Tech Talk

Fine Lines in High Yield (Part CXXXIV)

Copper-Copper Peelers

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This dreaded defect, as the name suggests, refers to a situation where two layers of copper have insufficient adhesion so that the two layers can peel apart if stress is induced, e.g. during IST testing or other similar thermal cycling tests. The adjacent copper layers may be electroless copper and electroplated copper. Examples are pattern-plated circuits, plated through-holes, and microvias. The other situation for potential copper-copper peelers is the interface between copper foil and electroless copper. Examples are the interface between base copper and electroless copper on outerlayers, and the interface between the capture pad at the bottom of a microvia and the electroless copper in the microvia. One could also include here the interface between the electroless copper and innerlayer copper in plated through-holes. If it is not clear where the locus of failure is, e.g. whether it is between the electroless copper and the underlying surface or between the electroless copper and the electroplated copper, one can analyze the surface for the presence of palladium catalyst. If palladium is present, the peel happened between the electroless copper and its underlying surface.

Avoiding copper-copper peelers in pattern plating

The outerlayer copper foil needs to be free of organic contaminants. The micro-etch, built into the electroless copper process sequence, will assist in the removal of minor organic impurities but will not remove heavy contamination. This micro-etch does remove loose surface oxide from the copper foil that can lead to copper-copper peelers. The innerlayer copper in the through-hole first needs to be “desmeared” from drill smear resin, using the customary solvent swell/ permanganate desmear chemistry. Desmear conditions may have to be adjusted for high Tg epoxy resins and high performance non-epoxy resins to assure sufficient desmear.

Once good copper to copper adhesion between the copper foil and the electroless copper is assured, we need to make sure that the electroless copper surface, after resist lamination, exposure and development, is free of organic residue, be it resist residue, or developer antifoam, or any other extraneous organic contamination. The pre-plate cleaning step is designed to get this job done, but it might not be adequate if upstream processing was out of control. Pre-plate cleaning may consist of an acid “hot soak cleaner”, followed by a micro-etch, followed by and acid dip which is typically the acid used in the plating bath, at the concentration used in the plating bath. Occasionally, the micro-etch is omitted. It should be noted that there are differences between photoresists in terms of pre-plate cleaning resist residues due to differences in binder and adhesion promoter systems in the resist composition. Such differences may require adjustments in pre-plate cleaning conditions such as pre-plate microetch depth, hot soak cleaner hold time and temperature. Selecting the proper type and level of antitarnish on electroless copper can help minimize resist lock-on in unexposed areas and avoid copper-copper peelers.

I mentioned upstream process conditions that could be out of control and contribute to poor pre-plate cleaning, and ultimately to copper-copper peelers. Examples are:

- Poor vacuum draw-down during exposure, causing partial exposure in non-exposure areas. This can lead to a positive resist foot and difficult to develop, semi-polymerized resist.

- Poor artwork, e.g. with insufficient Dmax or poor line definition.
- Over-exposure, leading to “blooming” of resist into non-exposure areas.
- Poor developer rinsing. This could be due to insufficient residence time in the rinse chamber, which in turn may be caused by development conditions that are to aggressive, i.e. too fast development. To maintain the correct breakpoint under such conditions, the conveyor speed is increased which means shorter residence time in the rinse chamber. Other causes for poor rinsing could be insufficient water pressure or colder than usual rinse water, which could be a seasonal phenomenon.
- If the developer breakpoint is too late in the development chamber, e.g. 80% instead of a recommended 65%, there will not be enough time for complete removal of resist traces from the developed channels which can lead to copper-copper peelers.
- Heavy antitarnish treatment on “unscrubbed electroless copper” may interfere with good copper to copper adhesion.
- Insufficient post-development drying is not a very likely cause of copper-copper peelers but if everything gangs up against proper copper interface adhesion, it could be a contributor in the sense that residual moisture in resist channels leads to more rapid tarnishing of the copper surface.
- If the post-electroless copper hold time is excessively long, corrosion of the electroless copper could become a problem.

Avoiding copper-copper peelers in microvias.

Most people agree that microvia failure if often a separation between the electroless copper and the copper capture pad. This phenomenon is often aggravated in stacked via constructions. So it is understandable that a good deal of development effort is going into improving the adhesion of electroless copper to its underlying surface. An example is MacDermid’s new electroless copper M-System Omega. According to MacDermid, poor electroless copper adhesion is often associated with the conditioner chemistry which can leave a barrier film between copper surfaces. By modifying the conditioning chemistry, MacDermid has improved copper to copper adhesion.

A potential source of copper-copper peelers in microvias is improper laser drilling. If insufficient laser pulses are used, or if the build-up dielectric layer is higher than specified, residual resin will cover the capture pad. The normal hole clean/ desmear process may not remove such residues. Specialized AOI inspection equipment is used to inspect microvias after drilling and cleaning to detect such residues, as well as inspect for proper hole position and hole shape.

Historically, there have been fine line plating applications where the standard developer rinse conditions were insufficient for removing resist residues from high aspect ratio resist channels and plasma was used to further clean the channels prior to plating. Schmid (www.schmid-online.de) now offers an in-line plasma cleaner (“InlinePlasma”) for PWB surface cleaning or surface activation. One recommended application is its use before electroless copper, and it is also conceivable that this tool could be useful in post-development cleaning, prior to pre-plate cleaning.