



Figure 1: Pre-clean followed by electro-plate copper which uses two separate electrolytes: THF (through-hole fill) or MVF (micro via fill).

## GreenSource: Good for the Industry, Good for the World

### Feature by the I-Connect007 Editorial Team

Whelen Engineering has recently spun off their new printed circuit manufacturing facility to service the merchant market as a new business entity, GreenSource Fabrication LLC. Because of this strategic move, their collaboration with Atotech regarding production automation and green PCB manufacturing is getting serious attention. Our I-Connect007 editorial team recently conducted a teleconference with Alex Stepinski, vice president and general manager of GreenSource, and Atotech's team, including North America Business Director Moody Dreiza; Gerhard Kruse, sales manager at the equipment plant in Feucht, Germany; and Daniel Schmidt, who oversees global marketing for Atotech's electronics business unit. We discussed the foundation of this partnership, the technical challenges of building green, fully automated fabrication facilities, and GreenSource's plans for the future.

**Patty Goldman:** Welcome, gentlemen. Gerhard and Daniel, let's begin with you. Can you tell me how you entered this project?

**Gerhard Kruse:** I was involved in this project during the sales process, so I was brought in at the very beginning, before I handed it over to our project management.

**Daniel Schmidt:** In Q3 2016, when we heard about Alex's plan to build a full-fledged automated and green PCB production facility in North America for GreenSource, which was Whelen at that time, we invited him to meet our chemistry and equipment expert group in Berlin and Feucht to talk about the available Atotech processes and equipment solutions, as well as possible challenges on his way to realizing the project. As part of the process, we opened our doors to our global technical centers in Berlin, Yokohama (Japan) and Jangnan (S. Korea) and showcased our equipment in a production environment. Today, I am very happy to look at the status of the project and the amazing work by Alex and the Atotech team.

**Goldman:** Alex, why don't you give our readers an overview of what's going on with GreenSource.

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Alex Stepinski

Vice President at Whelen Engineering/Greensource Fabrication



**Alex Stepinski:** Your magazine has highlighted some aspects of our project in recent articles. Our involvement with Atotech on this new phase dates to September 2016, when we first made contact to discuss possibilities, and they presented us with some very interesting technologies at the meeting in Berlin, and then another meeting at Feucht. We went to a couple of their tech centers to understand the technologies better. I'll preface this by saying that Atotech was a very successful supplier for us for our original project<sup>[1]</sup>. They provided an equipment set and overall process that was very, very reliable. We had a good experience with it, and this is the reason we came to them.

During discussions initiated in September, and then some follow-up face-to-face in late 2016, we arrived at an overall specification to create this high-mix process. We could fill buried vias, fill through-holes with copper, plated copper, on very thin substrates and on very thick product; we're able to do high-aspect ratios. These are all horizontal processes that we procure from them, and they are also engaging with us on the chemical side developing a unique vertical process.

All of this is done with a simple zero-discharge mentality. Controls have been integrated throughout the line so that we don't even have rinse water coming out of the lines now. It's a unique overall process where we can run

a high mix of products through many different types of chemistries to achieve very challenging specifications, very fast, using equipment that's basically designed more for the Asian market in terms of high volume. But they re-engineered everything for us for a high-mix North American model. And they made it green as well. This is the summary of what we're doing to get there.

**Goldman:** I understand that Atotech has built three platers for GreenSource. Are they providing equipment and chemistry?

**Stepinski:** Three platers, two electroless lines, two surface treatment lines, and a direct metallization line, so it's more than just three platers.

**Barry Matties:** In this development process, what was the greatest obstacle that you had to overcome to achieve these results?

**Kruse:** The main obstacle for this project was the highest degree of flexibility requested by Alex and his team. Atotech's core competence is manufacturing high-volume horizontal plating systems for the PCB industry, and this is typically a combined line starting from desmearing through the electroless copper and finally the plating process. Alex was looking for something totally different—a smaller capacity line. He wanted to have the utmost flexibility for through-hole and for blind microvia production, but also for through-hole filling as well as for processing thin and thick panels, so he challenged us. To deliver a systems set offering the highest degree of flexibility, while at the same time the best reliable solution available in the market, we decided on standalone plating equipment, as well as in-line processing consisting of PTH and plating lines with individual loaders in front and unloaders in between, to provide the solution Alex was looking for. And this is what is installed now.

**Goldman:** What was new in the equipment that has never been done before, that you're aware of?



Figure 2: BondFilm LDD SR (splash reduction on laser-drilled holes followed by desmear processing).

**Kruse:** Regarding the equipment, we had a special request from GreenSource 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 are operating with recycled water. For this prerequisite, we installed new devices to the system to avoid dirt due to algae generation in the rinses. Algae generation is an issue when using recirculating water!

The plating systems we have installed is our UniPlate advanced plater, which is considered leading-edge in Asia markets, and today we are looking at hundreds of installations worldwide. The installation at GreenSource is the first in the Americas. What else is new? GreenSource is the first customer to use different chemistries for one plater, meaning we have to fill the plater, use it for production, then we have to pump the solution back to the holding tank and come back with a new solution to make the same line suitable for another product and for another process. That is a unique setting in the market today, and it was for us a great achievement to engineer and provide a systems' set offering this high degree of process flexibility to one of our customers.

**Goldman:** Sounds very involved.

**Schmidt:** Yes, I can confirm we have been very involved and engaged in the project. Usually our clients purchase production equipment for specific applications and production demands. In the case of GreenSource, at that time, Alex entrusted Atotech to come up with a solution where all types of printed circuit boards can be produced using the same set of equipment, but applying different wet chemical processes to realize through-hole and blind microvia production, as well as the processing of thin and thick panels. The production of complex high-density interconnect PCBs is new to the North American market and today more common in Asia. We are as excited as Alex to bring this kind of production know-how to North America.



Gerhard Kruse

But let me also add to the subject of flexibility. Atotech systems solutions offer the highest degree of flexibility in the production of different PCB board types (e.g., from standard multilayer to higher complex multilayer, or flex and rigid-flex and high-density interconnect PCB designs), all can be realized with the different settings that our systems offer: different

clamp design, oxamat and condenser, edge filter, automatic cleaning system (all for Uniplate P), transport systems, advanced fluid control system (Uniplate LB), reliable transport and uniform surface distribution (UniPlate Cu), etc.

In addition, all of our systems come with online controlling and analysis tools, supporting the systems integration to other machines and software, to comply with the highest degree of automation. Also important to mention is that our systems are designed to meet the highest safety standards and run at very low chemistry, water, and energy consumptions, while at the same time producing a minimum of waste (wastewater or drag-out chemistry), which, in the case of GreenSource, is exactly what Alex was looking for.

Also, the large amount and variety of different Atotech wet chemistry processes GreenSource has installed is remarkable and dates back to 2013, when Alex looked into conductive polymer-based direct metallization. Since then, and with the expansion, GreenSource is now using our high-throw electroless copper (Printoganth T1), the BMV filling process (Impulse 2HF), the electrolyte for through-hole, BMV and conformal plating (Impulse 2THF), electrolyte for conformal or flash plating (Impulse 2HT), as well as laser direct drilling pretreatment (BondFilm LDD SR), higher copper loading bonding enhancement (BondFilm HC), and recently also our ENIG process (Aurotech DC). Alex, is that correct?

**Stepinski:** Yes, that is the product mix we are using at our GreenSource site and yes, we are also bringing in the nickel-gold process.



Figure 3: Atotech's alternative oxide BondFilm HC (high copper).

**Moody Dreiza:** The nickel-gold process obviously is a surface finish process, and we're also very excited to partner with Alex on that. Patty, you asked what is new that has not been done before. From my perspective, I would certainly say a lot of these activities have not been done before in the North American market. Key to many of the systems is our transportation systems, which are most likely the most advanced in North America.

Also, we did some customization, which is potentially one of a kind worldwide. The plumbing in the equipment was customized to conform to Alex's concept for minimal water use within the lines and the ability to handle multiple electrolytes.

The flexibility mentioned is only possible because of Atotech's unique status as both equipment fabricator and chemistry. Atotech provides the overall system solution of both equipment and chemistry, of which we are very proud.

We talked a little bit about some of the innovations on equipment and on the chemistry, like our Printoganth T1. This is the first installation of this process in North America. Printoganth T1 is really targeting those blind microvias, specifically reliability of blind microvias, which is something that is becoming increasingly important in the industry as the via sizes shrink. And automotive requirements that we want are introduced into the market. We see a very high focus on reliability of blind microvias and from that perspective; we believe that we have a very robust overall solution.

**Matties:** You mentioned your conveyor transport. Tell us what makes that so special now?

**Dreiza:** The ability to handle different thicknesses of material was something that we wanted to make sure was an option that was available to our customer. And I would probably turn to Gerhard, if you would like to give more detail on that. Gerhard, maybe you can dive into some of the aspects of our UTS access system.

**Kruse:** Yes, as Moody and Daniel just said, we have different lines at the facility. The different lines are equipped with different conveyor systems. One conveyor system is equipped to transport thick panels, and another one is equipped to transport very thin panels. And the UTS-xs concept is designed to process standard panels of 44 microns in thickness including 2 x 2 microns of copper clad, which I would consider is already very, very thin and flexible material.

Fluid management is key to enable reliable transport in UniPlate systems and we have implemented a lot of control devices to do this. For example, we control the solution level in the process area of the modules, and we control the pressure of the solution flow from the pumps through the fluid devices to the panels. We have built-in devices, which look different and which are more advanced compared to what we normally use to enable reliable transport. By these means we achieve the latest requirements for transport capabilities as required in the industry today. And we have also implemented fine filtration systems for all lines. This was required because GreenSource also wanted to process fine-line structures on these lines. To allow exactly that, we have a fine filtration concept for all modules, not only active modules, but also on rinses and on the plating modules.

**Matties:** From this experience of all this new technology, how is this going to come forward or help other fabricators or how is that impacting your offerings in the North American market? What should others learn from this?



**Dreiza:** I would start by saying that I think the overall approach to one of a green manufacturing site, or a highly sustainable manufacturing site, that can handle some of the most advanced PCB materials and PCB projects, certainly is generating a good deal of interest from what we've heard in the North American market. It's a bold step, but it shows the possibilities of what is achievable. I'm seeing a high degree of interest in the market for comparable approaches. Maybe not necessarily to the whole way that Alex has put it together, because Alex has filled in a lot of the blanks and connected the dots between the different processes, which is already in its own right quite a good deal of work. But I think that certainly people are starting to sit up and take notice of what is possible with some of the more advanced systems, which is really the combination of equipment and chemistry.



Moody Dreiza

**Matties:** I would think that the zero-discharge requirement was a challenge and one that would be sought after as well.

**Dreiza:** Yes. So far as our horizontal systems, by design, are low-flow, low-water consumption. We have things, for example, like condensers on our exhaust, which capture a lot of the chemistry that is in the exhaust and brings it back into the tanks so that you're not just exhausting a lot of the chemistry and a lot of the water that you are bringing into the system. Our systems are, by default, already quite conservative in their use of water as Daniel also underlined. We are seeing that as a thing of very high interest in the market in all regions. I've seen it in the Northeast, and in the Southwest of the U.S., and in Canada. People are paying a lot more attention to it than I've ever seen before. What Alex has done of course is take that and multiply it across his entire factory, which is a great deal and achievement.

**Goldman:** It is. I guess a lot of people didn't think it was possible.

**Schmidt:** Yes, I agree. The results are remarkable and we are looking back at a great deal and achievement. Our systems have always run at a much lower chemical or water consumption rates compared to any of our competitors, and therefore also at a much lower process cost. In addition, we are looking at high productivity and yield rates at the GreenSource site. At GreenSource,

our systems could be even further trimmed to perform at almost zero raw material consumptions, water and energy levels, as well as almost no liquid waste/discharge.

What Alex and his team have accomplished here is really a great deal. Extensive cleaning cycles in the desmear process, what is today considered standard could be almost completely eliminated. The electroless copper process saves a lot of water, as well as sodium hydroxide and formaldehyde, compared to a vertical system. In the electrolytic copper plating step, we can realize fast plating, excellent surface distribution and yield at lowest chemistry consumptions when compared to other insoluble anode systems using copper oxide or copper carbonate; several tons of plating solution can be saved per year. Last, but not least, a high copper loading bonding enhancement bath allows GreenSource to reduce the bleed amount and make-up frequencies, while keeping the same reliable performance of the high-end bonding solutions from Atotech.

**Matties:** It is remarkable, indeed. It's an achievement that doesn't go unnoticed here. You guys have mentioned the growing demand for HDI production in North America. What sort of inquiries are you getting specifically related to HDI from North America? Have you seen a large increase in that?

**Dreiza:** We are seeing a high interest in, for example, microvia reliability. That seems to be one of the hot topics that we've heard about in maybe the last six months. But in terms of people adapting new equipment, new processes, to address those, I think those are still com-

ing from the industry. There are, of course, people who are looking at newer equipment, but I think maybe not something as advanced as what's been put together at GreenSource with all those dots connected. I can't underestimate the work around the equipment that we've provided, which is also very important. But we are seeing more interest in the industry, certainly.

**Matties:** And maybe one final question from me. Through this whole process, what has been the greatest surprise?

**Kruse:** That is a good question for our project manager to answer, who unfortunately cannot join us today. But what I saw, and what I experienced with these lines is that we have had no unexpected events. Everything was quite normal. Of course, as I said earlier, what Atotech normally provides to the industry are lines which possess a very high conveyor speed with a target to have a high output with a very high availability. And this is something that's different at GreenSource. They want to reduce the conveyor speed. They want to unload after one process and to load in front of the next process at whatever time they want. From my perspective, the high demand for flexibility was a challenge and maybe still is.

**Goldman:** Well, I think that most people who buy equipment simply come and say, "I need

equipment to run this many parts per hour, etc." They don't make the kinds of demands that Alex has made on you. And you guys picked up the challenge, which was great. I take it that it was a challenge—you couldn't just say, "Oh, well, yes, we'll use this and we'll use that." I'm sure it took a lot of collaboration and I think that needs to be recognized and congratulated. Alex, maybe you have some thoughts on that, too?

**Stepinski:** I do. This is the result of a lot of collaboration. The real bottom line here is Atotech is an advanced HDI equipment and chemical supplier on the electronics side, amongst other things. They really are focused on the mass production Asian market, and to take those ideas and turn it into a high-flexibility, green, North American solution was a great challenge. It took a lot of face-to-face time and a lot of conference calls. It was a very good experience overall. We're happy with the state of things right now, and look forward to continuing to work together.

**Goldman:** Did you ever doubt that it would happen? That you would meet all these requirements?

**Stepinski:** Well, we didn't doubt it would happen. I think the challenge was all in how much time we had to put into it.

**Matties:** Is there anything we haven't talked about here that you feel we should have covered?

**Stepinski:** The only other open topic is that we are doing collaboration on vertical chemistry for a unique tool that we've had built here that's being installed in the next six weeks. Those chemistries are associated with semi-additive processing as well as ultra-high aspect ratios of 50:1. This is something rather new. Some chemistry is being built specifically for this application, or at least modified for this application. It's just getting started now. There's not much to talk about, but we are partnering with Atotech on this over the next



Figure 4: T1 Electroless copper, with better throwing power than standard, followed by high throw electroplate copper HT.

months until we bring it to market in the United States. SAP, vertical high-density, very small line and space capabilities with blind via fill and ultra-high aspect ratio. So this is something we're working on together.

**Goldman:** You barely got this other project running, and you're off onto the next one.

**Stepinski:** This was always part of the plan from the beginning. It was just that this was the next case.

**Dreiza:** Just as Alex said, this is still a very early stage in that process, but I might add something from my perspective. Atotech normally builds and typically provides a lot of attention to horizontal processing. Our equipment that we manufacture is really for horizontal processing, but when it comes to chemistry, even though we do provide those sorts of combined equipment and chemistry systems in horizontal, in vertical such as what Alex is describing now, we also are quite open to providing chemistry for vertical processes. We have an entire suite of chemistry for vertical processes, be they vertical conveyerized or vertical hoist-type plating systems.



Daniel Schmidt

What I think Alex is alluding to here is that we are also willing to partner and try to find a solution, maybe one that doesn't even exist today, that would be able to do some of these, I would say, futuristic or forward-looking challenges such as the 50:1 aspect ratio. It is early in the project, and we are partnering with Alex to check that we are driving towards that goal.

**Schmidt:** Let me add to this by saying that an aspect ratio of 50:1 is pretty high, not to say exceptionally so. But while exceptional and certainly challenging, it doesn't mean that plating reliably into such holes is impossible.

If you would ask me, this is how I would describe you, Alex. You have very interesting, visionary, and challenging ideas, and you always choose the best to cooperate with to reach your goal, which is impressive and makes you a great achiever. We are early in this project and we are working hard to push this forward together with Alex. We are ready for sampling of boards coming with this very high-aspect ratio criteria. Of course, it all requires a good quality PTH process prior to the plating step, which is the challenge here too.

**Goldman:** Gentlemen, thank you so much for your time.

**Schmidt:** Same here. Thank you for having us.

**Dreiza:** Absolutely.

**Matties:** And thanks to you, Alex, and to your team for being so open and sharing what you're doing at GreenSource. It's good for the industry and good for the world.

**Stepinski:** Thank you everyone. PCB007

## References

1. Whelen Reduces Cycle Time by Building a New Automated PCB Factory, *The PCB Magazine*, October 2015.

Figure 5: Back side of the lines showing pumping system and dosing tanks.