Help for High Aspect Ratio Plating

PCB technology is constantly evolving. With the onset of SMT, *board designers no longer need to maintain hole diameters for component leads.* As hole *diameters continue to shrink, high-aspect-ratio plating* (HARP) *will become increasingly critical.*

The following questions are being asked by board manufacturers who are progressing to increasingly high-aspect-ratio plating, ranging from 6:1 to 12:1. The responses were provided by George Milad and Jerry Brewer of Atotech USA Inc. (State College, PA).

Q: *How can mass transfer be optimized to meet HARP demands?*

A: Mass transfer is a critical issue in high-speed plating, but it isn't the primary concern in HARP. To maintain mass transfer for plating uniformity, air agitation must be controlled and evenly distributed on both sides of the cathode. Cathodic agitation perpendicular to the cathode bar must be part of the system, and the maximum possible stroke length should be accompanied by low frequency.

Q: *Is vibration or cathode bumping an integral part of HARP?*

A: Vibration is only critical in the cleaning sequence. Here, the hole is completely wetted and air bubbles that could become entrapped in small-diameter holes released. Once the small holes are filled, they will not drain during subsequent processing steps.

Q: *Does impingement really help when plating small holes?*

A: Calculations demonstrate that high solution velocity in the through hole is not required to achieve adequate replenishment of plating chemistry.' Experiments conducted by Forrest show that controlled-air plating cells yielded better results than impingement cells.[2] Impingement has been used successfully in high-speed plating.

as How *does the anode/cathode interaction affect HARP?*

A: The greater the distance between the cathode and the anode, the better the acid copper surface distribution. However, this distance does not necessarily impact throwing power in HARP.

Q= How do *the concentrations of copper, acid, and chloride impact HARP?*

A: Organics' influence is tied to the transfer of reactants to the cathode surface. Organics also affect anode behavior. During plating, the amount of metal in the diffusion layer is depleted. This metal can be replenished by mass transfer, concentration diffusion, or the applied electromotive force. The concentration diffusion of copper to the surface cannot keep up with the plating rate. The mass transfer of ions has been shown to be easily achieved but is fixed by the agitation mechanism design. To go beyond the tank design to improve throwing power, you must influence the current/voltage relationship. This is achieved by changing the ohmic resistance.

Ohmic resistance is changed through a reduction of copper concentration. To maintain solution conductivity while reducing metal content, acid content should be raised. Both of these modifications have limits. If the copper concentration gets too low (less than 8 g/1) or the sulfuric acid concentration gets too high (above 300 g/1), polarization of the copper anodes can occur. With acid copper baths at high acid concentration, the chloride concentration must be run at the low end of the range, also to avoid anode polarization.

Q= *What effect do organic additives have on HARP?*

A: Organic additives in acid copper baths have less influence on plating thickness in a high-aspect-ratio hole than the inorganic and the agitation system do. The organics' primary influence is their ability to plate a leveled, ductile equiaxed copper deposit. This is achieved by keeping the plating rate fully sup-

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pressed with the carrier/leveler component of the additive system with the minimum amount of brightener.

a: *What current density should be used when processing boards with high aspect ratios?*

A: To maximize the amount of copper available for plating in the hole, a low-copper, high-sulfuric-acid electrolyte is used. This solution cannot handle high current without polarization; therefore, lower current densities are required. Although lower current density provides more uniform plating, longer plating times are necessary. Current densities of 5 to 15 amps arc common.

Q: *What are the advantages of pulse plating?*

A: Pulse plating has been successfully used in the general metal plating industry, but this procedure can be tricky with acid copper systems. Organic additives work in the diffusion layer at the liquid/cathode interface, which is what pulse plating is designed to disrupt. The pulse or frequency of this on-and-off cycle must be high enough (by milliseconds) to function as if there were no off time. This allows the diffusion layer to be replenished with copper ions more efficiently than if the current were continually on and provides a more uniform deposit on high-aspect-ratio panels. If the pulse frequency is too low, no effective diffusion layer will be produced and the bath will behave as if no additives were present. This is why the amount of ripple on a rectifier is important in acid copper plating.

Q: *Has additive-copper technology matured into a viable alternative for plating high-aspect-ratio MLBs?*

A: This subject has been intensely investigated for many years by various companies, some of which are now using the technology. The goal is to develop an electroless-copper plating bath that can yield the required physical properties of copper within a short enough plating time to make it acceptable for widespread use.

The increasing environmental and health concerns that have resulted in the pressure to eliminate formaldehyde from the manufacturing process, in addition to advances in direct-plating technology, make the additive-copper process less attractive. **FAB**

References

[1] Fisher, G. L., W. Sonnenberg and R. Bernards "Electroplating of High-Aspect-Ratio Holes." ***PC FAB,*** April 1989, p. 39.

[2] Forrest, Gregory. "Technologies of High-Aspect-Ratio Plating." ***PC FAB,*** July 1991, p. 44.

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