Tech Talk

Fine Lines in High Yield (Part CLVI)

Defect Problems & Defect Prevention in Development

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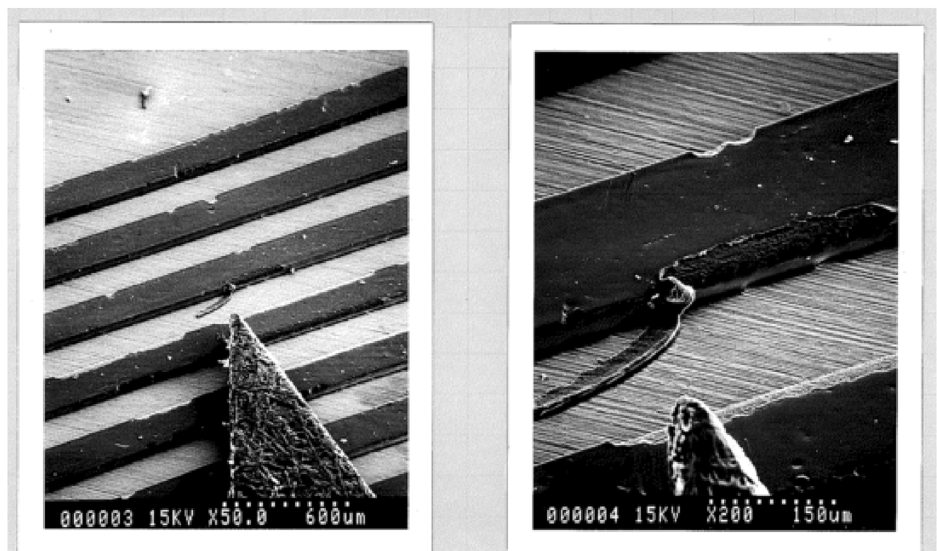
I recently reviewed my files on defect problems associated with the development of dry film photoresist and found some that I had not yet discussed in Tech Talk. At the same time I noticed a short report on the use of the development process to remedy a potential problem that originates in the cut sheet laminator.

Many improvements in equipment design (Ref.1) and in equipment maintenance (Ref. 2) have reduced the number of defects that are associated with development: the so called "contact-less" transport systems, the replacement of exit squeegee rollers by air knives, the elimination of antifoam through the use of an overflow weir and sprays that knock down the foam.

One nagging defect called resist "slivers" resurfaces off and on. It is a defect characterized by the fact the "nose" of the resist, i.e. the resist edge at the corner between the sidewall and the top surface of the resist, breaks off during development. Such a sliver can then deposit on the copper surface between two resist lines. This may not necessarily lead to a defect such as a short in a print-and-etch process, if the sliver is small and narrow enough and if the process is set up to over-etch slightly in order to form straighter copper sidewalls. But if the sliver is large enough, it can lead to a short. In a plating process it can lead to poor plating or no plating in the location of the sliver. It has been known that the origin of such slivers is the resist nose because occasionally one can see such a sliver still attached to the resist from where it broke off (see Fig. 1 & 2).



Figures 1 & 2: Resist Sliver, Still Attached to the Resist Trace.

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The formation of slivers has been associated with over-development, i.e. any condition that causes excessive attack of the developer chemistry on the resist such as early break-point, high carbonate concentration, or high developer temperature. Even if the break-point is correct but is achieved by a long dwell time (slow conveyor speed) in the development chamber, there can be a problem. The mechanism of the sliver formation is not well understood, at least I don't have a really good explanation. However, it is generally assumed that the resist swells more than it does under better controlled development conditions. Swelling is most prominent at the resist nose because the nose is exposed to the developer solution from two sides. If swelling is diffusion controlled, then the nose is most exposed to the diffusing developer solution. It will swell first, and more so than the bulk resist, causing stress between the bulk resist and the resist nose. The impact of developer sprays, especially from fan nozzles, can then knock off the nose and form the sliver. Several observations support these explanations. Photoresists that are more hydrophilic, i.e. more prone to swelling, are more likely to cause slivers. Secondly, reducing the spray pressure has been shown to reduce sliver defects. And going to milder development conditions generally helps reduce these defects.

Another unique defect has been observed (see Fig. 3). The defect is a neck-down or cut of a plated line near the pad of a plated through-hole. Plated lines adjacent to the defective line are perfect, the cut is only seen at the line leading to a through-hole. The defect occurs more often with smaller diameter, high aspect ratio holes. Troubleshooting efforts finally led to the root cause, namely poor developer rinse and drying (see also Ref. 3). Developer solution remaining in the hole was not removed by the developer rinse. The trapped developer solution then bled onto the pad and copper trace connecting to the pad and prevented plating in this area. When the rinse capacity was increased and drying improved, the problem went away.

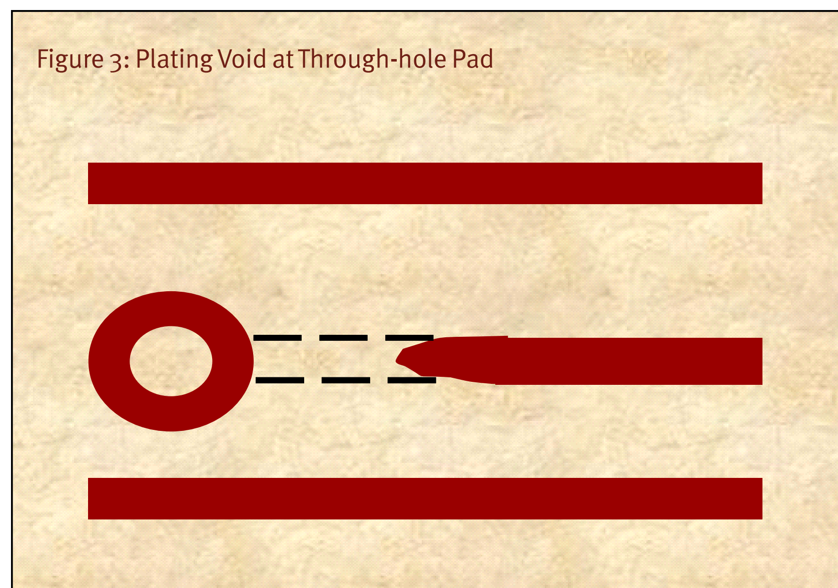
Figure 3: Plating Void at Through-hole Pad

In a third scenario, the developer was used to remedy a cut sheet laminator problem. When the dry film is cut, especially if the cutting knife is dull or defective, resist chips may form and cause imaging defects if the chips adhere to the board. One desperate process engineer came up with the idea to run the laminated board through the developer, with the Mylar® coversheet still in place. The unexposed resist chips dissolved in the developer and the number of imaging defects decreased dramatically. Getting a cleaner dry film cut in the first place seems like a more elegant solution.

References

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2. Fine Lines in High Yields, (Part LXIV): Developer Maintenance, Karl H. Dietz, CircuiTree Magazine, January 2001, pg. 42
3. Fine Lines in High Yields, (Part CXXIII) : Developer Rinse, Karl H. Dietz, CircuiTree Magazine, December 2005, pg. 89