PulsePlating



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To PCB or Not to PCB ...

I may be wrong, but I think Hewlett Packard's Stan Bamman built some of the first early '60s printed wiring boards by plating silver on Bakelite. Stan, rest his soul, spoke at our Santa Clara Valley Branch "Old Timers' Night" several years ago (check "Branch News," Dec. '96 or '97 issues of *P&SF* for details). Nearly 40 years later, we have multilayers, chips on boards, etc., and years from now we'll have multilayered chips on multilayered boards—who knows?

Advancing the design complexity stretches the plating limits of blind hole and through-hole dimensions. Hole diameter vs. panel thickness (aspect ratio) generally dictates plating parameters. It's not that they can't be plated—the problem is uniformity of plating. The geometry around the hole and panel edges tends to build owing to primary current distribution. If this is not addressed, the plate builds to seal the hole, regardless of panel thickness, etc.

In a review of adopting pulse plating and obtaining half the plating time with lower consumable costs from plate and etch,¹ adoption is driven by the technological need of better copper thickness uniformity. When this can occur at the surface, the result is better etched line width uniformity for circuits using finer lines. Meeting impedance control requirements while enabling very fine lines in a subtractive process is sufficient justification for technological investments.

Chemistry

One way to deal with surface uniformity is by use of specific chemical additives that block high current density (HCD). Some organics work by abstracting hydrogen and then locally pi-bonding, while other hetero-atomic-organics by specific surface adsorption to the HCD growing crystal edge. Synergistic influences allow lesser concentrations at ideal combined ratios. Electrolyte chemistry also involves viscosity, conductivity, anodic decomposition, etc., and need not be discussed here.

Reverse Pulse

Plating through the holes evenly has been accomplished by incorporating current reversal. Typically, 20:1 at 3:1 has been found generally useful.² This means that after 10-20 msec of plating, a reverse current is employed for one-half to one msec at two-andone-half to four-and-one-half times the forward plating current density. The edge overplate is thereby removed by anodic etching. This is done with only 10-15 percent of normal two-part additives (or variants) for the right grain growth for plate properties of elongation, ductility, etc.

The benefit of running at 85–90° F extends into regions of 60–100 ASF for 25–50 msec, with reverse ranges of 200–600 ASF anodic for 1.5–2.5 msec, assuming you're using an inert anode of titanium, tantalum and iridium oxides. (*Note:* Anomalous erosion of solely iridium oxides has been observed.)

It is recommended to use pulsing to initiate plating over palladium/sulfide direct metallization. Also, Hull cells won't work for evaluation. The use of CVS or RTA is required. A current review of reverse pulse is given in *Galvanotechnik*.³ One may characterize this as an electroforming technique.

Complex Waveforms

A published report,⁴ matched rectifiers with chemistries to shoot out holes of aspect ratios up to 18.5:1, with success to 13:1. Though each power supply was matched with each additive package, an easy winner used the complex waveform. This particu-

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lar waveform was not published in the article, but was offered to me for evaluation.⁵ It will not, however, be published here. It is of a pericyclic degenerate form with a reverse component always immediately preceding the forward. Trains of three or four forward/reverse waves terminate with the last reverse voltage component about three times the magnitude and time of prior reverses. Also, the beginning forward pulse after the final reverse "spike" is either the same as the rest $(^{2}/_{3}$ of the time) and followed by one 30-40 percent higher in amplitude, or the highest in that train (1/3 of the time).

Simple Solution Movement

As holes get smaller with increased panel thickness, solution flow through holes becomes an issue. The need for more uniform flow over the surface and through the hole is somewhat forgiven by pulse and reverse for forced convection. There is a need for optimized eduction for surface replenishment of electrolyte (experiments in progress). After all flow parameters are optimized (and electrolyte requirements satisfied), one can optimize the specific chemical additives mentioned above, which block HCD overvoltages. At this point, when all is optimized to deliver the best plating speed, wave design parameters may be incorporated. A review of high-aspect ratio platedthrough-holes can be seen at http:// www.finishing.com/Library/ cuthrow.html. The classical papers on throwing power are listed in Ref. 6, 7.

Surface Design Engineering

Elaboration of modes of current (or voltage) manipulation to effect desired surface characteristics is beyond the scope of this month's column. Suffice it to say that when the design of waveforms is not limited by the pulse power supply, electrochemical manipulation of the local and peripheral surface micro- and macro-geometries, integrated within a window of optimized electrochemical reduction parameters, opens a realm of surface designs. Again, real-time through-hole plating distribution feedback (not currently achievable) could substitute for *a priori* testing. Using both could automate all plating requirements for users, but this pipe dream is becoming more a reality, albeit slowly.

Progress is marked by presentations forthcoming in the Fifth International Pulse Plating Symposium, which will be held June 29 and 30, in conjunction with SUR/FIN[®] 2000 in Chicago. Particular topics include:

- Modeling the Current Distribution Over a Wire Electrode During Copper Pulse Plating
- Microstructures in Pulse-Plated Copper
- Pulsed Current Usage for Printed Circuit Board Production
- Is Periodic Pulse Reverse the Right Copper Plating Technology for Your PCB Manufacturing?
- Complex Plating of Copper for the PCB Industry
- Charge Modulated Electrochemical Deposition for Metal Distribution Control
- Recent Advances in Plating Power Supply Technology & Capabilities
- Pulsed Pulse Reverse Plating

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