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FLEX Circuit Manufacturing in a Box?

Inkjet printing may finally bring flex circuits up to speed.

by TOM WOZNICKI

There is a buzz in the flex industry about a new manufacturing technology for making high volume, dirt-cheap flexible circuits with copper conductors. The technology is still in its early stages (it has just recently come out of the lab) but many folks a lot smarter than me feel that this is a winner. Let's take a look.

Conductive Inkjet Technology (CIT) has partnered with equipment manufacturer Preco Inc. to create a method for making flex circuits using inkjet printing. CIT claims that it can make flexible circuitry with features down to 50 microns at speeds better than 30 feet per minute on a 6″ web.

Printing flex circuits is not new. Screened silver ink on polyester circuits have been around a long time and are widely used in commercial applications such as keyboards, calculators and disposable medical applications. So why is this a breakthrough technology?

Well, rather than suspending superfine metal particles in an ink or paste, CIT has developed a way to print the ink first and then metallize it. Apparently, because metallization happens in a separate step, manufacturers can use inkjet technology instead of silk screening. As a result, there are no worries about metal particles clogging up the printing operation.

FIGURE 1. Copper circuits on treated PET, created by inkjet.

In fact, this process does not use any particles at all. The ink that is initially printed onto the dielectric film is a catalyst. After the catalytic ink prints the non-conductive pattern on the film and is UV cured, it is immersed into a solution to activate the permanent catalytic portion and wash away a sacrificial portion. The circuit is then passed through an electroless plating bath to create a copper deposit thickness between .050 microns and 5 microns.

Not only will this process work with copper, but also with silver, gold, nickel, cobalt and other alloys. Treated PET, polyester or polyimide can be used as a dielectric material. See FIGURE 1.

As cool as the inkjet technology is, I also like what Preco has done to incorporate the printing, curing, metallization and plating steps into one machine – the MetalJet6000 (FIGURE 2). On one end you feed in the roll of dielectric material and out the other end pops real copper conductor patterns ready for finishing. It's almost flex circuit manufacturing in a box.

But as always, there are the pros and cons to any technology. Here are a few of each, in my opinion:

Pros. This technology eliminates many processes normally associated with flex circuit manufacturing. The conductor pattern is generated by software, so there is no plotted artwork to deal with or photoresist to develop and strip.

Another benefit of generating the conductor pattern with software is that the machine can incorporate small batches and prototypes with high volume production – the machine simply prints a few feet of the new circuit and then goes back

FIGURE 2. The Preco MetalJet6000 incorporates CIT's flex printing concepts.

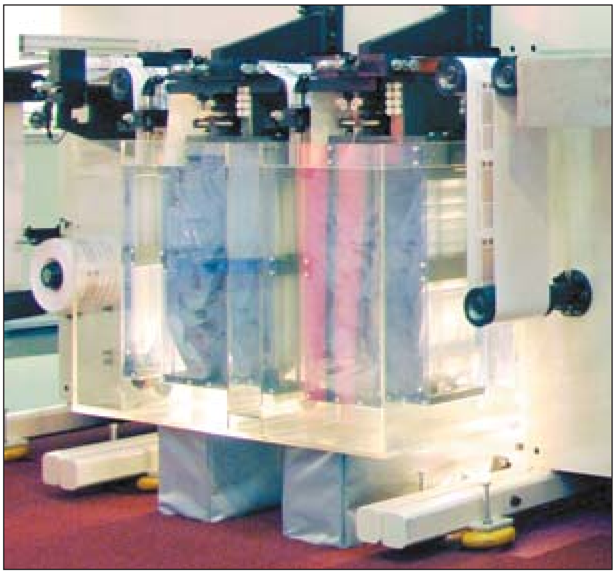

FIGURE 3. A close-up of the MetalJet6000 metallization and immersion plating tanks.

to high volume production.

While there is still some wet processing in the metallization and immersion plating (FIGURE 3), this technology does not generate the humongous volumes of wastewater and sludge that common etching creates. The finished conductor patterns come out RoHS-compliant; as long as the finishing operations are also RoHS-compliant, you will have a "green" flex circuit.

Finally, you get honest-to-God copper conductors. While the conductivity is not quite what you get from RA copper, the conductor pattern is solid copper that you can solder on. If the circuits are printed on a high-temperature film, such as polyimide, the company says that the temperature limit is 220°C, well within the range of many lead-free solders.

Cons. As mentioned previously, the thickness of the copper is very low – this stuff will never replace good old 1 oz. RA copper, although it still has sufficient signal-carrying capacity for many applications. The possible copper thickness, between .050 microns and 5 microns, depends on how long the circuit is immersed in the electroless plating bath. If more thickness is needed, the least amount of electroless is a good seed layer for electrolytic plating up to the required weight. However, with no dielectric or plating resist between the conductors, the copper will plate sideways as well as vertically. The circuit could start losing trace definition if left too long in the plating solution.

With that said, the conductivity of these circuits is much better than any screened silver ink circuitry. Not every application needs 1 oz. or .5 oz. copper, and some applications actually prefer a very thin copper layer. RFID is a perfect application for this technology; heater circuitry is another.

A feature that I'd really like to see in the MetalJet6000 is the capability for applying flexible soldermask or coverfilm. As the machine is currently configured, this must be done in a separate operation on other equipment. The Preco folks recognize this too – after the basic MetalJet6000 machine is in production, Preco intends to introduce their camera vision registration capabilities to the web path. Once that is done, CIT and Preco will be able to add lots of add-on capabilities, such as inkjet printing of solder masks, FlexStar UV laser microvia hole production, etc. This will make double-sided circuitry and multilayer HDI possible. Preco also looks to integrate their Inline Registered Lamination technology, which would make web-to-sheet and web-to-web lamination possible.

If CIT and Preco are successful in bringing the MetalJet6000 and add-on equipment into volume production, could it cause widespread industry change for single-layer flex-to-install circuitry? Possibly, especially for any application that doesn't require high-current capability. As a flex designer, I am particularly interested in seeing flex cycle test data for a circuit produced on polyimide that has a polyimide coverfilm. If such a circuit can survive several thousand flex cycles there are many applications that would benefit.

At this time it's not clear how CIT and

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Preco will bring this technology to the market. Rather than sell the MetalJet6000, would the two companies create a separate entity that will manufacture finished flex circuits using this inkjet technology? It would certainly make sense, since the equipment can easily handle both small batches and high volume. Such a pilot operation could create circuits for evaluation and also produce significant volume. After that, who knows: maybe build a larger plant, or perhaps sell the machines to other companies?

If the two companies do sell the equipment to other companies, it leads to another interesting thought. Could this "flex manufacturing in a box" concept enable OEMs or contract manufacturers to do their own flex circuit manufacturing? If flex circuitry were a key component of your product, it would certainly be worth doing a cost/benefit analysis to determine the payback period.

It should be interesting to see what happens with this technology in 2006. Flex printing may be getting up to speed. PCD&M

TOM WOZNICKI is president of Flex Circuit Design Co. He also publishes *The Flex Circuit News*, a newsletter about the flex circuit industry, available at www.flexdude.com. He can be reached at tom@flexdude.com; 408-629-8343.