

# Tech Talk

## Fine Lines in High Yield (Part CXXX)

### Via Fills

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Microvias, buried vias, and plated through holes are filled with conductive or non conductive materials for a number of reasons (see Figure 1):

- Improved reliability (avoidance of trapped air or liquids)
- Improved planarity of multilayer structures (for more reliable surface mount or improve photolithography)
- Higher interconnect density (e.g. via in pad vs dog bone designs)
- Better thermal management, or to
- Enable stacked microvia structures.

Non-conductive fills are typically epoxies, occasionally filled with metal oxides or metals, and they can be applied with vacuum assisted screen printers, stencils, or roller coaters (see Ref. 2 for details). Noda Screen's "flat plug process" uses a one stroke screen printing step for via filling, GIT (Japan) applies a roller coating method, and MASS GmbH (Germany) offers a machine that dispenses the via fill from pressurized heads under vacuum assist. Conductive pastes are applied similarly. Two examples of microvia processes using conductive pastes are the ALIVH process (Matsushita) and the PALAP process (Denso). A protective, disposable film (see Figure 2) covers the dielectric. The laser drills through the protective film as well as the dielectric. The microvias are then filled with the conductive paste, the protective film is removed and with it any conductive paste traces that may have contaminated the surface.

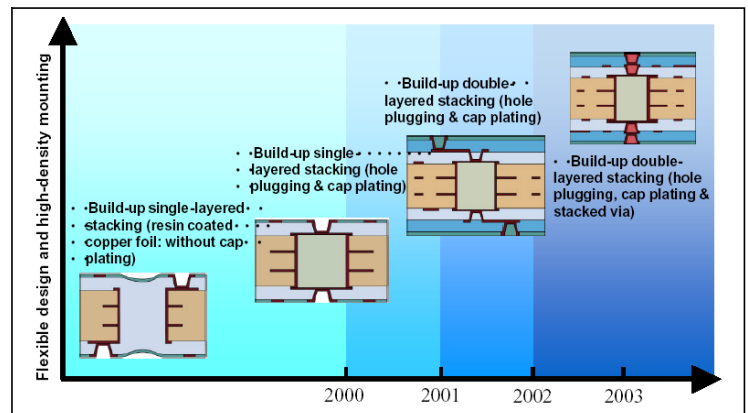


Figure 1: Development of Via Fill and Cap Plating Technology (source: Noda Screen, Ref. 1)

PALAP (Patterned Prepreg Lay Up Process) (process flow, partial) by Denso Corp. (Consortium: Denso, Wako Corp., Airex, Kyosha, Noda Screen, O.K.Print)

1. Copper foil laminated to thermoplastic resin
2. Laminate plastic film to resin
3. Circuitize copper layer
4. Laser drill from the resin (film) side
5. Screen conductive paste into holes
6. Peel off plastic film
7. Repeat Steps 1 through 6 several times



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Figure 2: PALAP Process Flow (abbreviated)

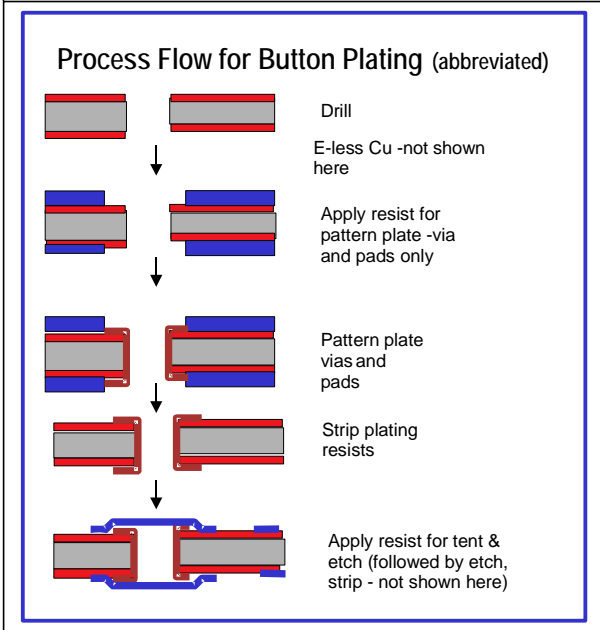


Figure 3: Button Plating (abbreviated)

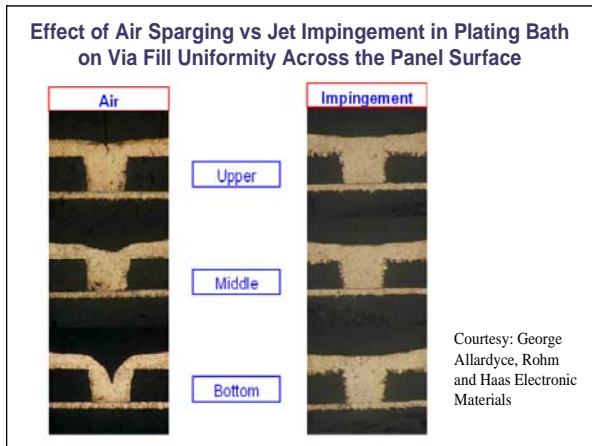


Figure 4: Effect of bath agitation mode on via fill uniformity

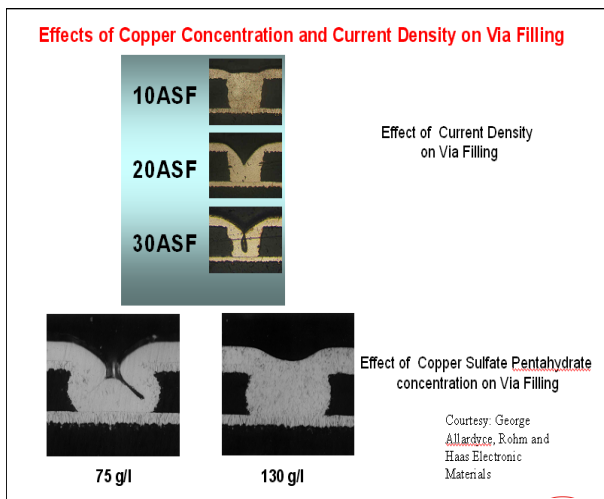


Figure 5: Effect of Copper Concentration and Current Density

In other processes, excess via fill is typically removed by mechanical means in a planarization step. In Noda Screen's Flat Plug Process there is a UV-cure step after screen printing to convert the resin fill to B-stage resin which facilitates the following planarization-polishing (buffing) step. After this step, the resin is thermally cured and converted to C-stage resin before a final polishing step.

Pola & Massa (Ref. 3) offers the PEM Planarizer that was designed for the removal of via hole pastes used in the hole plugging process. The machine is an evolution of Pola e Massa's patented Multiroll machine for deburring and cleaning without ovalization of holes and has been in the market for more than 10 years. The panels are conveyed on a rubber belt. There are 10 grinding rotating brushes that oscillate and move uniformly across the board.

In a special application called button plating the planarization of the through-hole resin fill may be combined with the removal of the copper "button" (see Figure 3), leaving only a copper rivet in the through-hole. This copper removal is desirable in fine line tent-and-etch applications. Without such copper button removal one would have to use relatively thick photoresist to assure good encapsulation of the pad, but this extra resist thickness is detrimental to fine line subtractive processing.

### Plating vias shut

Electroplated copper via fill is becoming the prominent conductive via fill for stacked and staggered vias in HDI. Atotech, Rohm & Haas, Uyemura and others have introduced special via fill plating processes. Figure 4 shows that air sparging gives poorer results than impingement plating. Figure 5 shows the effect of current density on via filling which parallels the experience with plated through-holes. The effect of the copper concentration, on the other hand, seems counterintuitive: the high-throw acid copper plating baths were developed from conventional bath by increasing the acid concentration and lowering the copper concentration. Figure 5 shows the beneficial effect of higher copper concentration, an observation that suggests a plating mechanism limited in a way that is different from traditional PTH plating. Figure 6 shows less complete filling of a microvia with a lower aspect ratio, another phenomenon that seems surprising.

### References

1. www.nodascreen.co.jp
2. Exploring novel via fill and planarization technology, Torsten Reckert, CircuiTree Magazine, April 2005, pg. 8.
3. www.polaemassa.com

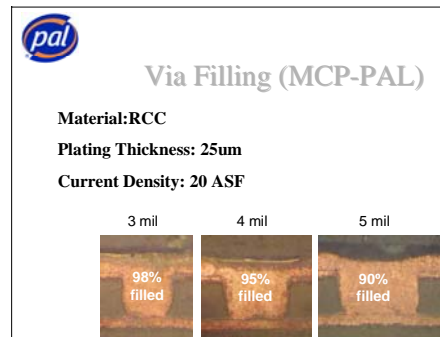


Figure 6: Effect of via aspect ratio on hole filling (source: PAL)



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