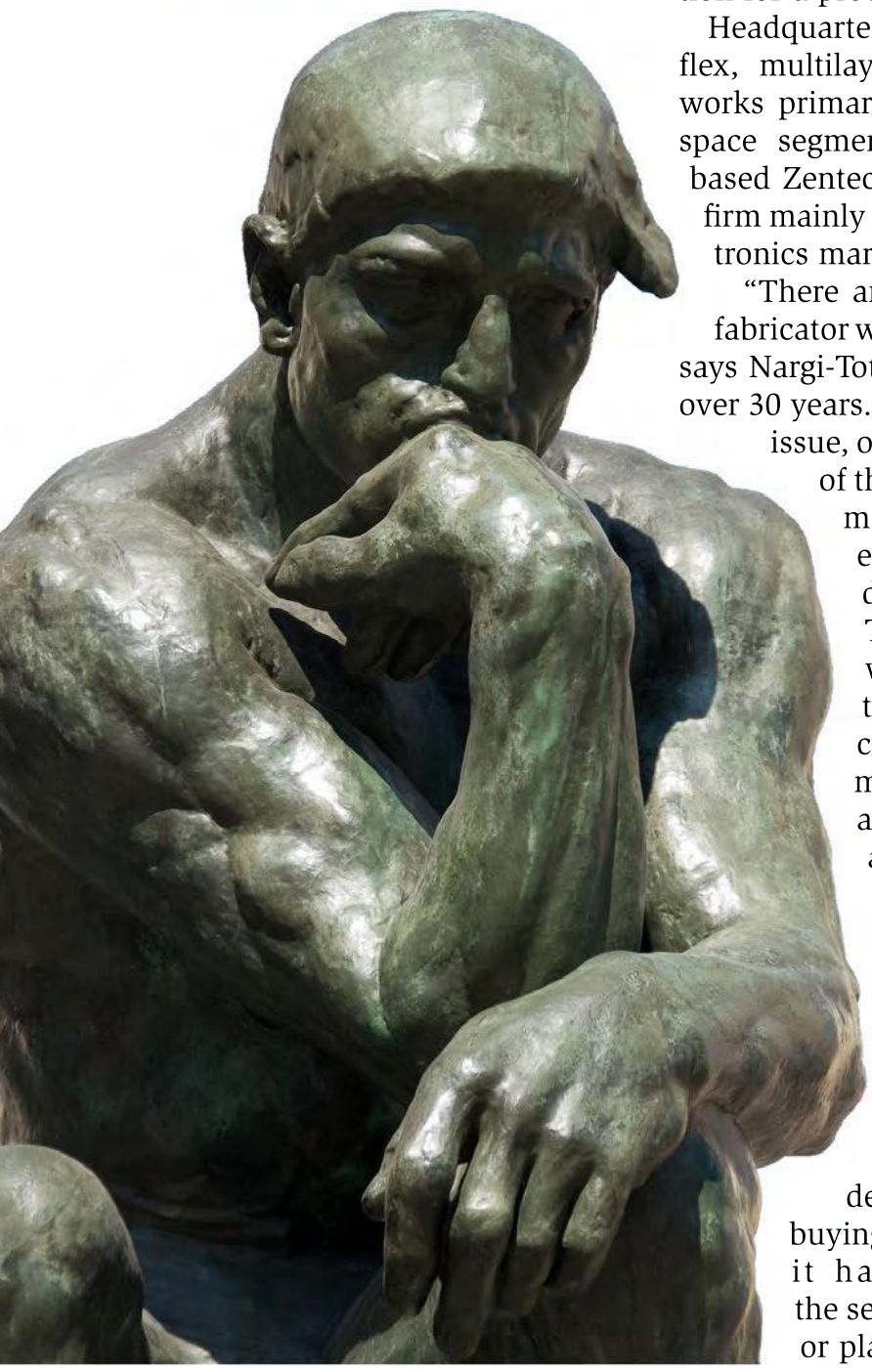
Making the Right Equipment Selection

Feature Article by Stephen Las Marias and Patty Goldman
I-CONNECT007



For this month's issue of *SMT007 Magazine,* our focus is on equipment—not just on who's got the latest and the greatest, but on how people decide what to buy, when to buy it, and how those decisions are made. In preparation for this issue, we invited Kathy Nargi-Toth, president of Eltek USA, and Matt Turpin, president and CEO of Zentech Manufacturing to a discussion on the decision-making process for new equipment, and the key considerations for choosing the best machine solution for a process.

Headquartered in Israel, Eltek manufactures rigid-flex, multilayer flex, and HDI PCBs. The company works primarily with the military, defense, and aerospace segment, and medical electronics. Baltimore-based Zentech Manufacturing, meanwhile, is an EMS firm mainly focused on the mil/aero and medical electronics markets.

"There are probably three main ways that a PCB fabricator would evaluate new equipment purchases," says Nargi-Toth, who has been in the PCB industry for over 30 years. "The first would be to address a capacity issue, or a bottleneck. So, you're looking for more of the same, perhaps. The second would be to meet a technical challenge that your current equipment can't. The last one would be to do something that is new or revolutionary. That case would follow your roadmap and would be looking to purchase equipment that may not yet be available. In these cases, it is best to be working with your main equipment suppliers. Often, they are already looking at new techniques that can advance you along your roadmap. Most fabricators are doing some amount of each of these three types of purchases, depending on how the particular operation is focused."

According to Nargi-Toth, in Eltek's case one of the primary focuses is equipment that can handle thin materials. "There seems to be an overriding decision-making process when we go about buying a new piece of equipment. How does it handle flex material? How does it handle the sequential lamination, sub-composite layers or plated through-hole innerlayers? This mate-

Kathy Nargi-Toth, Eltek USA

rial handing focus helps us concentrate on equipment that meets our overarching requirement, because we need to have equipment with 1-10 mil handling capabilities. As an example, we do a lot of hole filling, and we have been using one type of equipment for many years. But it wasn't as adept at handling the thin materials. So, when we looked to add more capacity we evaluated a different machine and found that gave us better fill, especially with those small holes, and was also better for handling thin material. The process, basically, is we have a need, we put together a proposal of what type of equipment we want to look at, we gather some samples, we run samples, we evaluate them versus what we have, and then decide. We've done that for our etching line, and we have done that for laser drilling. Basically, benchmarking new equipment against existing and looking at two or three different types of equipment from different suppliers in the same category. We just purchased another laser drill, and in that case, we did a survey of what was out there, and we ended up buying another machine like the one we had, because it best met our needs."

Being in the EMS business for about 35 years now, Turpin has already seen a lot of changes. According to him, in the old days—around 15 years or so back—an EMS firm could buy a set of equipment, and use the same set of equipment 10 years later. "Because technology just did not change that fast," he says. "Back in the old days, you had a lot more mom-and-pop shops. A lot of Tier 4s and Tier 3s, because it wasn't as capital intensive back then. It was great for an EMS business, selling from the equipment standpoint. I wouldn't necessarily say 'the good old days,' but there'd be times where you bought the equipment, you could run the equipment, and things didn't change that much. And then we entered a period where there was a rate of change, and we were like this until relatively recently, where you knew that there was new technology out there, but you could wait for a program, a customer, or an opportunity to come along before you buy. It's like, 'Okay, well, yeah I know that there are longer ovens out there. But if I get a 30-core layer board and it's a big enough program, I'll bite off and I'll buy a new oven."

Over the past five years, Turpin says you just don't need to wait for a program because there was enough research to figure out what you needed. "You had to become fast with the technology to even know how you'd end up quoting, because you can't just buy the equipment and start using it the next day. You have to develop a process around it. You've got to learn how to do it. You've got to hire people. In the EMS world, we are driven more towards having a technology roadmap, where we do need to plot out emerging technologies. Not just on the process side, but on the component side. Component suppliers are coming out with some crazy stuff that influences the equipment you need to process it. It is just creeping more into the EMS side."

As an example, Turpin said you cannot just get an oven only when you get a 34-layer board program. "You can't just have one oven, you need to have three ovens that can do heavy layer boards and highly integrated BGA technology on those boards. You need more than one rework machine to be able to rework BGAs that are on that. You have to get out in front of that," Turpin says.

One of the technologies that Zentech started looking at a year ago was cleaning technology. "We spent six months just looking at all the different versions. It used to be you'd see a couple of LGAs, a QFN, on a board. We've got some with hundreds of LGAs on a board now, and it forces you to a completely different cleaning paradigm where you can sort of clean it with the old stuff, but not really. So,

you really need to look at new technologies all the time. It's the same thing with 3D AXI. You can't use a manual X-ray system when you have a Class 3 board with 400 bottom-terminating components. There's no way any human being is going to accurately look at all those without glazing over. You need automated technology to do the heavy inspection on that type of work. You still have a human to do a sample to make sure you have compliant joints, but there's no way you can screen all those bottom-terminated joints manually," says Turpin.

Figure 1: When investing in new equipment for the factory, manufacturers should follow a proven evaluation procedure. (Photo Courtesy: Eltek Ltd)

Challenging Equipment Suppliers

Do they ever make demands on their equipment or department to come up with something better for their processes?

Nargi-Toth says some of their equipment is 'machine #1,' which is when they have challenged their suppliers to give the industry something better. "I think many of the #1 machines that Orbotech has introduced have spent some time in Eltek," she says. "We had one of the first laser direct imaging machines they made, and the first direct imaging solder mask machine they made. It is very important for our industry that these types of relationships exist between fabricators and the supply base. We are constantly challenging our suppliers to give us something better than the machine that we just bought from them."

But sometimes, current technologies have notable limitations. "We've tried to get better handling, say, in a DES line, and there are some limitations in available equipment. It may handle a 1-mil dielectric layer, but it doesn't necessarily handle that 1-mil film when we remove 75% of the copper from it. So, I would say, from our perspective as a panel flex supplier, there are some limits in what's currently available to meet our requirements," says Nargi-Toth.

Automation Vision

How is automation, or the drive towards it, affecting the decision process in acquiring new equipment?

"In the EMS world and certainly in the military/aero and the medical side, your raw material expense is going to be around 60–70% of your revenue," says Turpin. "The number one expense, in our world, is raw materials. From an automation standpoint, you certainly want to be automated in terms of how you buy, plan and process your raw materials."

While direct labor is always important, Turpin says it's even more important to have a robust process that can make sure you have virtually no scrap. "You've got these $25–$40,000-dollar-apiece PCBAs running through your facility at relatively low profit, low contribution margin. You really can't afford to have any scrap. Your shift is focused less on labor to more on quality, reliability, and taking scrap down to zero. And, pretty much, rework down to zero, too, because you can't afford to hold onto these components for very long. You're more looking for velocity than you are efficiency on the

labor side. Having said that, you're always concerned about efficiency, but it's not like it was in the old days because labor, as each year goes by, is increasingly a smaller percentage of your spend. At least, in my world."

On the PCB side, especially in the flex area, Nargi-Toth says they look at automation as a way of removing the typical handling issues and increase product yield and production efficiency. "As Matt said, handling can sometimes lead to scrap. And while automation has its own set of problems, it is more controlled and predictable," she explains. "At the end of the day, handling is critical throughout the manufacturing operations. Removing handling-related scrap improves yields and in-turn that improves efficiencies and the overall competitive position for the company."

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"And just to amplify what Kathy just said, anytime that we introduce automation, it's more about reducing variability, and increasing quality, reliability, reducing scrap, than it has anything to do with reducing labor content," says Turpin. "So that would probably be the main message I can suggest. It's automation for reducing variability and increasing reliability, not reducing labor."

No Longer Customer Driven

The decision to acquire new equipment was once driven by customer requirements, but not anymore. At least, not as much as it used to be, according to Turpin.

"Take the three periods of an EMS: First is what I call the good old days, when you could just chug along with the same set of capital for a decade or more. The second phase after that was really when it wasn't, 'Build it, and they will come' but 'if you get a program, you get a customer, then you go out and you buy the capital equipment to support it.' Now we've moved away from that to where you really have to get out in front of it. Generally, you have to get out in front of it with a technology roadmap, with some level of R&D. Because by the time a customer comes in with an opportunity, even though the equipment lead time may be four or six weeks, to do a thoughtful evaluation process takes a lot more than that. The capex is around automating a process—you can't just introduce a new piece of capital equipment to your process without doing a thoughtful process development, and analyzing it, training, making sure that you followed your due diligence to introducing that new process. By the time you stack up all those activities, the customer generally is going to wait if you're doing it on a wait-and-buy basis.

Having said that, we have one customer relationship where we do share our technology roadmap. We do have visibility into their engineering groups, and we do get to see where their head is at in terms of what the next thing may be, so we can pull from that. So, it's not wetting your finger and sticking it up in the air to see where the industry is heading. We can be a little bit targeted from a customer-needs standpoint, but we don't always have that luxury."

Advice for Designers

For Nargi-Toth, the best thing designers can do is engage early. "They need to engage early with the manufacturer. We can help designers best when we are brought on early and become part of the project team. It is important because the designer together with the board fabricator and assembler should be assessing the manufacturing trade-offs associated with new designs. Many times, the designers do not fully understand manufacturing constraints and if they wait to address them after a design is completed it will lead to delays. Designers often use simple DFM analysis as a first pass, but this approach is not going to fully address

Matt Turpin,
Zentech Manufacturing

more complex products like rigid-flex and HDI constructions. In these types of products, the material set is going to play a key role in how the boards are going to process and yield for tight tolerance items such as Class 3 annular ring or wrap plating requirements. For more complex designs you need to understand and select materials correctly, and design appropriately. Designers don't necessarily understand the myriad of manufacturing challenges the PCB producer must navigate when they are evaluating materials based primarily on electrical properties."

Turpin agrees. "That would be my number one: Engage with a PCB fabricator. And, at a minimum, understand their pain and their process, and, in general, what they can and can't do. Because the problem nowadays with PCB design is that the barriers to entry for somebody to call themselves a PCB designer are so low. There are so many people out there as contractors. More and more, even large companies are moving toward a contractor model. There are some bad designers out there that don't know anything about PCB fabrication, they don't know anything about what the EMS company has to do, and they come out with some really, really bad layouts that are almost unproducible," he notes. "And the problem is, with a lot of the ways the contracting worlds work, by the time it comes to Kathy and myself, the design has been bought and paid for, and you've got a customer that really doesn't even know what it is they're dealing with. Then we've got to be the bad guy to tell them that, 'No, this really isn't going to work, and you've got to do this, this, and this.' And it slows things down. Or worse off, they just don't have the time and they just try to build it as is. Or they go to some other bare board supplier that isn't going to ask the right questions, and just produce something that isn't manufacturable."

One of the issues that challenges manufacturers like Eltek is how we as an industry approach prototypes, according to Nargi-Toth. "If we look at the North American model today, we see a high number of prototypes that are being built in relatively small domestic factories. The fact is that even if they are not in the best facility in the world, they can make one or two of anything and the design has been manufactured and is vetted as manufacturable. However, when you bring it to the production manufacturer they may say, 'We can't build this in production." And by this they usually mean, the tolerances are too tight, the yield will be negatively impacted and the material utilization on a standard panel is wasteful. Net result is the cost is going higher than predicted, or the board needs design modification and ultimately the customers' end target for time to market, price or both is missed. It's an important factor that can get missed when dealing with the prototype. It's best to work with a factory that can help you bring the product from design to market right from the start," she says.

Turpin notes that the problem in the PCB fabrication side is that when you're building prototype quantities, the manufacturability sometimes gets lost in the equation. "Because when you're buying one board or three boards, it's either going to cost you a lot or it's going to cost you a whole lot. If it's going to have a high repeatable cost, a lot of times it won't get caught until later," says Turpin.

"Right, and then when it goes into production, nobody wants to carry that poor design forward," says Nargi-Toth. "In the prototype model, you don't care what your yield is. You never track it because you're never going to see the part again. You make it one time and you're on to the next one. When it comes to production and you're going to be seeing the same part number every month, you can't live with a poor yielding design. That is what we try to avoid by early engagement with our customers."

Figure 2: Investing in equipment is essential to keep pace with the driving forces of ever-evolving technology. (Photo Courtesy: Zentech Manufacturing)

Communication

Nargi-Toth says that now, more OEMs and designers get in touch with them early on. "I would say we engage with the OEM in about 50% of our relationships. We do a lot of work directly with the OEM, especially on the medical side, because we work together with them through the FDA process. We help them to lock down materials and processes. For these types of projects, we are involved with the designers at the beginning," she says. "With flex and rigid-flex projects, the designer wants you to be involved early because they have a concept and often they need our help to figure out how best to get what they need on the board and get the board folded into the final package. It becomes a mechanical as well as electrical design project from the beginning, so we certainly can add value by our early involvement."

Turpin prefers to get involved from the beginning. "Last year we acquired a design service bureau, so we could have the scale and the toolsets to be able to do the layout on pretty much any platform. And that has worked, so the extent that we can get involved in the beginning, do the layout up front, and take care of all those issues and make the bare board fabricator's life easier, make our life easier, and generally make it up. We're reliable, cost-effective, with quicker time to market," says Turpin. "In some cases, the OEM will have their own engineers. And, generally, when they're doing their own layout—which is probably half the time if we're not doing the layout—our customer has a dedicated designer who knows what they're doing, and they will almost always look for input before they release the final package."

"In other words, to do one final look through a DFM and DFA to bring out any things that may have been missed or, particularly with the new package types, we always get calls from designers in our customer base when they are using a new package, in terms of talking about what footprint to put in a design. Because most of them are smart enough not to use the footprint that the manufacturer gives. They'll use that as a basis, but they'll always tweak it based on something. But it's not enough. I

wish it was 100% of the time we or somebody else could get involved. I would say 25–30% of the time we just get what we get, and we try to make it work."

There is a difference depending on if it is a commercial or military/medical application. "On the commercial side, it is more transactional. You may never meet the designer unless they have a problem and they may already be on Rev B or C. Unfortunately, the manufacturer is now coming in after the fact and trying to make changes, which is more difficult and wasteful," says Nargi-Toth. "But for sure, in some of the new programs in mil/aero, or in medical, we find often that the OEM already knows they need assistance, and they want to reach across the table and engage early. They have a history of positive experiences with collaborative efforts that have produced successful projects that were on-time and met the commercial targets and they want to build on this positive experience."

Conclusion

When it comes to making decisions on investing in new equipment for the factory, manufacturers should have some sort of an evaluation procedure, according to Nargi-Toth.

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"I think most companies do have a procedure when they evaluate new materials and new equipment. Obviously, they need to know what the end goal is for the equipment," says Nargi-Toth. "If it's a bottleneck fix, the leadership should come from operations and engineering. The decision is based on what is needed to improve productivity for one process or another. If it is technical development, advancing the process based on a current need that has already been identified then engineering and product development are tasked with developing the evaluation criteria. And if it is something that is needed for a next generation product following a roadmap such as what Matt talked about, the company needs to do some research to better understand what's out there today and what is being worked on and may be available in 12-24 months."

First, manufacturers must define what type of equipment they need and what they are trying to accomplish. Once that's done, it's time for a project plan to evaluate what's available.

"Even if we're talking about some of the simplest equipment in fabrication, we're talking $250,000. If I want to go out and buy a new automatic plater, we're talking about $5 million. It's a lot of money to invest, and you're not going to do it by just by running a few samples," says Nargi-Toth. "It all needs to begin with a project plan and a solid understanding of what the goals are for the new equipment. Once that has been established you can determine how you're going to evaluate the available technologies to make sure that you're making the correct decision and purchasing the right piece of equipment for your particular needs."

Turpin agrees. "Everything that Kathy said would apply to not just the EMS business, but, I would say, to any problem that anybody is trying to solve. Don't buy a piece of capital equipment unless you know what problem you're trying to solve, whether it's a technology problem, whether it's a process problem. Maybe it is an efficiency problem. Know what you're trying to solve, and then, whether it's your evaluation requirements with the capex supplier, share those goals with them and how you're going to evaluate it," says Turpin. "Certainly, for a project plan, make sure that you're checking for that, and in your turn-up of the process, that the problems you're trying to solve are the processes you're developing, and documenting, and rolling out during the

roll out of the new piece of capex. But, that said, from a high level, start with a problem in mind. Don't just start with, 'Hey, I need to buy a piece of equipment X, Y, Z.' Start with, 'I've got a problem, A, B, C. How am I going to solve it?'"

Finally, Turpin noted that, inasmuch as they want to be tightly integrated with their customers, he hopes that component manufacturers were as integrated with the automation suppliers. "To make sure that the things they're doing are integrated with the way of properly placing components, cleaning components, inspecting components, things like that."

Nargi-Toth says having an open dialogue with customers and sharing roadmapping activities is beneficial to both parties. "Because in doing that, we can use the information we gather from them to help direct our research efforts and it benefits the customers because we are better able to meet their future requirements," she explains. "So, if we do know that sub-1 mil lines and spaces will be a reality in implantable medical devices in the coming years, that's the direction we have to move in. And how we get there becomes an actual research effort on our part before we can even begin to go out and evaluate equipment. First, we must understand how we're going to get there. What's going to be the best way to get there? Can it be done subtractively or do we need to move into additive processing? That's the kind of thinking that keeps us always forward looking."

Every company has a roadmap Perhaps, a five- or 10-year plan. This underscores the need for communication in the industry, throughout the supply chain. Working closely with both customers and suppliers can provide vision and help determine when and what new equipment will be needed for a company's long-term success. **SMT007**

Researchers Demo Quality Optical Microstructures Using Lithium Niobate

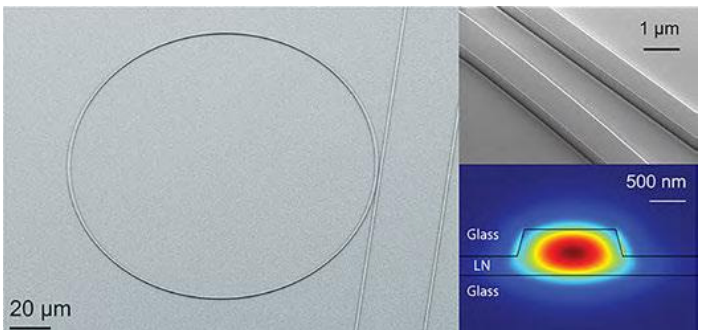
Researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) have developed a technique to fabricate high-performance optical microstructures using lithium niobate, opening the door to ultra-efficient integrated photonic circuits, quantum photonics, microwave-to-optical conversion and more. The research is published in Optica.

"This research challenges the status quo," said Marko Loncar, the Tiantsai Lin Professor of Electrical Engineering at SEAS and senior author of the paper. "We demonstrated that you can fabricate high-quality lithium niobate devices–with ultralow loss and high optical confinement–using the conventional microfabrication processes."

Most conventional optical microstructures are made using processes of chemical or mechanical etching. But lithium niobate is chemically inert, meaning that chemical etching is off the table. But the Loncar lab–which is known for their diamond work–has experience with tough materials. Drawing on that expertise with diamonds, the team used standard plasma etching to physically sculpt microresonators in thin lithium niobate films provided by the company NANOLN.

The researchers demonstrated that the nanowaveguides could propagate light across a meter-length path while losing only about half their optical power. In comparison, light propagating in the previous lithium niobate devices would lose at least 99 percent of light over the same distance.

The researchers aim to build on these results and develop lithium niobate platform for a wide range of applications including optical communication, quantum computation and communication and microwave photonics.



The research opens the door to manufacturing ultra-efficient integrated photonic circuits, quantum photonics, and more.