always do. What is more challenging is the industry 4.0 integration software, which is still ongoing. We are working closely with the software engineers at GreenSource to find the best approach for the integration. We have experience with other projects, but every customer is different and has their unique set-up and special requests. Everyone has their own things to add to these set-ups. The basic framework of how the integration should look is clear, but there are ongoing detail discussions as to what is the most suitable set-up. I'm sure challenges will surface down the road and adjustments will be necessary, but this is our know-how and we have the expert team to tackle these challenges.

Figure 5: An operator monitoring AWP's automated etching line installed at GreenSource Fabrication.

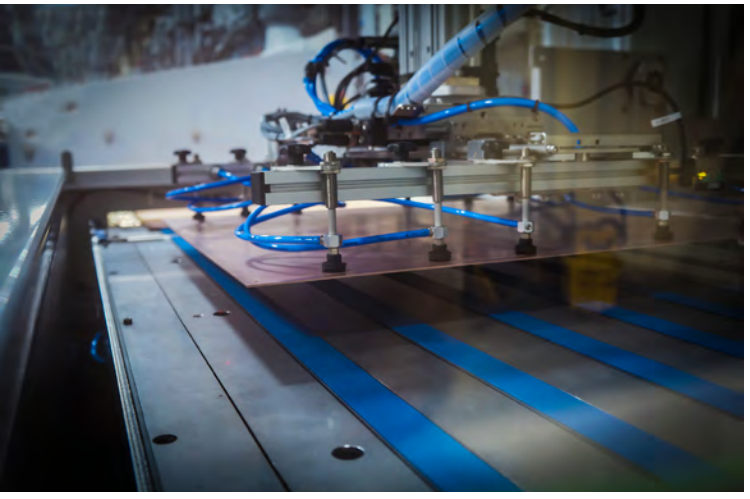


Figure 6: Close-up of an AWP material handler in action at GreenSource Fabrication.

Matties: It sounds like a tricky process overall.

Zeller: Yes, it will be due to unique set-up of each customer. It will be an ongoing process with close communication and meetings to get the final version.

Matties: Will the transport system be running very thin materials also?

Zeller: Yes, all the machines are laid out for 1-mil cores. On the handling units we don't use any mechanical centering anymore. All the centering and aligning process of the panels is done with optical components to avoid any damage to the thin or sensitive products. In addition to the thin core set-up we also have all handling units fitted to handle heavy outer layer panels with a weight of over 3.0 kg per panel. The switch between thin core and heavy panel set-up is done automatically.

Matties: That's sounds unique. Are there many companies trying for that mix in the same factory?

Zeller: No, this is not very typical, but we have this set-up for the whole project, so we can switch between thin cores and heavy panels. It's all done automatically and based on DMC code and data. We don't need an operator to do it. We know what kind of panels are in process and as soon as we read the DMC code on the panel we will automatically set up the handling units for these products.

Holden: How does the new equipment process differ from the first phase in terms of water conservation for rinsing, ventilation, and the temperature of the process to create more evaporation?

Zeller: We worked very closely with Alex on water conservation. All the rinses are set up with what we call "one plus four" or "one plus three." The first stage is a drag-out stage, which is separated from the other cascades. Thus, we concentrate the first stage, and then the following stages are standard cascading set-up. With this set-up the water usage is greatly reduced and in line with Alex's expectations.

Figure 7: Plumbing, controls, and tanks provide AWP's chemistry and environmental controls.

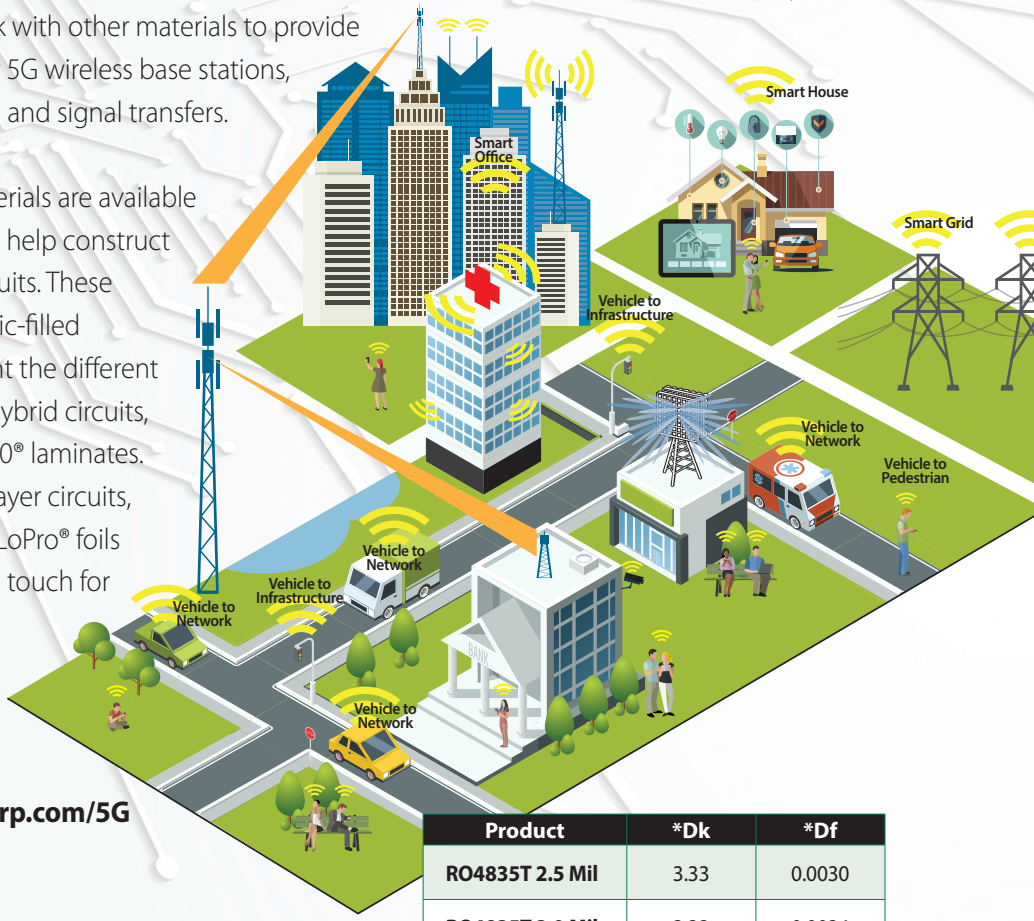
5G: Higher Frequencies!

Do you have the **right** circuit materials?

Frequencies at 28 GHz and higher will soon be used in Fifth Generation (5G) wireless communications networks. 5G infrastructure will depend on low-loss circuit materials engineered for high frequencies, materials such as RO4835T™ laminates and RO4450T™ bonding materials from Rogers Corporation!

Rogers RO4835T spread-glass-reinforced, ceramic-filled laminates are low-loss materials in 2.5, 3.0, and 4.0 mil thicknesses. They are well suited for millimeter-wave frequencies as part of the inner cores of 5G hybrid multilayer PCBs. They can work with other materials to provide the many functions needed by 5G wireless base stations, including power, signal control and signal transfers.

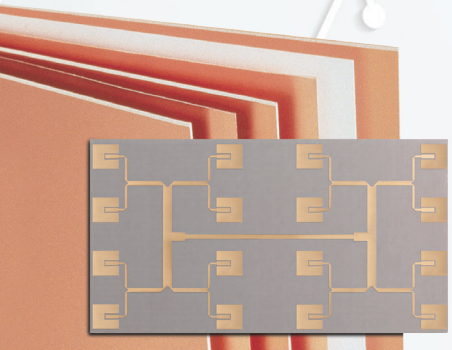
Rogers RO4450T bonding materials are available in 3, 4, and 5 mil thicknesses to help construct those 5G hybrid multilayer circuits. These spread-glass-reinforced, ceramic-filled bonding materials complement the different materials that will form these hybrid circuits, including RO4835T and RO4000® laminates. And for many 5G hybrid multilayer circuits, Rogers CU4000™ and CU4000 LoPro® foils will provide a suitable finishing touch for many hybrid multilayer circuit foil lamination designs.



5G is coming! Do you have the right circuit materials?
Learn more at **www.rogerscorp.com/5G**

Product	*Dk	*Df
RO4835T 2.5 Mil	3.33	0.0030
RO4835T 3.0 Mil	3.33	0.0034
RO4835T 4.0 Mil	3.32	0.0036
RO4450T 3.0 Mil	3.23	0.0039
RO4450T 4.0 Mil	3.35	0.0040
RO4450T 5.0 Mil	3.28	0.0038

** IPC TM-650 2.5.5.5 Clamped Stripline at 10 GHz - 23°C*



ROGERS CORPORATION
Advanced Connectivity Solutions

USA - AZ, tel. +1 480-961-1382 • EUROPE - BELGIUM, tel. +32 9 235 3611
www.rogerscorp.com

All our wet process equipment has a different set-up of squeegee rollers. On all process modules we use four sets of squeegee rollers at the entrance and exit. The same applies to the water rinses, where we use four sets of squeegee rollers at the module entrance and exit and between each cascade step. A lot of our competitors only use two sets of squeegee rollers between cascades which results in more drag-out. With our set-up we have less drag-out between the cascades and can ensure the rinsing process is more efficient. We also included several conductivity sensors in the rinsing stages where we control the water quality and addition based on conductivity.

Figure 8: AWP's innovative panel flipper enables back-to-back bottom etching for both sides of the panel.

Another great advantage we have with regard to ventilation and evaporation is our unique "Module in Module" design that we use in all process modules. We enclose the entire spray area to contain all spray fumes in that confined housing inside the main process module. The exhaust system is connected to the outer module and therefore reduces the loss by evaporation dramatically.

Holden: Did you supply any point treatment for the water rinse as part of the equipment, so you didn't have to pump it out?

Zeller: No, all of that is done by GreenSource. We supplied a unique pump-out system, with no additional tanks, to save space, and all the connection points are aligned with the points defined by Alex's design. In addition, we fitted all alkaline rinses with fully integrated UV light to avoid any contamination.

Matties: Before we finish, is there any particular piece of equipment you would like to highlight?

Zeller: The project as a whole is pretty exciting and very advanced. However, a highlight on the wet process side is that the DES line doesn't need any change in speed on the etcher to process different copper thicknesses and therefore the etch program can be changed on the fly without emptying the etcher. Another interesting aspect of the DES is the setup with two etcher sections connected by a panel flipper to give full flexibility to etch either single-sided or double-sided. The idea for this is not new, but the combination with no speed change makes this machine quite unique and advanced. There is a fully automated warehouse in front of the pre-clean that holds 500 trays with different materials that will be loaded directly into the preclean based on MES data.

Then there are the handling units that can handle ultra-thin cores and heavy panels in one unit. There are the flexible buffers without any belts for particle control and reduced maintenance that tie in the entire line set-up. There are the handling units that enable the fully automated Schmoll drill stacker/de-stacker unit. These are just some of the highlights, there are a lot more details in the entire project that make this project so advanced and exciting. It is a great opportunity to be part of this future-oriented project.

Matties: Thanks for taking part in our coverage of GreenSource. It's been great to catch up with you.

Zeller: Thank you.

Goldman: Thank you so much, Jochen. PCB007

UPCOMING Programs

October 19, 2018
Bannockburn, IL, USA
Assessing the Health of the Defense Electronics Industrial Base Industry Workshop

October 24, 2018
Wisdom Wednesday — Utilizing Grant Funding for Workforce IPC Certification
30 minute webinar — FREE for IPC Members only

October 24–26, 2018
Taipei, Taiwan
International Microsystems, Packaging, Assembly and Circuits Technology Conference

November 6, 2018
Raleigh, NC, USA
IPC Technical Education
Designing Boards with HDI Technology
In conjunction with PCB Carolina

November 6, 2018
Raleigh, NC, USA
IPC Day
In conjunction with PCB Carolina and IPC Technical Education

November 6–7, 2018
Silicon Valley, CA, USA
i4.0 Connect Forum in cooperation with IPC and i4.0 Today

November 6–8, 2018
Odon, IN, USA
The Pb-Free Electronics Risk Management (PERM) Council Meeting No. 38

November 13–14, 2018
Bloomington, IN, USA
IPC Counterfeit Electronics Symposium: Methods For Detection And Best Practices For Avoidance

November 13–15, 2018
Schaumburg (Chicago), IL, USA
IPC/SMTA High-Reliability Cleaning and Conformal Coating Conference

November 14, 2018
Wisdom Wednesday — SNEAK PEEK into IPC APEX EXPO Tech Conference
30 minute webinar — FREE for IPC Members only

November 28, 2018
Wisdom Wednesday — Results of PCB Technology Trends Study
30 minute webinar — FREE for IPC Members only

November 28–29, 2018
Brussels, Belgium
IMPACT Europe

December 5–7, 2018
Shenzhen, China
HKPCA International Printed Circuit & IPC APEX South China Fair

December 12, 2018
Wisdom Wednesday — SNEAK PEEK into IPC APEX EXPO Professional Development
30 minute webinar — FREE for IPC Members only

January 26–31, 2019
San Diego, CA, USA
IPC APEX EXPO

May 14–16, 2019
Hanover (Baltimore), MD, USA
IPC High Reliability Forum

For more information, **visit www.IPC.org/events**

Circuit Connect and Green PCBs: Bringing Business Back to New Hampshire

Feature by Nolan Johnson
I-CONNECT007

Sometimes it seems as if the PCB manufacturing industry is slow to evolve and resistant to change overall. But if you have a great idea, word spreads fast through this tightly-knit community.

Bob Lazzara, president of Circuit Connect in Nashua, New Hampshire, has encouragement for GreenSource. "When Whelen went zero-discharge for their new facility, everyone applauded," says Lazzara. "Kudos to Whelen. Their strong presence has had the side effect of bringing suppliers back to the region." Lazzara sees this as an indirect positive result.

More supplier presence means more options for Circuit Connect to innovate, evolve, and refine their processes too. The local PCB fabrication industry has been "decimated," according to Lazzara. The migration started 35 years ago, and companies are still shutting down facilities. By Lazzara's count, four board shops have closed in the last four years.

Circuit Connect has operated under this name since 1990. When founder and CEO Richard Clutz started the company, his first action was to design, specify, and install waste treatment systems. Clutz did not proceed with the rest of the facility until the waste treatment infrastructure had been inspected and permitted by local and state oversight.

"Because of this early awareness years back," Lazzara says, "Circuit Connect became a model site for future chemistry businesses in New Hampshire. Companies looking to start a similar business in New Hampshire had to tour our facility to see how we operate." He adds, "Caring and awareness for the environment have been here since day one." Circuit Connect is four months away from certification as a zero-discharge facility as well.

What drives the all-green culture in New Hampshire PCB fabrication? "We did it because it's the right thing to do," Lazzara replies. "New England was ground zero for the American Industrial Revolution. Manufacturers took advantage of the systems of rivers in the region to mechanize, going from water wheels to steam generation and beyond. But those factories also used the rivers as their sewers and gutters. Throughout New England's history,

A new set of rules for PCB production

Less process steps. CAM to etch in minutes instead of hours. Maximum yield. Minimal environmental impact.These are just a few of the PCB production rules that Lunaris has redefined.

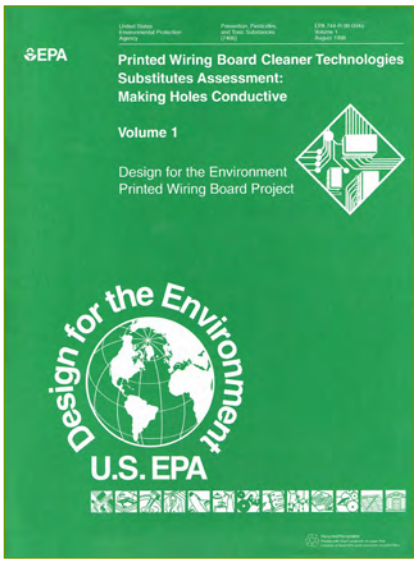
We've put together a complete set of all the new rules made possible by Lunaris ...get yours today!

Download all the new rules:
The Official Lunaris Rulebook

CLICK HERE TO DOWNLOAD

mutracx
THE BETTER WAY

www.mutracx.com



you can find a number of episodes in which we were not environmentally responsible. However, as the environmental impact became apparent, a certain reverence for our region and our planet has come to the fore."

There isn't as much government involvement in the green movement as one might think. Lazzara points out that no specific government programs require zero waste. He adds, "There's no government group leaning on us, no specific government advocate, no tax breaks for zero emissions. In fact, it's a risk-mitigation strategy. When we go zero emissions, then the opportunity for a pollution violation goes away entirely."

Figure 1: Environmentalism and pollution prevention is a necessary part of the New Hampshire PCB industry.

But does it cost more to protect the environment? Lazzara says no. "We save money by being zero waste. Our wastewater plant generates all the deionized [DI] water our processes consume, so I don't have to pay for DI. Hazmat storage, transportation, and offsite treatment go away, too, which saves us money and potential environmental liability."

"We're the first ISO 14000 certified PCB fab in New Hampshire *[editor's note: ISO 14000 is a family of standards related to environmental management].* Customers will ask us about ISO 9000 or our other certifications, but nobody seems to make environmentally green processes a deciding factor in selecting their supplier," he explains. So zero-waste, environmentally-friendly manufacturing isn't necessarily a selling point.

Nevertheless, the payoff is there inside the business and outside in the community. Lazzara makes this final observation, "Whelen Engineering and other 21st century companies—like Circuit Connect—are making it their responsibility to overcome the past. We are the stewards."

A wise perspective for PCB fabricators around the world. **PCB007**

WHAT DO ALL OF THESE LEADING COMPANIES HAVE IN COMMON?

ATOTECH

CIMS
Creativity in Motion

Cerambus
Technology Group

COMETGROUP
Technology with Passion

DownStream
Technologies

esi
Designed for Brilliance. Engineered for Production.

KIC Making Ovens Smarter™

KYZEN

MacDermid Enthone
ELECTRONICS SOLUTIONS

Mentor
A Siemens Business

PULSONIX

orbotech
The Language of Electronics

ventec
INTERNATIONAL GROUP
騰輝電子

環球集團
World Wide Group

They all benefit by advertising with us–PCB007 China Magazine.

Should your name be on the leaders' list?

GET STARTED NOW!

I·Connect007
GOOD FOR THE INDUSTRY

pcb007china.com

In the Analytical Lab at GreenSource

Feature interview by Patty Goldman
I-CONNECT007

I caught up with Mark Chassé, one of the engineers, in GreenSource's analytical lab for a brief chat.

Patty Goldman: Mark, tell me more about your "trust with verification" program on incoming materials and chemicals. Let's begin there.

Mark Chassé: We haven't gotten into inspection of incoming materials, but we have certified chemistries that have come in from our suppliers. And the trust factor is very high, which is important. Periodically, we'll make up a bath right here in the lab and then we'll test it, and that gives us an idea as to where things are. It's basically a spot check. We haven't had an incident of a recall that I remember, so it's a unique situation that we have. The suppliers that we work with are high-grade.

Goldman: That's good. How about materials like laminate and things like that?

Chassé: I don't get engaged with that. I'm dealing with the wet process and chemical usage, in particular with surface cleaning and metalization. Right now, I'm focusing on the electroless copper process.

Goldman: And what's happening with that? Just fine-tuning?

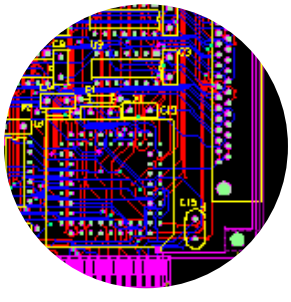
Chassé: We're learning about these machines, so we're putting the machines through their paces; in fact, we had our highest throughput to date yesterday. So we're very excited about that. The process is putting down a pristine deposit that I haven't seen before. It's a new chemistry. We're running a beta site test with Atotech and it's proving to be a very good material. It's going down significantly faster than anything that I've worked with.

Goldman: And a nice deposit in the end?

Chassé: Yes. Because we're restricted in space, everything must happen in that six-meter space, and the process is doing it beautifully.

Having trouble keeping up with front-end demand?
We have people for that.

Here are six ways that outsourcing CAM and related front-end work can help manufacturers not only stay in business but also help them thrive:



- **Increased on-demand capacity**
- **Improved automation**
- **Faster turn-around times**
- **Reduce costs**
- **Improved quality**
- **Ability to build redundancy in critical areas**

We deliver the highest quality PCB CAM and Mechanical CAD engineering services to customers around the world.

Find out how we can help you >

ENTELECHY GLOBAL

www.entelechyglobal.com

Goldman: That's good to hear. Now, tell me about the people working in the lab.

Chassé: We have someone working with cyclic voltammetric stripping, CVS, to analyze the electroplating copper baths. Right now, we have four different chemistries. And that particular analysis requires great attention to detail. One set of analyses could take up to three hours.

Goldman: Wow, just to analyze everything in it.

Chassé: Yes, you must set up your system, everything must be right, and then for the two-species analysis of the one particular bath, it takes about an hour, total. So, if you're walking around the plant and you see the big machine in the back, that can add up to eight different chemistries. We really have to be experts at the utilization of that machine.

Mark Chassé

Goldman: Of course, what you're doing basically are checks.

Chassé: Yes, system checks.

Goldman: Unless there is something that happens to be out of whack, all your adds and so forth happen automatically.

Chassé: That's correct. We have a lot of dosing systems on the lines. As long as those are maintained, and nothing goes awry, this is precisely what you said, a system check. Over time, as we develop more time and experience with these new chemistries, we'll have a greater understanding of how often we have to do these analyses.

Goldman: That would be nice, since it is so time-consuming. How frequently do you do it now?

Chassé: Sometimes twice a day just to make sure. It depends on the workload, or if something had gone awry, you get your result, you make your correction, and then you have to recheck it. It's a long day.

Next to CVS is another work station that handles most of the chemistries that we have to analyze in-house: typical acid-base titrations, colorimetric titrations, potentiometric titration, those kinds of things. It's straightforward. You'll see this type of equipment in more laboratories, and it does a really good job. What's nice about that system is it's modular. If something goes awry, it's easy to replace, easy to clean, and easy to fix.

Goldman: Now, again, are you analyzing as a check or to make adds?

Chassé: Well, it's both. If you're running a new system and you don't have your dosing rates set yet, it could take a week or two weeks. You need a good series of data points to establish what reality is, and then as you make tweaks you can spread out your frequency of analysis.

Goldman: You start dialing things in.

Chassé: That's right. Ultimately what you want is for it to be a check. But sometimes you must have your start-up analyses done, especially on a Monday. Those are the times when it truly is a start-up analysis, and it's to get to ground zero.

Goldman: Here in the lab I see grinders and things like that, so you're doing cross-sections and checking. Everything is check, check, check, right?

Chassé: That's precisely it. That's one point of reference, for example, in the copper plating. And out at the line you saw me working yesterday, we do not have online analytics out there, so I'm working with those. And that's one point of reference. What they're doing here is a visual reference. Even though it's a two-dimensional representation, it gives you an idea of where you are, and it's a piece of the puzzle. All these things are in place to let us know that everything is normal.

Goldman: At some point, do you expect that you will be backing off on some of these checks?

Chassé: Given the standard requirements, it's only going to be more. Especially for the cross-section analyses.

Goldman: Eventually you're going to be doing outside work and they're going to require cross-sections. Everything changes on almost every job, so you've got a lot to dial in.

Chassé: It's a lot of stuff. We were reflecting last night at how many steps there are in the manufacturing process of a printed circuit board. Each step is necessary so that you can proceed to the next step. One feeds the next. And everything, all your hoops, must be aligned.

Goldman: Okay, I know you've got somewhere else to be, but thanks very much for your time.

Chassé: And you'll see me out at the line, so feel free to come by.

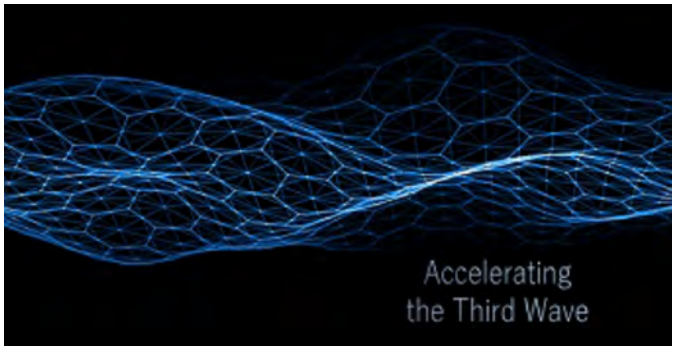
Goldman: Thanks. **PCB007**

DARPA's $2 Billion Campaign to Develop Next Wave of AI Technologies

Over its 60-year history, DARPA has played a leading role in the creation and advancement of artificial intelligence (AI) technologies that have produced game-changing capabilities for the Department of Defense. Starting in the 1960s, DARPA research shaped the first wave of AI technologies, which focused on handcrafted knowledge, or rule-based systems capable of narrowly defined tasks. Starting in the 1990s, DARPA helped usher in a second wave of AI machine learning technologies that created statistical pattern recognizers from large amounts of data. The agency's funding of natural language understanding, problem solving, navigation and perception technologies has led to the creation of self-driving cars, personal assistants, and near-natural prosthetics, in addition to a myriad of critical and valuable military and commercial applications. However, these second wave AI technologies are dependent on large amounts of high quality training data, do not adapt to changing conditions, offer limited performance guarantees, and cannot provide users with explanations of results.

To address these limitations, DARPA seeks to explore new theories and applications that could make it possible for machines to adapt to changing situations. DARPA sees this next generation of AI as a third wave of technological advance, one of contextual adaptation. To better define a path forward, DARPA announced a multi-year investment of $2 billion in new and existing programs, the "AI Next" campaign. Agency director, Dr. Steven Walker, unveiled the large-scale effort during closing remarks at DARPA's D60 Symposium.

(Source: DARPA)



MilAero007 Highlights

IPC Issues Call for Papers for Third Annual IPC High Reliability Forum ▶

IPC—Association Connecting Electronics Industries invites engineers, researchers, academics, technical experts and industry leaders to submit abstracts for IPC High Reliability Forum to be held May 14–16, 2019 in Hanover (Baltimore), Maryland.

Artificial Intelligence: Super-Exciting, Ultra-Competitive ▶

Artificial intelligence (AI) and machine learning (ML) have become common everyday words, however, the present reality and future potential are yet to evolve. This article looks into the key considerations and strategies to better leverage these trends that are expected to transform the manufacturing world.

IPC Renews Concern Over Third Round of U.S. Tariffs on Chinese Imports ▶

John Mitchell, IPC president and CEO, issued the following statement on the decision of the U.S. government to impose additional tariffs on about $200 billion worth of Chinese imports, the third such list announced this year.

John Karkoski to Lead Zentech's Mil-Aero and Space Market Initiative ▶

Zentech Manufacturing is pleased to announce that John Karkoski has joined the Zentech Manufacturing, Inc. team as director, Business Development - MilAero and Space Markets.

Insulectro Hires Michael King as DuPont Product Manager ▶

Insulectro, the largest distributor of materials for use in printed circuits boards (PCB) and printed electronics manufacturing, has hired Michael King as product manager its DuPont product offerings.

intelliFLEX Welcomes Jim Donnelly as Director of Programs ▶

The intelliFLEX Innovation Alliance announced that Jim Donnelly has joined the organization as director of Programs.

Alun Morgan Named Technology Ambassador for Ventec ▶

Ventec International Group Co., Ltd. announced that Alun Morgan, chairman of the EIPC, has been named technology ambassador for Ventec International Group.

U.S. Navy Awards Boeing $805 million MQ-25 Contract ▶

Boeing will provide the MQ-25 carrier-based unmanned aerial refuelers known as T1s to extend the range of deployed fighters. The T1 has completed engine runs and deck handling demonstrations designed to prove the agility and ability of the aircraft to move around within the tight confines of a carrier deck.

AI Helps Track Down Mysterious Cosmic Radio Bursts ▶

Researchers at Breakthrough Listen, a SETI project led by the University of California, Berkeley, have now used machine learning to discover 72 new fast radio bursts from a mysterious source some 3 billion light years from earth.

ERAPSCO Inks $64.6M in Navy Sonobuoy Contracts ▶

Sparton Corporation and Ultra Electronics Holdings plc (ULE) announce the award of subcontracts valued at $64.6 million to their ERAPSCO joint venture, for the manufacture of sonobuoys for the United States Navy.

ISO 9001 Quality Management

AS-9100D

PROTOTRON.COM
(888)847-7686

Your Passport to Global PCB Sourcing

We are pleased to announce that with the same fine service, quality, delivery and attention to detail that our customers have grown to rely upon, we are now adding a complete global solution to meet all of your needs, both today and in the future.

Our Solutions:

- *FLEX & RIGID-FLEX*
- *HDI / MICROVIA*
- *COMPETITIVE VOLUME PRICING*
- *PRE-QUALIFIED OFFSHORE PARTNERS*
- *QUICK-TURN PROTOTYPES*
- *COMPLEX MULTILAYER*
- *MIL-SPEC PRODUCTION*
- *SPECIALTY MATERIALS*

LEARN MORE
PDF DOWNLOAD

Prototron Circuits

A COMPLETE GLOBAL SOLUTION

REDMOND, WASHINGTON • TUCSON, ARIZONA • GLOBAL PARTNERSHIPS

The Art and Science of Photoresist Stripping, Part 1

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

In the world of chemical processes, the action of the chemistry to bring about the desired result is often a blend of both art and science. The two mesh together quite easily. The job of the chemical supplier is to ensure that sound science is behind the formulation and designed for the job at hand. Remember, the PWB fabricator hires a product or process to perform a certain job, but it is not that simple. Photoresist stripping has become a complicated process due to many unique resist formulations on the market. The expectation is that many new concoctions will be introduced over the next few years. What happens chemically during the stripping process depends on a myriad of factors. Some of these factors are easy to understand, while others seemingly resemble alchemy.

Problems and Solutions

Stripping problems usually result from two performance deficiencies: failure of the anti-tarnish system and/or wide variance of stripping speed and quality with use of the stripper.

Most photoresist strippers give adequate anti-tarnish performance when the stripper is fresh but at some time during the life of the stripper, the panels start coming out tarnished. This is frequently thought to be the result of the anti-tarnish chemistry being consumed, which is not the case. The real reason this occurs is that dissolved copper in the stripper

TECHNICA, U.S.A.

Fulfilling Manufacturing Needs Throughout the Electronics Industry

Celebrating 30 YEARS

YOUR COMPLETE D.I. SOLDERMASK PROCESS SOLUTION PROVIDER

D.I. EQUIPMENT

CBT

Most reliable Digital Imaging equipment—"The Proof is in the Production".

SOLDERMASK

ELECTRA

EMP110 DI is next generation LPI Universal Soldermask for digital imaging. Idealfor high-reliability, HDI applications.

SPRAY COATER

DYNACHEM
Automatic Lamination Technologies

SmartSpray series S1 PCB Soldermask spraying technology, dry film laminators and vacuum applicator equipment.

SPECIALTY CHEMICALS

Tailored to meet the precise surface preparation requirements of the industry's most advanced circuit boards.

rbp

EQUIPMENT

Mechanical and chemical process solutions for PCB fabrication.

Wise worldwide enterprise

Available exclusively through Technica, U.S.A.

1-800-909-8697 • www.technica.com

is a catalyst that accelerates the tarnishing of the copper metal substrate. As the stripper is used, the dissolved copper content builds and the stripper becomes increasingly corrosive to the exposed copper metal substrate. This is a good reason to not use high pH resist stripper formulations with concerns such as the oxidation or tarnishing of the copper. Some fabricators continue to employ low-cost, highly concentrated caustic-based strippers, but they are mistaken because this approach is not actually low cost (more on this later).

Thus, in reality, the tarnishing of panels in a used stripper is a failure of the anti-tarnish chemistry to deal with the increased corrosivity of the copper-contaminated stripper. This unfortunate situation can be avoided by selecting a stripper with anti-tarnish chemistry robust enough to overcome the corrosivity of high levels of dissolved copper. This choice can result in saving a tidy sum of money on stripper chemistry. The stripper can then be used to its real capacity rather than being prematurely dumped because it is tarnishing the copper. This is the more obvious problem.

A second issue relates to the dramatic decrease in speed of stripping with usage of the stripping chemistry. This results in an increase in resist stripping cost. Costs can come in several forms: lost productivity, potential for rejects due to resist residues remaining on the surface, adding fresh resist stripper to the working solution, and inadequate removal of resist skins from the sump. The addition of fresh stripper is usually a losing proposition depending on the stripper formulation and other factors. Other factors include the amount of stripped resist film in the sump, the reactivity of the exposed resist with the stripper ingredients, and whether or not the resist film is breaking up into particles/skins or is partially dissolving.

Figure 1 shows the relative behavior of a monoethanolamine (MEA)/choline-based resist stripper. These two chemicals are found in many of the commercially available resist strippers on the market today. Please note that in Figure 1, while representing a typical resist stripper operation, there are subtle differences from one resist to another. However, the general shape of the curve is representative.

Notice that the speed over the first 30% of the stripper bath is very high and almost completely uniform. As the choline depletes, the stripper starts stripping with the MEA. Consequently, the speed drops suddenly and dramatically and is uniform through its life. At this point, the stripper is acting as if it were a pure MEA-based product and choline was never present. For an outer layer stripper formulation, it makes sense to not have an MEA/cho-

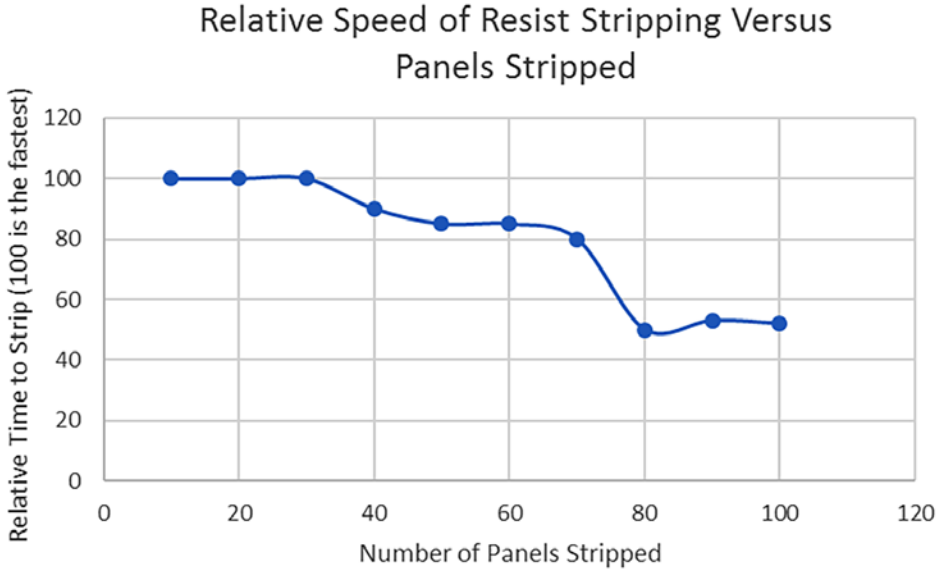


Figure 1: Stripping behavior of a MEA/choline-based resist stripper over time.

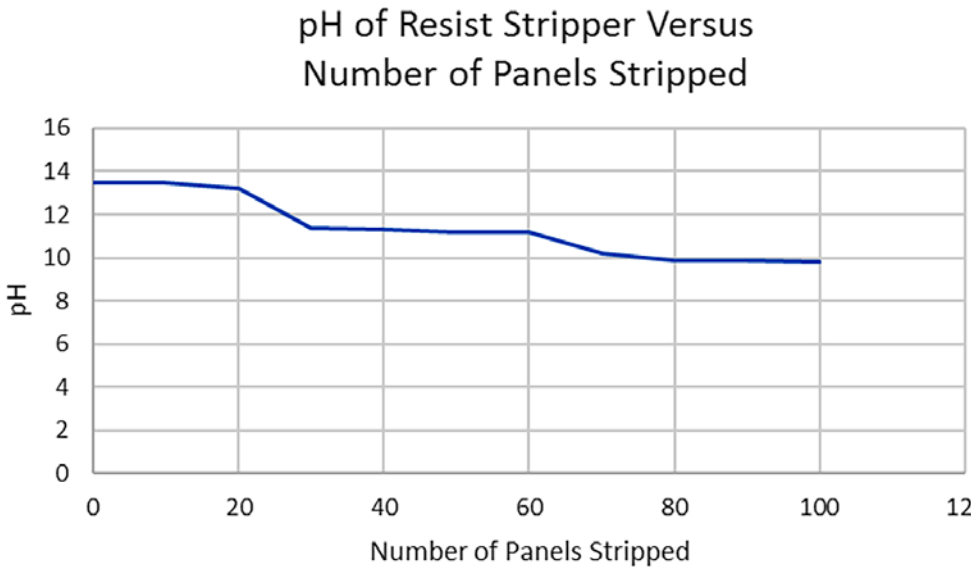


Figure 2: Chart showing pH as monitoring tool for MES/choline-based resist stripper.

line-based mixture. Perhaps the choline with the potential for a solvent assist is a more cost-effective process for photoresist stripping of outer layers.

Meanwhile, what is the best way to control the performance of the resist stripper? Notice in Figure 2 that the stripper containing choline starts at a pH over 13. When the pH drops to 11.5, no choline remains, so all remaining stripping occurs with only the MEA. This is a handy way to control this stripping chemistry and a much better approach than the traditional titration, which does not address quality or strength of amine present and only looks at the overall quantity of alkalinity present.

Figure 2 shows that controlling this type of chemistry by monitoring the pH, not by titration, is the best way to ensure the quality of stripping. This process is set up to run the line until the minimum acceptable quality of stripping is observed, followed by checking the pH. This pH becomes the minimum measurement at which the bath gives acceptable results. As one can see, photoresist stripping is a blend of art and science. However, in the end, it is about science. More details about resist stripping to come in a future column. **PCB007**

Michael Carano is VP of technology and business development for RBP Chemical Technology. To read past columns or contact Carano, click here.

A New Brain-Inspired Architecture Could Improve How Computers Handle Data and Advance AI

IBM researchers designed a new computer architecture with co-located memory and processing. In studies, their prototype ran 200 times faster than conventional computers. Unlike the stovepipe components in conventional computers, the authors propose that brain-inspired computers could have coexisting processing and memory units.

The IBM team drew on three different levels of inspiration from the brain. The first level exploits a memory device's state dynamics to perform computational tasks in the memory itself, similar to how the brain's memory and processing are co-located. The second level draws on the brain's synaptic network structures as inspiration for arrays of phase change memory (PCM) devices to accelerate training for deep neural networks. Lastly, the dynamic and stochastic nature of neurons and synapses inspired the team to create a powerful computational substrate for spiking neural networks.

IPC Legislative Victories Reached with Outstanding Member and Industry Support

One World, One Industry

by John Mitchell, IPC—Association Connecting Electronics Industries

After months of working with legislators in the United States to ensure our industry is well represented, I am pleased to say that we have been successful in our efforts—particularly concerning defense electronics and workforce education. The work of industry and IPC members cannot be understated. By telling real-life stories to legislators, you provided valuable input on how their constituents are affected by what happens in the electronics manufacturing industry.

Regarding defense electronics, the U.S. president recently signed legislation that will bring long-term focus to military electronics—specifically Section 845 of the FY2019 National Defense Authorization Act (NDAA), which calls on the Secretary of Defense to prepare a report on the health of the U.S. defense electronics industrial base. The report must include a plan to formalize the long-term resourcing and mission of the Executive Agent, the principal Defense Department entity charged with assuring the security and availability of printed circuit and interconnect technologies for defense electronics. IPC continues to provide industry data and opportunities for U.S. legislators to hear directly from our members.

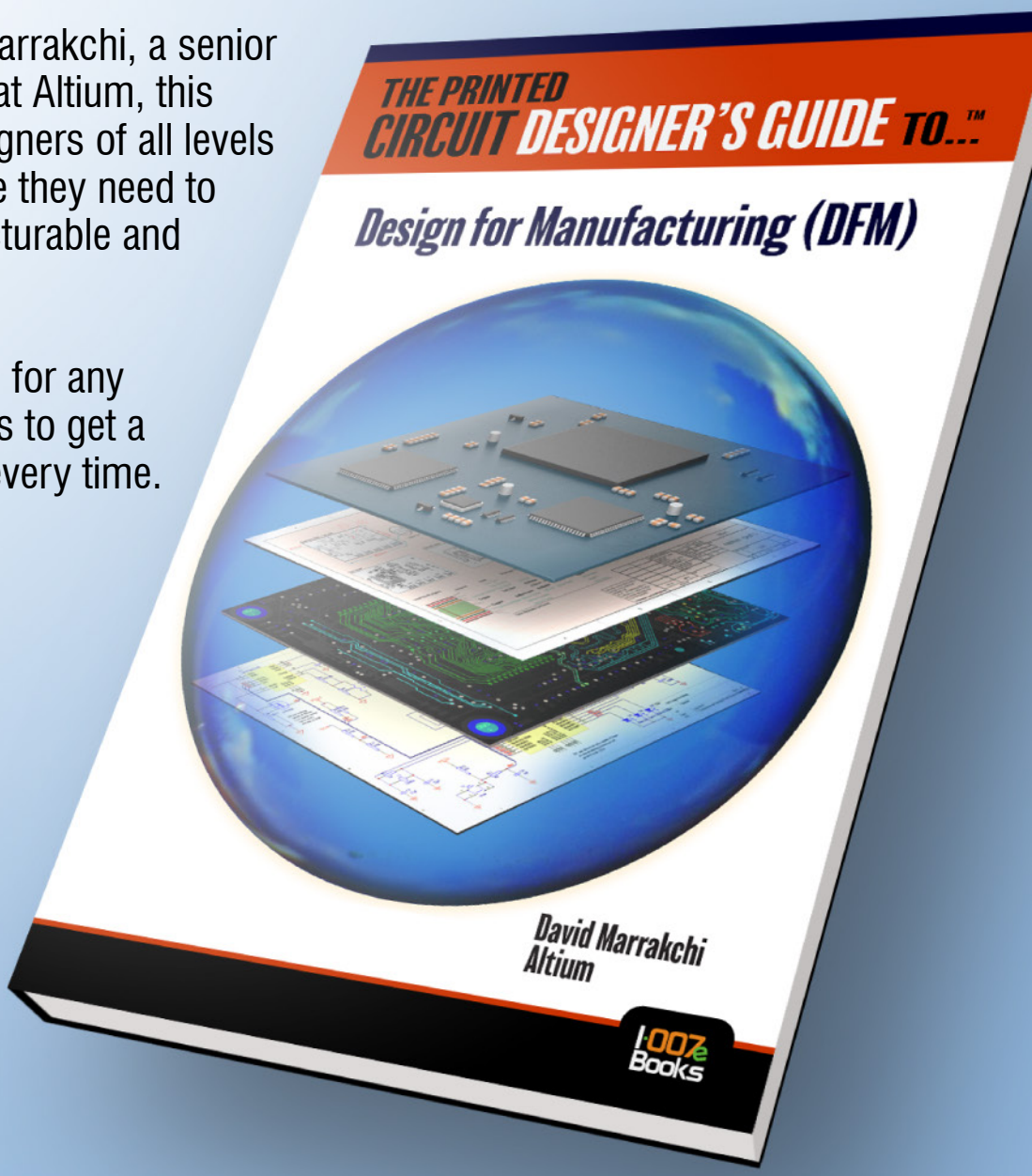
In workforce education, the U.S. Congress sent legislation to the president that will strengthen workforce education training efforts. The President signed the Perkins Strengthening Career and Technical Education (CTE) for the 21st Century Act. This was another issue that benefited from our member company executives explaining to leaders in Congress and the Administration how the skills gap is constraining the growth of their companies, and in some cases, their long-term

“A guided tour through the entire DFM process.”

Kelly Dack
CID+, CIT, EPTAC Corporation

Written by David Marrakchi, a senior technical engineer at Altium, this book provides designers of all levels the DFM knowledge they need to produce a manufacturable and functional board.

This is a must-read for any designer who wants to get a good board back, every time.



DOWNLOAD NOW

I-007e Books

I-007ebooks.com/dfm

viability. I was also happy to sign a letter to the leaders of the Senate Health, Education, Labor and Pensions (HELP) Committee urging them to complete their work on the bill. Because the Perkins CTE Act is now signed, it assures me that our industry has support as we work to train and certify the future workforce.

These victories in North America will set the stage for the work we are doing globally as we continue our international outreach. In November, we will rely on our European members to provide input to legislators as we support our industry at IMPACT Europe in Brussels. We couldn't do any of this work without you, and I'd like to take this time to thank you for your support. I look forward to continuing our advocacy efforts around the globe. By working together to support our industry in the face of numerous legislative and political changes, we can continue to keep the electronics manufacturing industry at the top of the individuals' minds who are making decisions that affect the work we do every day.

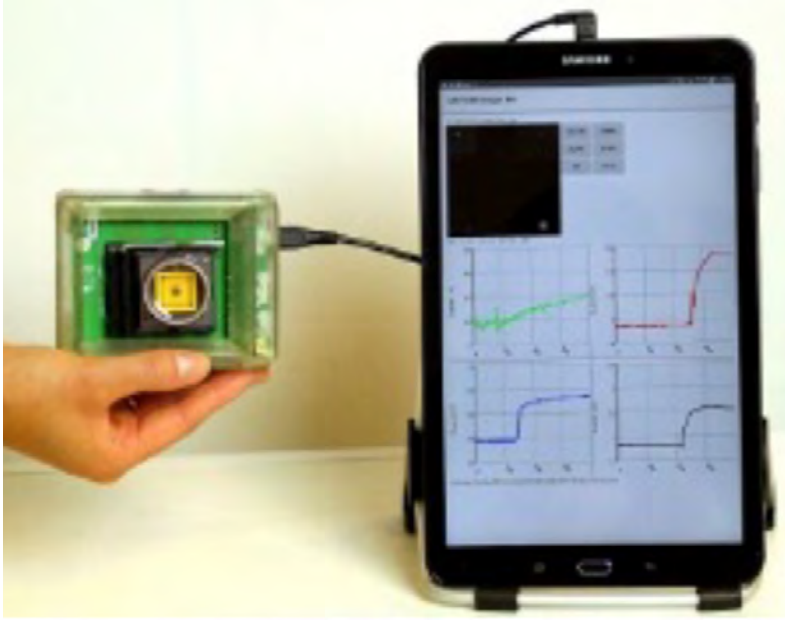
If you have any questions or comments on IPC advocacy efforts, please contact me or Chris Mitchell, IPC's vice president of global government relations. **PCB007**

John Mitchell is president and CEO of IPC—Association Connecting Electronics Industries. To read past columns or contact Mitchell, click here.

Researchers Unveil Star Trek-Inspired Diagnostic Device

A Star Trek-inspired handheld device based on a silicon chip could help make rapid, sophisticated medical diagnostics more accessible to people around the world. Researchers from the University of Glasgow describe the latest development in their 'multicorder' project, inspired by Star Trek's famous tricorder device, which the show's medics use to make quick and accurate diagnoses.

Their new device which pairs a handheld sensor with a smartphone app to measure the levels of various metabolites in fluid samples from patients. Metabolites are small molecules found in fluids from the human body. By measuring and monitoring their relative abundance, scientists can keep track of general health or the progression of specific diseases. The ability to rapidly detect and quantify multiple metabolite biomarkers simultaneously makes this device particularly useful in cases of heart attack, cancer and stroke, where rapid diagnosis is vital for effective treatment.



While metabolites can currently be measured by existing processes such as nuclear magnetic resonance and hyphenated mass spectrometry techniques, both approaches are expensive and require bulky equipment which can be slow to offer diagnostic results. The researchers' new device is built around a new form of complementary metal oxide semiconductor (CMOS) chip. CMOS chips are inexpensive to produce and are often used in imaging devices.

The chip is smaller than a fingertip and is divided into multiple reaction zones to detect and quantify four metabolites simultaneously from body fluid such as serum or urine. The device can be operated via any Android-based tablet or smartphone which provides data acquisition, computation, visualisation and power.

(Source: University of Glasgow.)

Get the spark you need to tune up your sales team.

When an engine doesn't fire on all cylinders, performance is limited. The same goes for your sales team. We provide the spark to get your sales to the next level ...and beyond.

We've helped dozens of companies big and small improve their bottom line.

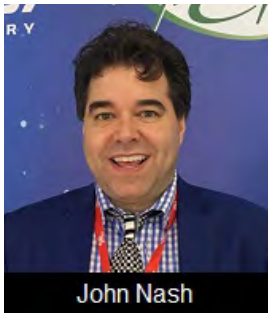
db MANAGEMENT GROUP

Learn how we can help YOU

207-649-0879 danbbeaulieu@aol.com

Recent Highlights from PCB007

1 Cerambus Discusses the Next Generation of PCB Plating ▸


John Nash

Cerambus Technology Inc. president John Nash sat down with I-Connect007 for a discussion on the latest developments in plating technology, challenges and opportunities in the China market, and their strategy for sustaining growth in a highly competitive industry.

2 Atotech on Challenges and Opportunities in PCB Manufacturing ▸

Abel Ruivo, Atotech Deputy Business Director of Electronics for Greater China, and Daniel Schmidt, head of Global Marketing for Electronics at Atotech Group, spoke with I-Connect007 about the various challenges of PCB manufacturing in China, as well as about the opportunities in the sector.

3 Ventec Keeps 'Shaking Things Up' with tec-speed 20.0 ▸


Mark Goodwin

At the EIPC summer conference, I-Connect007 Publisher Barry Matties caught up with Ventec Europe & Americas COO Mark Goodwin, who provided an update on Ventec's new products, the current state of the company, and how Ventec is shaking things up in the materials marketplace.

4 MacDermid Enthone Talks Wet Processing Tends in 2018 ▸

I-Connect007's Patty Goldman, Barry Matties, Andy Shaughnessy, ad Happy Holden were recently joined by MacDermid Enthone team members Jordan Kologe, technical marketing specialist; Ted Antonellis, applications manager for electronics specialties; and Don Cullen, marketing director for electronics solutions and MacDermid performance solutions. The discussion topic was the wet processing end of PCB manufacturing.

5 Solder Mask: You've Come a Long Way, Baby! ▸

I-Connect007's editing team met with Electra Polymers' Shaun Tibbals and Antony Earl to discuss what's new with solder mask, including direct imaging and inkjet printing of solder mask, and what PCB manufacturers and OEMs need to know.

6 Circuit Automation on the Ever-Evolving World of Solder Mask ▸

In a recent conference call, the I-Connect007 editorial team was joined by Circuit Automation's Yuki Kojima, VP of engineering; Larry Lindland, sales and applications manager; and Tom Meeker, CEO, for a lively discussion about solder mask. Spoiler: it's not all about the equipment.

7 Thermal Capabilities of Solder Masks: How High Can We Go? ▸

This article focuses on three different coating material groups that were formulated to operate under high thermal stress and are applied at the printed circuit board manufacturing level. While used for principally different applications, these coatings have in common that they can be key to a successful thermal management concept especially in e-mobility and lighting applications.

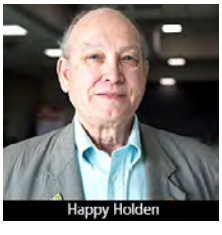
8 Building a Better Board: It Always Comes Back to Communication ▸

For our experts meeting on August's theme of reliability, we reached out to Mark Osborn, president and CEO of Colonial Circuits, Kevin Knapp, quality manager, and Rodney Krick, manufacturing manager, and asked them to participate in a conference call with our I-Connect07 editorial team.

9 Autocatalytic Gold: How it Fits as a Final Finish ▸

For process sequences or more information regarding semi-autocatalytic gold baths or the latest in the development of a fully autocatalytic gold bath that can eliminate corrosion at thickness of > 100 nm, please contact the author.

10 The IPC High-Reliability Forum for Mil-Aero and Automotive Sectors ▸



I-Connect007's Happy Holden had the pleasure of attendng the IPC's High Reliability Forum (HRF) in Baltimore in May. As the IPC scripted it, it was a "Technical Conference with a Focus on Electronics Subjected to Harsh-Use Environments."

For the Latest PCB News and Information, Visit: PCB007.com

Career Opportunities

Pssst! Are You Looking for Someone?

Place your notice in our Help Wanted section.

For just $500, your 200 word, full-column—or, for $250, your 100 word, half-column—ad will appear in the Help Wanted section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs and suppliers.

Potential candidates can click on your ad and submit a résumé directly to the email address you've provided. If you wish to continue beyond the first month, the price is the same per month. No contract required. We even include your logo in the ad, which is great branding!

To get your ad into the next issue, contact:
Barb Hockaday at barb@iconnect007.com or +1.916.608.0660 (-7 GMT)

I-Connect007
GOOD FOR THE INDUSTRY

smt007 pcb007 pcb design007

Career Opportunities

PCB DFM Engineer

Apple products are as alluring on the inside as they are on the outside. Inside our products are some of the world's most challenging consumer PCB assembly and flex designs. Imagine yourself as a select member of the team that brings these assemblies from concept to high-volume manufacturing.

Key Qualifications

- At least 5 years of experience with printed circuits, including hands-on process engineering experience
- Creativity and curiosity about materials science and electronics packaging at all levels
- Deep knowledge of industry specifications, especially IPC and JEDEC specifications
- Understanding of the relationship between manufacturing processes and printed circuit defect conditions, especially latent defects
- Ability to travel overseas for up to 25 percent of your time

Primary Responsibilities

- Maintenance of PCB design guidelines for all Apple products as well as the technology road map and acceptability specifications
- Establishment and maintenance of the supplier site/material/technology qualification matrix
- Direct responsibility for all PCB-related quality issues and excursions
- Providing mentorship to product designers on available PCB technologies and materials

Education

BS or higher in Materials Science or Mechanical, Chemical, or Electrical Engineering

apply now

Senior Manager, Flex/PCBA DFM

On this team, you'll be responsible for new product development, sustaining products and failure analysis while leading and mentoring design, process, and quality engineers and managers. You'll collaborate cross-functionally with Product Design, Electrical Engineering, strategic suppliers, and contract manufacturers to ensure the manufacturability of Apple products and maintain Apple's high standards for quality.

Key Qualifications

- At least 10 years of experience, with 5+ years of experience as a senior manager or director
- Experience managing other managers is preferable
- Experience in design and manufacturing, preferably in the electronics fabrication and assembly industry
- Deep technical knowledge complemented by a good sense of how engineering decisions impact business concerns
- Excellent communication skills, from extemporaneous discussion to synthesis of detailed technical reports and distillation to executive-level presentation

Primary Responsibilities

- Development of several design engineers and first-level managers
- Primary escalation point to resolve blocking issues related to design release, design spec compliance, or production process problems
- Engagement with vendor senior management to set expectations and to communicate feedback
- Highlighting all project risks to executive management and identifying, evaluating, and recommending the best path to resolution

Education

BS or higher in Materials Science or Mechanical, Chemical, Electrical, or Industrial Engineering

apply now

Career Opportunities

FREEDOM CAD SERVICES

Sr. PCB Designer – Allegro

Freedom CAD is a premier PCB design service bureau with a talented team of 30+ dedicated designers providing complex layouts for our enviable list of high-tech customers. Tired of the commute? This is a work-from-home, full-time position with an opportunity for overtime at time and a half.

Key Qualifications

- EXPERT knowledge of Allegro 16.6/17.2
- Passionate about your PCB design career
- Skilled at HDI technology
- Extensive experience with high-speed digital, RF and flex and rigid-flex designs
- Experienced with signal integrity design constraints encompassing differential pairs, impedance control, high speed, EMI, and ESD
- Experience using SKILL script automation such as dalTools
- Excellent team player that can lead projects and mentor others
- Self-motivated, with ability to work from home with minimal supervision
- Strong communication, interpersonal, analytical, and problem solving skills
- Other design tool knowledge is considered a plus (Altium, PADS, Xpedition)

Primary Responsibilities

- Design project leader
- Lead highly complex layouts while ensuring quality, efficiency and manufacturability
- Handle multiple tasks and provide work leadership to other designers through the distribution, coordination, and management of the assigned work load
- Ability to create from engineering inputs: board mechanical profiles, board fabrication stack-ups, detailed board fabrication drawings and packages, assembly drawings, assembly notes, etc.

apply now

American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

CAM Operator

American Standard Circuits is seeking a CAM Operator for its Phoenix, Ariz., office. Qualified applicants will need experience in using Valor/Genesis (GenFlex) CAD/CAM software with printed circuit board process knowledge to edit electronic data in support of customer and production needs.

Job Requirements:

- At least 5 years' experience in PCB manufacturing
- Process DRC / DFMs and distinguish valid design and manufacturing concerns.
- Modify customer supplied data files and interface with customers and engineers
- Responsible for releasing manufacturing tooling to the production floor
- Prepare NC tooling for machine drilling, routing, imaging, soldermask, silkscreen
- Netlist test, optical inspection
- Work with Production on needed changes
- Suggestions on continual improvements for engineering and processing.
- Be able to read write and communicate in English
- Must understand prints specifications
- Must be US Citizen or permanent resident (ITAR)
- High School Graduate or equivalent

Join our Team!

Founded in 1988, American Standard Circuits is a leading manufacturer of advanced circuit board solutions worldwide. Our ongoing commitment to leading-edge higher-level interconnect technology, cost-effective manufacturing and unparalleled customer service has put us at the forefront of advanced technology circuit board fabrication.

We manufacture quality rigid, metal-backed and flex printed circuit boards on various types of substrates for many applications.

apply now

Career Opportunities

ELECTROLUBE
THE SOLUTIONS PEOPLE

Sales Development Manager

Electrolube has a new opportunity for a sales development manager covering the Midwest United States. This is an exciting role involving all aspects of sales development and account management for the Electrolube brand.

The successful candidate will have relevant experience within the electro-chemicals industry and a strong commercial background. This position will report directly to the U.S. general manager.

Applicants should apply in writing and submit a CV by clicking the button below.

apply now

Ucamco
Former Barco ETS

International Field Service Engineer located in ITALY

The successful candidate will:

- Install and service our plotters and direct imaging machines at customer sites Europe-wide
- Carry out maintenance in the field
- Frequent travel: 4 to 5 days a week, 3 to 4 weeks a month
- Assist product manager

We are looking for a team player who is:

- Strongly customer-oriented and experienced in on-site support
- Accustomed to travel, and willing to travel frequently
- Motivated, independent and enterprising
- Technically-minded with training/background in electromechanics/electronics
- Experienced with software (setup, configuration, and usage of Windows-based CAM front-end software and Linux-based RIP software)
- Fluent in Italian and English (German and/or French is a plus)
- An analytical thinker
- Capable of problem solving

The right candidate will be a valued member of a friendly, team-oriented, growing international company that is a leader in its field, dedicated to excellence in all it does. Dynamic and fun, the company offers a great working atmosphere, and this new position is forward-looking and open, with plenty of opportunities for enterprising individuals whose results could be rewarded with prospects for progression in technical development.

Apply to Anja Ingels after clicking below.

apply now

Career Opportunities

MacDermid Enthone
ELECTRONICS SOLUTIONS

Product Group Field Manager
Waterbury, CT

Do you have what it takes? MacDermid Enthone Electronics Solutions is a leading supplier of specialty chemicals, providing application-specific solutions and unsurpassed technical support.

The position of the Product Group Field Manager will be responsible for creating and driving a strategic plan for the regional product line, including the following:

- Possess a thorough understanding of the overall PCB business, and specifics in wet processing areas
- Play an integral part in developing a commercial and technical customer strategy
- Create and deliver customer facing presentations
- Provide technical training for field staff
- Create and execute a product rationalization program
- Develop new product roll-out packages

Hiring Profile

- Bachelor's degree or 5 years' job-related experience
- Strong understanding of chemistry and chemical interaction within PCB manufacturing
- Excellent written and oral communication skills
- Strong track record of navigating technically through complex organizations
- Willingness to travel

apply now

GO Gardien

Role: Vice President Gardien Taiwan
TAOYUAN COUNTY, TAIWAN

Gardien Taiwan is a service provider of circuit board (PCB) quality solutions, including electrical testing, AOI optical inspection, engineering (CAM), fixture making, repair and rework. Gardien Taiwan operates service centers in Taoyuan and employs about 100 employees and is currently seeking a vice president to manage and oversee the entity.

Candidate Profile:

- Proficiency in Chinese and English (written and spoken)
- Excellent communication and organization skills
- Experience in change management
- PCB background appreciated, but not mandatory
- Management experience in internationally operating companies
- Savvy in standard office software (Word, Excel and Power Point)

If this sounds like you, please click here to send us an email with your attached CV.

About Gardien Group - Gardien is the world's largest international provider of independent testing and QA solutions to the PCB industry with a global footprint across 24 service centres in five countries and we cater to a whole range of customers, from small family owned PCB shops to large international fabricators. Gardien's quality solutions and process standards are trusted by leading high-tech manufacturers and important industries including aerospace, defense, and medical technology.

apply now

Career Opportunities

ZENTECH

Zentech Manufacturing:
Hiring Multiple Positions

Are you looking to excel in your career and grow professionally in a thriving business? Zentech, established in Baltimore, Maryland, in 1998, has proven to be one of the premier electronics contract manufacturers in the U.S.

Zentech is rapidly growing and seeking to add Manufacturing Engineers, Program Managers, and Sr. Test Technicians. Offering an excellent benefit package including health/dental insurance and an employer-matched 401k program, Zentech holds the ultimate set of certifications relating to the manufacture of mission-critical printed circuit card assemblies, including: ISO:9001, AS9100, DD2345, and ISO 13485.

Zentech is an IPC Trusted Source QML and ITAR registered. U.S. citizens only need apply.

Please email resume below.

apply now

Manncorp™

Sales Associate - Mexico

Manncorp, a leader in the electronics assembly industry for over 50 years, is looking for an additional sales associate to cover all of Mexico and to be part of a collaborative, tight-knit team. We offer on-the-job training and years of industry experience in order to set up our sales associate for success. This individual will be a key part of the sales cycle and be heavily involved with the customers and the sales manager.

Job responsibilities:
- Acquire new customers by reaching out to leads
- Ascertain customer's purchase needs
- Assist in resolving customer complaints and queries
- Meet deadlines and financial goal minimums
- Make recommendations to the customer
- Maintain documentation of customer communication, contact and account updates

Job requirements:
- Located in Mexico
- Knowledge of pick-and-place and electronics assembly in general
- 3+ years of sales experience
- Customer service skills
- Positive attitude
- Self-starter with ability to work with little supervision
- Phone, email, and chat communication skills
- Persuasion, negotiation, and closing skills

We offer:
- Competitive salary
- Generous commission structure

apply now

Career Opportunities

Mentor®
A Siemens Business

PCB Manufacturing, Marketing Engineer

Use your knowledge of PCB assembly and process engineering to promote Mentor's Valor digital manufacturing solutions via industry articles, industry events, blogs, and relevant social networking sites. The Valor division is seeking a seasoned professional who has operated within the PCB manufacturing industry to be a leading voice in advocating our solutions through a variety of marketing platforms including digital, media, trade show, conferences, and forums.

The successful candidate is expected to have solid experience within the PCB assembly industry and the ability to represent the Valor solutions with authority and credibility. A solid background in PCB Process Engineering or Quality management to leverage in day-to-day activities is preferred. The candidate should be a good "storyteller" who can develop relatable content in an interesting and compelling manner, and who is comfortable in presenting in public as well as engaging in on-line forums; should have solid experience with professional social platforms such as LinkedIn.

Success will be measured quantitatively in terms of number of interactions, increase in digital engagements, measurement of sentiment, article placements, presentations delivered. Qualitatively, success will be measured by feedback from colleagues and relevant industry players.

This is an excellent opportunity for an industry professional who has a passion for marketing and public presentation.

Location flexible: Israel, UK or US

apply now

BLACKFOX
Premier Training & Certification

IPC Master Instructor

This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

apply now

A NEW QUARTERLY MAGAZINE

With original content dedicated specifically to flex system and PCB designers, electrical engineers and those responsible for integrating flex into their products at the OEM/CEM level, you won't want to miss a single issue of ***Flex007 Magazine****!*

Subscribe **Contribute** **Advertise**

I-Connect007
GOOD FOR THE INDUSTRY

Events Calendar

SMTA International ▶
October 14–18, 2018
Rosemont, Illinois, USA

International Wafer-Level Packaging Conference Exhibition ▶
October 23–24, 2018
San Jose, California, USA

IMPACT 2018 ▶
October 24–26, 2018
Taipei, Taiwan

Medical Design & Manufacturing (MD&M) Minneapolis ▶
October 31–November 1, 2018
Minneapolis, Minnesota, USA

IPC Southeast Asia High Reliability Conferences 2018 ▶
November 1, 2018
Penang, Malaysia

IPC/SMTA High-Reliability Cleaning and Conformal Coating Conference ▶
November 13–15, 2018
Schaumburg, Illinois, USA

electronica 2018 ▶
November 13–16, 2018
Munich, Germany

International Printed Circuit & APEX South China Fair ▶
December 5–7, 2018
Shenzhen, China

IPC APEX EXPO 2019 ▶
January 26–31, 2019
San Diego, California, USA

Additional Event Calendars

PUBLISHER: **BARRY MATTIES**
barry@iconnect007.com

SALES MANAGER: **BARB HOCKADAY**
(916) 608-0660; barb@iconnect007.com

SALES: **ANGELA ALEXANDER**
(408) 489-8389; angela@iconnect007.com

MARKETING SERVICES: **TOBEY MARSICOVETERE**
(916) 266-9160; tobey@iconnect007.com

MANAGING EDITOR: **NOLAN JOHNSON**
(503) 597-8037; nolan@iconnect007.com

CONTRIBUTING EDITOR: **PATRICIA GOLDMAN**
(724) 299-8633; patty@iconnect007.com

TECHNICAL EDITOR: **PETE STARKEY**
+44 (0) 1455 293333; pete@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **DAN FEINBERG**
baer@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **HAPPY HOLDEN**
(616) 741-9213; happy@iconnect007.com

PRODUCTION MANAGER: **SHELLY STEIN**
shelly@iconnect007.com

MAGAZINE LAYOUT: **RON MEOGROSSI**

AD DESIGN: **SHELLY STEIN, MIKE RADOGNA , TOBEY MARSICOVETERE**

INNOVATIVE TECHNOLOGY: **BRYSON MATTIES**

COVER: **SHELLY STEIN**

COVER IMAGE: **BRYSON MATTIES**

PCB007 MAGAZINE

PCB007 MAGAZINE®
is published by BR Publishing, Inc.,
942 Windemere Dr. NW, Salem, OR 97304

October 2018, Volume 8, Number 10
PCB007 MAGAZINE is published monthly,
by BR Publishing, Inc.

ADVERTISER INDEX

Coming Soon to *PCB007 Magazine:*

NOVEMBER 2018: Medical Electronics
Opportunities and Challenges

DECEMBER: IPC APEX EXPO 2019
Preshow Issue

I-Connect007

GOOD FOR THE INDUSTRY

FREE SUBSCRIPTION

myiconnect007.com

mediakit.iconnect007.com

EDITORIAL CONTACT

Nolan Johnson

nolan@iconnect007.com

+1 503 597-8037 GMT-7

SALES CONTACT

Barb Hockaday

barb@iconnect007.com

+1 916 365-1727 GMT-7

www.iconnect007.com