Printed Circuit Plating Technology Update From the IPC Printed Circuits Expo

By Dr. James H. Lindsay, AESF Fellow, AESF Technical Editor

The IPC (Association Connecting Electronics Industries) held its annual IPC Printed Circuits Expo at the Long Beach Convention Center in Long Beach, CA, March 24–28. Those who made their way through the barriers, fencing and bleachers being set up for the race course for the 2002 Toyota Grand Prix of Long Beach on April 14 (Michael Andretti won it), learned of the latest developments in the printed circuit industry, through an industrial exhibit, day-long short courses and a comprehensive series of technical sessions.

Among the 15 technical sessions were two related to plating—one entitled, "Improved Processing Techniques for Today's Plating Needs," and the other, "Plating: Taking Its Pulse." What follows is a summary of what was said by the eight speakers who participated in these sessions.

Improving Distribution For Small PCBs

The common thread in the first session was the need for improved distribution in the ever-shrinking features in printed circuit boards (PCBs). These include blind micro-vias as well as through-holes.

Traditionally, the copper plating of PCBs uses soluble copper anodes with everything oriented vertically. A major shift in thinking has come to the forefront as lines with a horizontal orientation, using insoluble anodes, become successful. M.J. Niksa (ELTECH Systems Corp.) and several co-authors discussed these new systems in their paper, "The Use of Insoluble, Mixed Metal Oxide Coated Titanium Anodes to Improve Quality and Decrease Plating Times for Circuit Boards." They compared the performance of soluble and insoluble anodes, and reported that a fixed and closer PCB-to-anode spacing led to improved current distribution and throwing power. The ability to get the copper into through-holes and blind vias was enhanced. With soluble anodes, the current efficiency within blind vias tended to drop off as the current density was increased. This drop-off was not observed with the insoluble anode systems. The authors also noted improvement in copper ductility with this emerging cell geometry. The economics seemed favorable, as improved throughput, decreased maintenance, and potential for more boards in the tank were noted.

As printed circuit boards have evolved in complexity and the various features have decreased in size, the ability to get the metal into through-holes and blind micro-vias in sufficient quantities with the necessary deposit quality (no roughness or burning) has been a major challenge. Bert Reets and Stephen Kenny (Atotech Deutschland GmbH) considered this issue in "The Influence of Fluid Dynamics on Plating Electrolyte for the Successful Production of Blind Micro-Vias: Laboratory Investigations Leading to Optimized Production Equipment." Mass transport is one of the keys. The authors outlined the methods they used to assess the ability to plate into micro-vias in the laboratory, and how they implemented the results into simulated production equipment. Here, they considered both horizontal and vertical orientations, each with insoluble anodes and reverse pulse plating. They looked at conventional flooding, flat spray nozzles, spray hoods and tangential flow. In a horizontal cell, a flat spray set perpendicular to the panel, improved results were obtained at current densities up to 10 A/dm^2 (92.9 A/ft^2). Improvements with vertical cells were more problematic, but the use of flow eductors in the tank showed promise.

There are many paths to improved mass transport for copper plating of PCBs. Richard Menini (Industrial Materials Institute, NRC) and Joël Fournier (Centre of Chemical Process Studies of Québec) discussed the use of ultrasonics in "Use of Ultrasonic Agitation for Copper Electroplating, Application to High Aspect Ratio Blind Via Interconnections." They noted that, besides solution flow problems, entrapped air bubbles also are a major hassle. Specifically, they found significant improvements in plating into blind vias, about 36 percent having a diameter of 6 mils and aspect ratios between 1.25 and 1.5. A more drastic 75-percent improvement in throwing power was found for 4-mil-blind vias with aspect ratios of 1.9 and 2.4. The surprise was that these improvements were accomplished with ultrasonic energies of about one order of magnitude less than those normally used in ultrasonic cleaning operations, ranging from 0.5 to 2.1 watts/L (2.0 - 8.0 watts/gal).

In addition to the papers on horizontal cells, improvements in vertical cell technology were given their just dues as well. S. Hashimoto (Uyemura & Co.) and his colleagues presented information on "Vertical, Continuous Plating Equipment for Printed Circuit Boards." He described newly developed equipment designed to improve thickness distribution and accommodate varying sizes of circuit boards passing through the system. The boards are transported through the line continuously and use no conventional racks.

In "Accelerating Plating Cycles and Reducing Costs: Improving the Plating of High Aspect Ratio Holes & Blind Vias,"

James Taylor (Duratech Industries) discussed a unique approach to assuring proper initiation of the copper deposition and enhancing uniformity. He noted that accepted practice involves *activation* of the cathode surface prior to start of plating. Here, he looked into the opposite approach (*i.e., passivating* the substrate). Intuitively, one would envision that adhesion problems and massive exfoliation would ensue. Taylor has not found this to be the case, however, and reports increased throwing power in low-current density areas and improved bonding. In his process, he produces a hydrophobic layer on the surface that , like traditional activation, removes the natural oxide and prevents it from recurring. Something is left behind, however, in the form of an "extremely dense polymeric structure, probably not more than two or three molecules thick." Beyond circuit boards, he has found success with nickel and cadmium on steel.

Plating with Pulse Waveforms

The second session, cleverly named "Plating: Taking Its Pulse," dealt with—what else?—pulse plating, a subject that has been of interest for decades in various segments of the industry, but truly seems to be here to stay for the long term. Here, the underlying theme addressed the fact that the various features on PCBs came in many sizes and aspect ratios, and a single pulse waveform could not necessarily fill them all uniformly or satisfactorily.

Dr. Jenny Sun (Faraday Technology) and her co-authors gave a talk, "Electrically Mediated Pulse Reverse Copper Plating of Electronic Interconnects without Brighteners/Levelers." In it was described a process for plating interconnects for advanced electronic modules. The premise was that "electrically-mediated" pulse-reverse copper plating can ultimately allow quality plating without organic additives—a "Holy Grail" to many if there ever was one. She described how specific pulse-reverse waveforms can be applied to specific geometric features. For example, a relatively longer, but shallow reverse current pulse is favorable for improved throw into plated through-holes and for effectively filling micro-vias. It would seem that one could someday "dial up" the plating waveforms to match the geometries and aspect ratios.

In the same vein, Enrique Gutierrez (TecNu, Inc.), in his paper, "Beyond Periodic Pulse Reverse," discussed the sequencing of a series of waveforms, with each element in the sequence specifically keyed to a particular artifact geometry. Feature "A," therefore, could receive proper throw and distribution with a waveform appropriate to its geometry. Once this was taken care of, feature "B" would be attended to with a second waveform appropriate to its geometry. And the pattern continues. Not only is it no simple DC anymore ... it doesn't appear to be simple pulsing anymore either.

M. Chu and C.W. Seo (CSS Technologies) gave a paper entitled "Use of Modulated Current Technology for High Performance Pulse Reverse Plating." The authors addressed the problem of having several sizes of holes in a given circuit board. A given pulse-reverse waveform could plate well in one size of hole, but do poorly in others. In this paper, the authors discussed a controller that generated complex multiple waveforms to overcome these geometric problems.

The subject of electroplating was well addressed at the IPC Printed Circuits Expo. The trends pointed out were in the areas of cell designs and tailored waveforms, addressing the increased geometric challenges of the features being designed into PC boards. ***P&SF***