当发现电路板设计的问题时，大多数企业会选择重新设计。“加成电路板”(additive circuit)相信是较便宜和更简洁的方案。“网络电路板”(web circuit) 概念要求在焊盘之间、元件之间和导通孔中安装铜迹线 - 基本上，任何需要互连的地方。该工序的成本只是重新设计的几分之一，返工的电路板可于一天内完成。整个工序符合RoHS的规定。“网络电路板”也可解决其它方法未能解决的电气性能问题，如需要已知或可预测的电气性能时。

‘Web Circuits’

Mike Buetow

Avoiding re-spins is made easy and economical through a novel additive process.

A large network systems company had a single prototype PCB to prove out its design change before re-spin and ordering new prototypes. However, the change required traces connected to BGA pads under the device to be brought out and new SMT pads installed.

- One of North America’s largest electronics firms has production scheduled with its Mexican EMS provider and 6,700 RoHS PCBs are in the supply chain. Traces and SMT pads need to be added and reliability is a major concern.
- Another major company has five boards with OSP finish requiring four additional components and the boards.

While most companies in these situations would opt to re-spin the design, cost and time often make that a gut-wrenching decision. Laconia, NH-based Additive Circuits (additive.com) believes it has a less expensive, more elegant solution.

“Web circuits” are the brainchild of Art DesMarais, founder of Additive. His concept calls for installing solid copper traces and SMT pads between existing pads, vias and through-holes – basically, anywhere an interconnection is needed on the unpopulated board. The process, he says, costs a fraction of a re-spin and reworked boards can be turned around in days.

Avoiding the re-spin starts with the Gerber files and engineering change orders. Although Additive works only with bare boards, the company provides customers with a range of known design rules, everything from conductor width and spacing to the eventual component placement soldering operations. “We’re concerned with the assembly, the compatibility with it,” says DesMarais.

Once the CAD files are in place, unwanted traces are deleted and designated pads are isolated, including inner-layers. Then comes the web circuit process. The “web” starts with 1 oz. electrodeposited copper foil that conforms to IPC-4562. The foil is mechanically etched into the shape, length and width of the to-be-installed traces. This is also where the web circuit gets its name. “The circuit is held together with tabs,” explains DesMarais. “If the tabs were broken, it would fall apart, like a spider web.”

The process can add circuits on outerlayers, but also can perform etch cuts on innerlayers and pad isolations. Mechanical end-mills with computer x,y and z control are used for cuts, which DesMarais finds faster and more cost-effective than lasers.

Next, an isolation layer made from B-stage epoxy

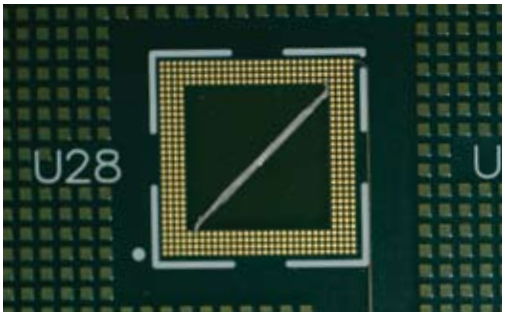

Figure 1. Used to avoid design re-spins, Web circuits can connect BGA pads …

is added. The web circuits are fabricated and applied to the board. Circuits are aligned to the isolation layer using registration pads created from the PWB Gerber file and based on the size and shape of nearby lands, "so that when it's optically aligned, we know all the circuits line up," DesMarais says.

Once the circuit is registered atop the B-stage isolation layer, the board is exposed to a mild lamination process, involving sufficient heat, time and pressure to partially cure the material and flatten the circuit, with the epoxy adding adhesion. At this stage the actual cure is about 45%.

The material – a one-part epoxy with insulation resistance of about 1000 volts per mil – serves as an insulating layer. The temperature of the board itself never rises above 280°F, and is heated only for a few seconds in order to limit the thermal excursions.

Next, paste is either dispensed or printed, and the pads and terminations are then touch-soldered. Soldering is performed with an iron, although Additive is studying the use of automated soldering equipment. The solder used matches the customer's specifications.

Inspection is performed using a video inspection system, and continuity test is conducted on all etch cuts, and "anything nearby," including innerlayers.

The final step involves a line solder mask, which is heated at 275°F for 45 minutes – about 80% of the necessary cure and well past the point of tackiness. (The remaining polymerization will occur during assembly.) Final PWB finishes can range from OSP to gold, HASL, or immersion silver or tin.

The entire process meets RoHS requirements, DesMarais says. "Everything we use is compatible. In our RFQ, for example, we ask about the solder paste, and use the same or a compatible version in order to meet the requirement." And aesthetically, the ECOs to the reworked boards are hard to detect (**Figure 1**).

Additive is gaining traction with EMS companies looking to expedite time-to-market or where re-spinning can't occur, such as with continuous flow manufacturing, he says. "You could redesign and wait and spend and wait and spend," says DesMarais.

Web circuits can resolve electrical performance issues, such as when a known or predictable electrical performance is needed that other alternatives would not resolve. For instance, he says, "when your application calls for timing – jumper wires won't do that; and polymer ink is limited in terms of surface finish, and is lead-containing." Web circuits also have been used where wires can't go, for example, under a BGA and connecting to microvias. Another use is inventory control.

Today, Additive has capacity to rework orders "from a single board to the tens of thousands" of boards using the web circuit process, DesMarais says.

Down the road, Additive's business model calls for a number of "completion centers" located in strategic spots around the world. Using overnight couriers like DHL, DesMarais says, "We can put up to 500 web circuits in a letter pack and ship them anywhere." The completion centers would be staffed with a handful of employees who would perform final assembly and delivery. DesMarais envisions centers along the Mexican border, in Eastern Europe, the Asia-Pacific and South America. The web circuit technology would remain in the US, he says. However, the CAD files could be sent to the centers so tooling could begin immediately.

And thus, Additive's web circuit technology would truly envelop the globe. ■

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Figure 2. … Through-hole and microvias …

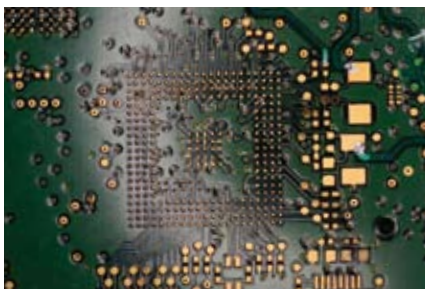

Figure 3. … And resolve timing and other electrical issues that jumper wires cannot.