Advances in Copper Plating Technology

Price of Copper to double! LME metal prices set to shoot through the roof! Shortages forecast! These dire predictions have all become reality, and things are set to get even worse. The worldwide PCB manufacturing industry continues to try and absorb these extra costs under the desperate pressure of competition, which hardly allows for price increases under any circumstances. PCB shops are unable to influence the Copper market, since the total PCB consumption of Copper is tiny compared to other uses. So other solutions must be found that lead to savings and sustain the performance of processes that today’s PCB manufacturers require.

Better plating distribution is key to reducing costs and simultaneously improving the quality of PCBs. Soon, nearly every multilayer circuit board (MLB) will require filled blind via holes (FBVH). How will that be achieved whilst maintaining cost effectiveness? Advanced MLBs can no longer afford to be 'handcrafted' - they must be made with volume production equipment. While board manufacturers are struggling to achieve decent yields in the production of fine line, high aspect ratio designs that are required to mount the new chips with ever-increasing clock speeds, plating machine technology seems unable to go beyond conventional methods.

Brief history of plating technology

Many years ago, the application of two simple mechanical devices - the suspended agitation frame and the floating shield - laid the groundwork for the initial improvement in plating distribution technology. A study of flux density across a plating cell had revealed the full treachery of current flow and the torture of Faraday’s laws, when striving for best distribution (Figure 1). These forms of agitation are required to provide the metal and component replenishment at the interface with the surfaces where deposition takes place. The PAL standard method of inclining the PCB 15 degree means that a Venturi effect is created, which washes solution into the holes and helps any gas bubbles to be flushed out. Add vibration to this and the best chance of removing gas bubbles is obtained. Furthermore, the suspended agitation frame concept does not transfer vibrations to the machine structure. This concept can also be applied to desmear and electroless Copper PTH machines.

The trouble with plating machines was getting fresh solution efficiently to the target surface, as high current density areas plated thicker and the other areas plated thinner. More sophisticated designs were introduced to assist the basic floating shield, giving tremendous protection from over-plating the bottom of the board. A further shield was introduced in the Anode Screen design, which also enabled to save on the use of anode bags, keeping any particulate matter away from the catholyte and allowing this to be freshly cleaned, having just been returned from the filtration system. As a result, smaller architecture panels were not subject to the ruinous effects caused by particulate contamination. The anolyte was pumped out in proportion and kept fresh by the flow from the catholyte compart-
ment through the anode screens.

This hydraulic management system allowed for the introduction of a weir into the plating cell, over which a good proportion of solution was returned to the off-line sump tank, where cooling took place and additions were made. A weir was necessary for the top-racking of a single row of panels. This controlled the height of the solution at the top edge and surface of the boards and prevented the over-plating of the top edges – a dream come true for many platers. As the plating on the outer edges of the panels could easily be influenced by the careful placing of the outer anode baskets, and the inner panels edges looked after each other by mutual shielding (but with no overlaps), the whole panel was now under control. At least as far as the circuit pattern allowed, although a properly set up cell for ‘panel’ plating still gave better performance for these problematic boards. Several companies enjoyed a 20%+ saving in Copper consumption as a result of these improvements.

Pulse Plating

It was the foresight of Ian Lang at Exacta Circuits that led to the revolutionary introduction of Pulse Plating - another quantum leap in the ability to handle awkward circuit designs. Coupled with newer chemistries and the use of Educator agitation, economies in Copper consumption provided a big boost to the cost effectiveness of the plating process.

At this point, the ‘real estate’ issue surfaced again: conventional methods of MLB construction were changing to allow even more components to be placed on the surface, thus increasing the necessity of removing heat from the structure in a safe way.

The fact that Copper is such a good and cheap conductor of both heat and electricity laid the basis for the development of the FBVH concept. Filled blind via holes can act not only as electrical paths, but also as paths for removing heat efficiently from inside the panel through thick ‘ground planes.’ These pathways could be built as a stack, one on top of the other, meaning that a column of Copper would rise through the panel (Figures 3).

This provided the circuit designer with major benefits, but represented a real headache for manufacturers. Much work was done by drill machine companies to get highly-accurate z-axis control so that the buried layer could be routinely exposed to a subsequent set of chemical processes. Laser obliteration of the required holes followed rapidly, proving a very successful technology.

Manufacturers were faced with the problem of a variety of hole sizes and diameters that trap air and hampers solution exchange. Two forms of plating were requested. Conformal plating, where the deposit followed the geography of the hole like a large plated pit, quickly followed.
by the desire to fill the hole with Copper to permit additional layers to form the Copper columns described earlier (Figure 4). Existing manufacturing systems could not reliably overcome this tight geometrical problem, so new systems for the movement of solution were investigated.

**Overcoming FBVH problems**

Because it could be automated and handle thin material with ease, the horizontal processing of PCBs was in vogue just prior to the collapse of the worldwide electronics industry in the early 2000’s. Sadly, the running costs for such machines were exorbitant and maintenance was difficult. Technical results were also less than satisfactory. At the end of 2001, when the market was in the doldrums, PAL licensed a continuous vertical machine technology from Marunaka in Japan, who had sold many Continuous Platers (MCP) to their home industry base. PAL seized on the simplicity of this machine concept and set about overcoming the issues associated with FBVH boards, as well as normal plating distribution issues associated with conventional panels.

Figure 5 shows a typical comparison between continuous vertical plating results and those from a well set-up regular hoist type vertical machine. Once again hydrodynamics came to the rescue, enabling a breakthrough to be made. The innovation provided the necessary mass transfer properties in the blind vias enabling them to be flushed with new chemistry and filled with plated Copper (within the capabilities of the partnered chemistries), as well as enabling the plating of holes in high aspect ratio MLBs (Figure 6).

Special algorithms for the solution spargers were fashioned to ensure that every part of the PCB received the correct flow of solution, this being delivered by a Mini Eductor system mounted on the sparger pipes positioned parallel to the PCB surfaces. Distribution results proved to be excellent and reproducible, with the design of the MCP machine guaranteeing that every panel was subjected to the same plating parameters (Figure 7).

An understanding of ‘Faraday-influenced’ plating issues allows to define the practices necessary to handle the leading edges of the panels by shielding and controlling plating currents. The bottom edge was again controlled by a neatly modified shielding system, which can be changed via software when panel sizes need to be changed. Again the top edges are at solution level and controlled accurately by weirs to ensure no over-plating at the top of the panels. Simplified panel handling means less damage to resists and less rejects from all causes.

Both panel and pattern plate versions are available for production rates of 60 panels per hour and upward. Additionally a PTH machine is close to beta site testing.

Every possible parameter has been checked out to provide the optimum combination of flow rates, agitation rates, vibration methods, DC and pulse current densities, brightener additions and also pre-treatment processes.

This modified and proven sparger system was successfully transferred from the MCP machine to the traditional vertical hoist type machine, again taking great care with the geometry of the cell and using the algorithms for evenness of exposure of the board (Figure 9).

All these improvements are available to PCB manufacturing companies looking to implement this proven technology to produce boards reliably and in a cost-effective manner.