# Tracking the Ultrathin Trend

PCMCIA lead the way into creativity.

Jerry Murray, West Coast Editor

Itrathin PCBs complicate fabrication in terms of materials, imaging, exposure, solder mask application, lamination, and inspection techniques. None of these complications calls for fundamental processing changes, but simultaneously coping with all the fine-tunings and tweakings involved with ultrathins presents a challenge throughout the plant. And while the fabricator is trying to keep all the little processing balls in the air, he is also occupied with basic problems in handling the thin cores and producing a flat product,

The reason for all this activity is the exploding PCMCIA market. Some say that offshore producers already have the low-tech four-layer PCMCIA market locked up. Some say that U.S. fabricators remain well ahead of the world on the mid- and high-tech levels. Still others feel sure the dynamics of PCMCIAs are revolutionizing the industry. All agree that ultrathin fabrication isn't easy, hut it certainly can he done.

# Handling

Right at the start, a PCB maker advised, "You've got to train your people to always pick up thin cores by the corners, not the flats, so they won't buckle and take a permanent curl." An easy enough solution, providing that everyone handling the panels does so properly every time. Understanding how easy and expensive it is to create defects by mishandling makes the training easier; working with larger sheets, as at the laminate plant, makes it tougher.

Some sort of leader is universally used to get thin cores safely through develop/etch/strip lines lest the flimsy sheets become snarled in the rollers. The simplest form of leader consists of a piece of rigid laminate taped along the leading edge of the panel. Purveyors of both horizontal and vertical DES equipment, Gary Slagle and Jerry Hayhoe of Circuit Image Systems (Orange, CA) arc adapting a mesh carrier used in chemical milling to convey panels through vertical lines. For now, however, they recommend horizontal wet processing for panels that are less than 5 roils thick and that have less than 1 oz. of surface copper.

But horizontal equipment doesn't automatically solve ultrathin processing problems. "Unless you tape the material to a bottom carrier, " says Slagle, "the thin cores undulate on the rollers, forming puddles along the board and exposing the edges of the circuitry to more pressure, so small nicks end up as opens. Even when carrier sheets are used, the topside pressure should be reduced from the normal 25 to 30 psig to 10 or 12 psig. The carrier should be rigid substrate with the copper etched off, 15 to 20 roils thick, usually two inches larger than the panel, so the edges of the work can be taped to it. The tape seal is important. No seepage can be allowed. It's a pain, and it involves a lot of handling, but the carrier gets the job done and reduces defects."

Ultrathin substrates are available with a carrier sheet applied by the manufacturer. The carriers are usually made of aluminum, which can be either etched away or peeled off after develop/etch/strip. Even starting out with this type of material, the fabricator must tape his own carrier sheet to protect the initially processed side.

Data Circuit Systems (San Jose, CA) uses a transport rack designed by Mike Berg, the company's production manager, to hold thin cores upright through plating. The rack attachments are entirely mechanical, because the plater's tape could leach out contaminating chemicals during plating. According to sales manager Mike Kadlec, the transport rack is a key to Data Circuits' success in building six-layer, 18-mil-thick and eight-layer, 24-mil-thick PCMCIAs. "It's a single-layer system, routed from material common to every board shop, that doesn't transport dragout while it holds the work taut, preventing wander and flexure." To eliminate the oxide process and increase adhesion, Data Circuits Systems uses double-treat laminate for its ultrathin boards.

High-volume producer Advance Circuits Inc. (ACI, Minnetonka, MN) turned to Amtech (West Jordan, UT) for a custom handling system. Robotic devices deliver thin cores to Primecoat imaging and take them out of the imaging process and into vertically racked carts for transport to exposure. There the cores are returned to the horizontal mode for exposure, develop/ etch/strip, and post-etch punching. According to ACI engineer Paul Berndt, the Amtech system was installed without a hitch, has been working well for almost a year, and readily handles 2-mil cores.

Cray Research (Chippewa Falls, WI) is so far along on the ultrathin evolutionary ladder that it considers 1.5-mil core thick. The company, as a lowvolume producer, does its handling in-house. Plater's tape holds the thin cores to specially designed frames used to transport ultrathin through develop/etch/strip, and mechanical frames hold them flat and taut during plating. Easily loaded and unloaded, the mechanical frames involve less labor than taping but, according to senior R&D engineer Paul Schroeder, "They take up enormous space." Backing material is ordered on the special ultrathin substrate that Cray developed in cooperation with W. L, Gore Associates ( Newark, DE),

## The Materials

Now offered as a standard material, Gore's Upalex is a cyanate ester-filled product with a Japanese-made nonwoven PTFE-base. The material is designed to be more chemically and dimensionally stable than flex substrates of similar thickness. Only 0.8 mils thick, its use enables Cray to mount two hundred 384-pin ICs on a 64sq.-in. PCB. According to sales engineer Bill Wachal, Gore's high-dielectric ultrathin are collectively referred to as Gore-Flex. They are built on a polyimide or Kapton core material with thin layers of Gore Tek, copper foil, and aluminum backing material on each side.

The tight economics of PCMCIAs keeps their makers largely constrained to FR-4. Laminate manufacturers cite a few handling problems with thin cores, but none complains about meeting the increasing demand for ultrathin products. Wil Gonzales, technical representative for ADI/Isola (Fremont, CA), relates, "When I was with Synthane-Taylor many years ago, we got a big order for 3.5-mil core, and at the time it created terrible handling problems. The plant manager fought tooth and nail not to have to make it. But of course we did." Gonzales says that ADI/Isola's production of laminate down to 1.5 roils is now routine, and users report that the consistency of the product has helped them in manufacturing PCMCIAs. Today at Synthane-Taylor (La Verne, CA), President Nick Riman credits sophisticated treaters and process control with enabling the consistent production of ultrathin stock.

Dave Iguchi, technical service director for Nelco (Fullerton, CA), says that today's increasing demand for ultrathins has not changed the company's manufacturing operations. "We've been using vacuum lamination for a long time, which makes it easier to produce smooth, flat substrates on which 3-mil lines and spaces can be formed. You have to take care in keeping thin material stiff and separating it from the caul sheets, but the handling from there on is the same as 5-core. The real handling problem with thin cores occurs when the customer etches off copper and it loses its rigidity. It's particularly difficult to oxide the thin core material. It's like putting pieces of paper in water and watching them go limp. Consequently, the use of double-treat has significantly increased.

"How thin can it get? Getting down to 1.5 roils brings up issues like the copper tooth profile," says Iguchi. "If the copper tooth profile is 0.2 to 0.3 roils on either side of 1.5-mil laminate, it's conceivable to have less than 1 mil of dielectric. Laminate manufacturers don't want to get involved with the problems of using rolled copper, so we're working with low-surface-profile ED copper foils with good bond strength."

Kelly Nottingham, multilayer product manager at GE Electromaterials (Coshockton, OH ), immediately cited handling as the main problem area with ultrathin. The high Tg and low dielectric constant of the company's Getek, says Nottingham, was aimed at making the material especially suitable for manufacturing ultrathin boards with controlled impedance.

AlliedSignal's (La Crosse, WI) product manager Jerry Bouska says, "The thin multilayer marketplace is rapidly changing because of PCMCIA applications that are making PCB fabricators develop new handling and processing techniques for thin materials. Three improvements that board manufacturers want in an ultrathin laminate are better dimensional stability, smoother product for small feature definition, and better thickness tolerance. At every level, the ultrathin marketplace is very competitive, and yet it may be some time before standards are written for the PCMCIA laminates. This may lead to extensive diversity of available materials that won't support the need to control costs. "

### Processing

Although punches and excimer lasers would seem ideal for ultrathin holing, mechanical drilling remains the process of choice. The problem with punching thin cores returns us to the handling issue, as the flimsy material needs broader support than is offered by punch press platforms. The sagging problem has also been encountered in post-etch punching. Multiline Technology (Farmingdale, NY) addresses this issue with solid platforms on new machines and by retrofitting existing machines with fill-in supports for the open areas of the platforms.

Peter Cholakis, operations manager at Resonetics (Nashua, NH) reports that ultrathins have aroused new interest in excimer laser drilling. The company's micromachining center uses these lasers to ablate holes in sample boards sent by prospective customers. Masks or lenses are used to simultaneously micromachine large numbers of holes in prototype runs of 4-mil core and thinner that the fabricator can process into finished products. The company's systems are said to have an uptime of more than 94% and a hole-to-hole repeatability of 1 '%. They call also double-duty as repair tools for shorts.

Liquid imaging presents no problem in thin-core manufacturing—providing the equipment used applies the liquid with even pressure on both sides of the work at once. The Burkle USA (Newport Beach, CA) DCR roller coater processes product at the rate of 200 panels/hr. before delivering the coated panels to springloaded clips that carry them through an IR-curing oven. Circuit Automation (Fountain Valley, CA) demonstrates the ultrathin-coating capabilities of its DP-10 double-sided screening machine by applying LPISM to both sides of a sheet of 1-oz. foil. And the double-sided screeners distributed by Otto Isenschmid Corp. (Plainview, NY) perform similarly on thick or thin work.

One PCMCIA fabricator said, "We electrically test every panel because we had too many false defects with AOI." Hadco's (Salem, NH) Greg Blake explained, "AOI inspection of very thin cores can be influenced by patterns on the other side of the panel. It's a matter of choosing the right AOI technology. Double treat, for example, causes huge problems with reflective machines because there's not enough contrast between the copper and the laminate. Fluorescent machines handle double treat just fine. Sometimes parameters should be changed. Slowing the dynamic response, for instance, reduces the chance of inadvertently inspecting both sides at once. "

Some say that ultrathin boards can't be hot-air solder leveled without the occurrence of some warping, and that nonthermal finishes such as organic coatings or immersion gold must be used for PCBs of less than 14 roils. Odi Cardenas, president of Solder Station One (Santa Ana, CA), says that isn't so. "We've been solder leveling very thin boards for years. With our vertical equipment, we put them in a frame. For horizontal solder leveling, we put a leader on the front edge and a little trailer on the end."

### Warping

After pointing out that problems are inherent with any rapidly emerging industry, GSS Array's (San Jose, CA) Vice President of Technology Rich Freiberger said, "Finding solutions is inherent to our operation. One recurring problem is warping during reflow, but we don't blame it on our substrate fabricators, because we understand they too are making products whose parameters are still being defined. We anticipate some warpage and compensate for it by singulating the panels and running them two-up in a transfer frame through assembly.

"We know that boards can be designed in ways to reduce warping," Freiberger continues, "but that's in the hands of the OEMs. We know that new specifications are needed for PCMCIAs, but we don't write specs. Our equipment suppliers are saying, 'Wait, you can't screenprint or pick-and-place with our machines because they were developed and built around the 10-mil warpage IPC standard.' It may take five years to rewrite the specs, and we have to work with the components, equipment, and market we have today." Like its board suppliers, says Freiberger, GSS Array is somewhere in the middle of a technology that's turning into a big business much faster than anyone expected. "All we can do is solve this week's problems while we keep on manufacturing reliable products that work," he concludes.

Warping doesn't usually raise its head until reflow. The solution to the problem, however, is being sought as far upstream as one can go. In the case of the GSS Array product, for example, Nelco is supplying the company's major PCMCIA board fabricator, Diceon (Santa Ana,

CA), with different resin systems and a UL-approved version of Nelco-2 with a Tg of 180°C; Diceon is working with different lamination cycles; and GSS Array is feeding back the results of its warpage tests.

"The PCMCIA industry is growing so fast," says Bryan Fuller, Diceon's new product development manager, "that all the subtle problems it imposes make my job more than a little stimulating. We started with a fourlayer, 24-mil-thick board. Now we're doing six-layer, 18mil-thick boards and are working with eight-layer boards with blind and buried vias. The root of the problem is volumetric constraint. The PCMCIA defined a card of a certain size format, and with the basic configuration locked in, it has hundreds, even thousands of new applications. This is causing everyone to become very creative from a packaging standpoint.

"Problems always go hand in hand with creativity," Fuller continued, "but none of the problems with ultrathin board fabrication is fundamentally inhibiting. They all involve fine tuning. How do you support parts during solder masking, for example? How do you minimize light bleed-through during double-sided exposure so you don't expose both sides? UV blockers? Nonwoven substrates seem to work better, but they cost more, and this business is so competitive that you've got to solve problems at no cost. Layer-to-layer registration is a problem because 2-mil panels tend to float around a lot," says Fuller, "but we're handling it.

"Ultrathin processing," he says, "will bring about a fresh look at the specifications covering copper in holes, board finishing, and many other aspects of fabrication. In the meantime, we'll continue to work the issue with our material suppliers, our construction methods, our customers' feedback, everything."

Everything includes design, and as Slagle said, "Designers, now more than ever, have to be in touch with the fabricator. More cooperation, more interface is needed as the PCMCIA market grows."

Iguchi agrees: "You want every break you can get from the manufacturability standpoint. If you can get that from the designer, that's great. But," he adds, "the designer can only go so far in terms of balancing real estate between functional circuitry and manufacturability. Sooner or later board fabricators are going to have to learn how to handle thin core. They'd better get familiar with thinner materials for PCMCIA applications, because these are the same materials and thicknesses that are going to be used for making the high-tech boards of the 1990s. In short, smart cards represent the entry technology for MCM-Ls."