Tech Talk

Fine Lines in High Yield (Part CXXIX)

Copper Whiskers

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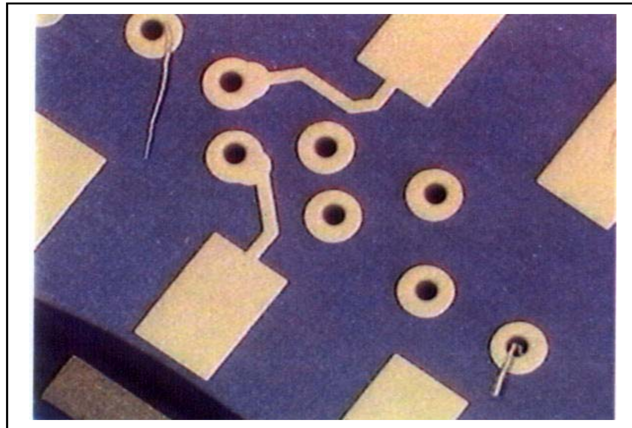
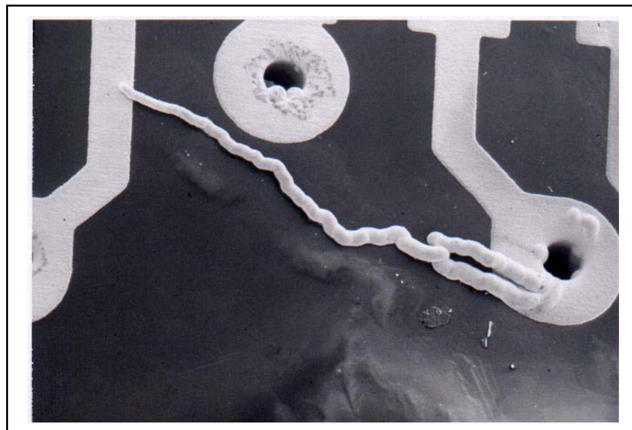
Copper whiskers? Who has heard and cares about copper whiskers! You probably meant tin whiskers? No, copper whiskers! True, the phenomenon of "tin whisker growth" has fascinated and plagued the industry for decades and has more recently been studied extensively as lead-free surface finish alternatives are being qualified. One of the best sources for such studies is ITRI Ltd., formerly known as the International Tin Research Institute, and its website www.tintechnology.com. But back to copper whiskers. First a caveat: my colleagues and I have wrestled with copper whiskers in a heuristic, trial-and-error way, so that the information offered in this column is somewhat anecdotal. In fact, I would welcome deeper insight in the subject matter from those who have fought the copper whisker battle more systematically, and have won!

Copper whiskers are ugly filaments that form during copper electroplating and can obviously lead to defects such as space violations and shorts (see Figures 1 and 2).





Figures 1 & 2: Illustrations of Copper Whiskers

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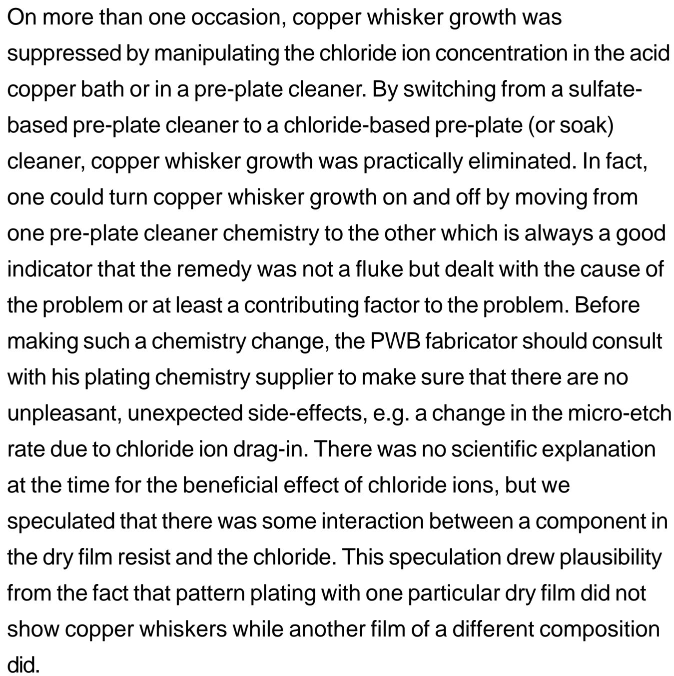

On more than one occasion, copper whisker growth was suppressed by manipulating the chloride ion concentration in the acid copper bath or in a pre-plate cleaner. By switching from a sulfate-based pre-plate cleaner to a chloride-based pre-plate (or soak) cleaner, copper whisker growth was practically eliminated. In fact, one could turn copper whisker growth on and off by moving from one pre-plate cleaner chemistry to the other which is always a good indicator that the remedy was not a fluke but dealt with the cause of the problem or at least a contributing factor to the problem. Before making such a chemistry change, the PWB fabricator should consult with his plating chemistry supplier to make sure that there are no unpleasant, unexpected side-effects, e.g. a change in the micro-etch rate due to chloride ion drag-in. There was no scientific explanation at the time for the beneficial effect of chloride ions, but we speculated that there was some interaction between a component in the dry film resist and the chloride. This speculation drew plausibility from the fact that pattern plating with one particular dry film did not show copper whiskers while another film of a different composition did.

In another case, copper whiskers were found to bridge copper circuits. These whiskers were 0.5 to 3 mils wide and 2-60 mils long. Troubleshooters dissolved the whiskers by etching them in sodium persulfate and concluded that the whisker had not grown around a foreign matter filament. However a carefully cross-sectioned sample showed a carbonaceous core by EDX. Later it was detected that due to an error in the test method that determines that chloride content in the copper plating bath, the chloride concentration was actually controlled at 20ppm instead of the recommended 60ppm. When this error was corrected and chloride was controlled at the recommended level, copper whisker growth was reduced substantially, but not completely eliminated.

In another case, troubleshooters speculated that copper whisker growth can be linked to stresses in the copper deposit. When checking tensil strength and elongation of the copper deposit it was noticed that while these parameters were still within specifications, they had drifted to the lower end of the acceptable range. When the plating bath was re-batched with fresh organic additives with additive concentrations at the high end of the recommended range, tensil strength and elongation improved and copper whiskers disappeared.

In yet another case, the troubleshooters suspected that the dry film photoresist was laminated over a copper surface that had rough spots, protrusions, or nodules which were the nuclei for whisker growth. On this notion the debur process, de-noduling, and pumice scrubbing were upgraded with generally favorable results on yield but little effect on copper whisker growth.

Here is my favorite one: one observant troubleshooter noticed algae growth in the brightener chemistry, notable in the feed lines. These are stringy structures, generally 0.003-0.008 inches in diameter and can grow up to 0.100 inches long. When these stringy contaminants enter the plating bath as brightener is replenished, they become the nuclei for whisker growth, or so goes the theory. Thus, companies periodically flush out the brightener feed lines to the copper electroplating baths where contaminant eventually get trapped in filters. Another technique is to add a small amount copper sulfate salts to the brightener to act as a fungicide.

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