Hands-on Management



Fred Mueller, CEF • Wendt Dunnington Co. Linfield Corporate Center • 546 Enterprise Drive • Royersford, PA 19468

Pulse Plating & Other Myths

Pulse Plating: Mythor Reality Truth be told, pulse plating is not a myth. Why then do so many conversations about pulse plating begin with the phrase, "I tried pulse plating but it didn't work." Well, first off, there is the time factor. The fitting of the pulse plating variables to a particular physical and chemical plating environment could take an investment of about 60 working days. So let's go over some background and then examine some situations where pulse has been used successfully.

In a well-mixed plating solution, the number of metal ions, brighteners, etc. are pretty much the same through-

Free Details: Circle 120 on reader service card or visit www.aesf.org/psf-qwiklynx.htm. out the solution. This changes as soon as the power is turned on. At the work piece, the metal ions are depleted and the brighteners start to concentrate. This forms a layer around the part that has a different chemical makeup than the bulk of the plating bath. One name for this layer is the diffusion layer. In direct current (DC) plating, the formation of the diffusion layer happens fairly quickly—not instantaneously, but over some finite time span. It forms by:

- Depletion of the metal ions adjacent to the cathode's surface
- The concentrating of the plating bath's organics

In its simplest form, pulse plating is turning the DC rectifier for the acid gold off for 30 to 60 sec, halfway through the plating cycle, to improve the corrosion resistance. This works because a percentage of new crystals start to form over the boundaries of the first half's crystals (nucleation sites). Depending on the variables used, pulse plating can plate a very pure metal deposit, or it can work with the organics in the bath to optimize the features you are looking for in the deposit. Pulse helps the low efficiency bath chemistries tremendously by bumping up the efficiency, yielding improved plating speed, uniformity, lower stress levels and less porosity.

Some terms that must be considered in order to understand pulse plating a little better are:

Frequency

Frequency is defined as wave peaks per unit time. "The greater the frequency of the applied pulse, the

thinner becomes the diffusion layer adjacent to the cathode. This transforms the entire plating surface from a microprofile (think of the surface as an English muffin, with all the nooks and crannies) into a macroprofile (represented by a very smooth surface, because the thinner diffusion layer allows faster replenishment of metal ion to the recesses), so that regions that would otherwise develop into protrusions and recesses are always equally accessible for transport, inhibiting any roughness. Also, as frequency increases, it is possible to plate at higher peak current densities, thereby achieving a greater nucleation rate and a finer grain structure."1

Duty Cycle

DC plating has a duty cycle of 100 percent. The duty cycle for pulse plating is expressed by the on-time divided by the off-time.

Pulse Reverse

Pulse reverse, or periodic reverse, plating has consistently been found to produce a smoother and harder deposit than pulsed current plating.

Pulse Plating Success Stories

Pulse plating has found a home in precious metal plating because of the possible cost savings. In gold plating, less thickness is needed for equal protection because the deposit has less porosity. Pulse gives more consistent distribution, yielding greater economic paybacks because of the high price of gold. It is used in semiconductors to plate the "seed" layer over nonconductors better than DC (plating parts as large as 14 in. by 18 in.), and has been used for lead frames, reel-toreel selective and semiconductor wafers.

Pulse can help prevent photosensitive resists from breaking down. (Remember that pulse helps the lowefficiency bath chemistries tremen*dously* by bumping up the efficiency.) Hard acid golds are only about 40percent efficient, with the balance of the amperage generating hydrogen gas in the form of bubbles. Hydrogen permeates through the resist to disrupt and break the bond between the base metal and the resist. This causes the resist to lift so that the gold can then plate under the resist, causing a short circuit. Pulse creates the conditions for less hydrogen and superior distribution (shorter plating times) by plating more efficiently.

Pulse works extremely well with hard chromium. Because the deposit is crack-free, very smooth deposits can be produced. The smooth deposit, in turn, creates a very hard chrome layer. An interesting application is the use of pulse for plating engine cylinders. By using pulse at the beginning of the plating cycle, a hard chrome layer is placed next to the base metal. Then, in order to give oil a place to cling, the waveform is changed over to DC to produce micro-cracking. Pulse can be used to get the best of two worlds out of the same plating bath chemistry.

Hard coat anodizing and chrome plating are the two most successful, large-scale (based on the size of the rectifier) commercial applications. In anodizing, one of the principal benefits is higher current density without burning. Pulse waveforms work remarkably well with high copper alloys, such as 2024.

Copper Plating of PCBs

I'd like to give you some background on the use of pulsed current for copper plating and, in particular, printed circuit boards (PCBs). Major improvements have occurred in the last few years in copper (sulfate) electrodeposition in PCBs. The conditions that typically have been used in pulsed plating of copper are pulse lengths on the order of milliseconds or longer, and peak currents only slightly higher than those used in DC plating. Early PCB copper pulse plating, using the brighteners of the day, was an example of the old axiom, "the operation was a success for the

bath died." The breakdown products were produced much more rapidly than in DC plating, causing major problems with through-hole cracks. Pulse reverse plating is the hottest area in bright acid copper for fine lines, small geometrics and recessed areas. The bath chemistry has been matched to fit with pulse reverse. It is now possible to plate two to three times the amount of copper in the hole than on the lines. A back-pulse in the range of 1/10 of a millisecond at three times the amplitude or current of the forward pulse is the key. The backpulse keeps the holds from dogboning and removes copper from the lines faster than from the holes. Typical plating time for PCBs is 30 to 60 min.

Pulse nickel plating works about the same as for plating copper. It can provide a very uniform deposit over extremely complex shapes and significantly reduces the plating time. Having said this, however, sometimes pulse plating doesn't scale-up very well. In tin-lead plating, pulse is stuck in the middle because of economics. It works best, however, with the higher tin alloys.

Pulse plating has more to offer today than ever before—new waveforms and a better understanding of the factors behind the successful use of pulse. What must be remembered is that for pulse to be used successfully in your shop, there should be a strong economic return on investment. The projects that have worked well all have a unique hook: cost savings. P&SF

References

- 1. P. Kristof & M. Pritzker, "Improved Copper Plating Through the Use of Current Pulsed & Ultrasonic Agitation," *Plat. & Sur. Fin.* (November 1998).
- M. Aroyo, "Theoretical & Practical Aspects of Electrodeposition of Metal Coatings with Improved Properties," *Plat. & Sur. Fin.* (August 1998).



5th International Pulse Plating Symposium June 29–30 • Chicago's Navy Pier (inconjunction with SUR/FIN® 2000)

Free Details: Circle 121 on reader service card or visit www.aesf.org/psf-qwiklynx.htm.