

Tech Talk

Fine Lines in High Yield (Part CXXXViii)

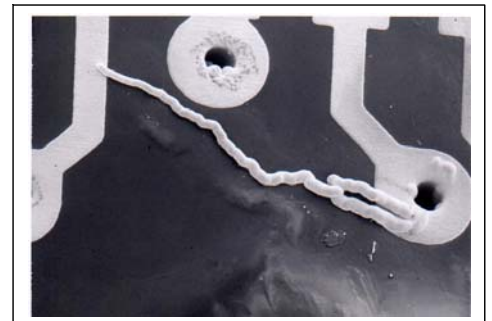
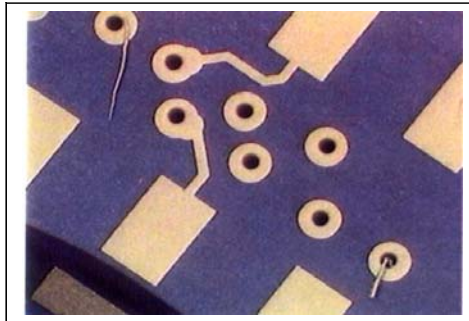
More on Copper Whiskers

Karl H. Dietz (for CircuiTree Magazine, March, 2007)



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The June 2006 Tech Talk was dedicated to the esoteric topic of Copper Whiskers (or stringy nodules) that can make the lives of electroplaters miserable when they strike, and sometimes mysteriously disappear again before the root cause can be identified. Thus, information on copper whiskers is often anecdotal which caused me to invite readers to share their experiences with CircuiTree readers. So, here is more on copper whiskers.



Figures 1 & 2: Illustrations of Copper Whiskers

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).

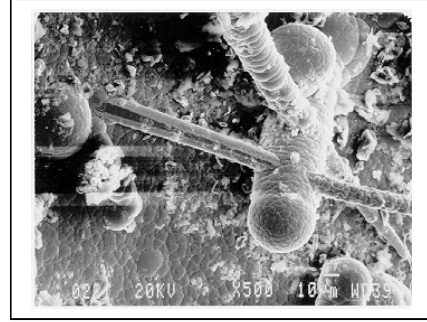
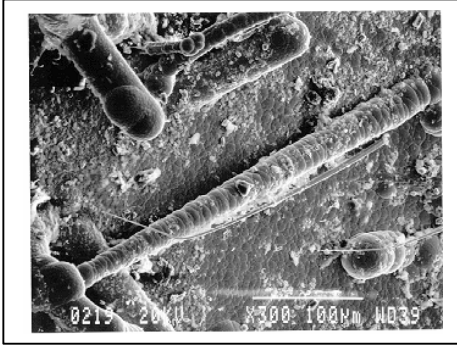
In one particular case, the copper whisker problem had affected all plating baths of a PWB shop, was evident on all plated boards and nearly caused the demise of the company. The plating engineers scrutinized the brightener, all copper surface preparation processes (scrubbing, preplate cleaning, microetching), the quality of the incoming water, the filters in use, the electroless process, dry film, pollen etc. The problem was ultimately traced to the anodes and the non-uniform distribution of phosphorus. After the fact, the engineers learned that this was apparently a known potential cause.

In a different incident, after examining SEMs and optical microscope pictures of the plating defects (see Fig. 3-6), the plating trouble-shooter came to the conclusion that he had a bad case of "stringy nodules". These stringy nodules were postulated to occur when a biological growth is introduced to the copper plating bath from an outside source. The growth is killed by the copper sulfate, the growth carcass becomes impregnated with copper sulfate, becomes conductive, and is deposited on the board surface along with standard copper deposition. These nodules can take on many shapes: filament-like, a tangled mess, even undulating through the deposited surface copper.

The biological growth can be very difficult to remove from the system. Brightener feed systems, rinses following cleaners, and contaminated water systems have all been found as primary



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Figures 3 & 4: SEMs of "Stringy Nodules"




Figures 5 & 6: Optical Microscope Pictures of "Stringy Nodules"

sources for the phenomenon. While most copper additives have an algacide/fungicide built in, brightener feed systems with long brightener dwell times have been known to grow material resistant to the biocides. Neither the type of brightener used nor the supplier chosen seem to have any bearing on growth if it is going to occur. Another source are natural fibers (cotton, wool) that tend to degrade in a similar manner in the acidic copper medium.

If the phenomenon is caused by biological growth, the immediate fix is improved house keeping. Rinses must be dumped and sanitized (usually with either bleach or peroxide). Brightener feed tanks need to be sanitized and feed lines are best replaced. Cleaner and etch tanks may also need to be rebuilt. Copper tanks need to be micro-filtered, preferably into separate tanks so that the entire solution passes through the filter medium. This is an opportune time to carbon treat, since many work hours are committed to the bath clean-up, and the carbon filter pack removes extremely fine particles.

Another war story manifesting the difficulty of pinning down the source of contamination and the effort to get rid of the problem reports that a PWB facility chose to simply re-batch all plating chemistries from scratch after sanitizing the entire line. The shop installed UV sanitizers on an incoming water line when the problem persisted after the plating chemistry supplier was changed.

During an earlier stringy nodule episode a bleach treatment of the DI water system was done resulting in nodule recession in the next several days. It was found that the stringy type of nodules appear to be related to the amount of "bug" content in the DI water feeding the preclean, rinse, and copper tanks. As copper is a very good algacide, the copper tank itself is not the site of the living organism, but the resting place of deceased accumulated organic matter. It was further found that the nodule, in cross section, has no central nucleus. It was believed that the organism gets "electroformed" to the board and is dissolved by the high sulfuric acid content. As the organism depletes from the solution the stringy nodules appear to subside to more regular nodulation until all traces are gone. If the



water system is not aggressively treated, the problem may continually appear and disappear as colony growth comes and goes.

The DI water generation area is “the usual suspect” for causing stringy nodules. Potential trouble spots in the system and things to be checked out are:

- Anthracite sediment removal beds, their expected life cycle, and frequency of backwashes required to maintain clean media that is not a growth area for biological colonies.
- The elimination of dead areas in the system that allow the water to remain stagnant and act as breeding and inoculation sites.
- Check of the bag filter micron size and its ability to trap particulate.
- Consider the introduction of a carbon polish cartridge on the exit end of the DI water generation system to reducing organic content.
- Consider a regular purge frequency to keep colony growths under critical limits.

A major problem in trouble-shooting stringy nodules is the inability to reproduce the phenomenon in bench scale plating equipment. Another curious aspect of the stringy nodules is the lack of a nucleation site. Many cross sections have been meticulously ground trying to locate a nucleation site that just does not seem to be there. This lack of a nucleation site may be a clue in and of itself. To produce a nodule of the length that many of them are, the plating must take place around a filament, as opposed to a single point nucleation site. The plating time is insufficient to grow such long nodules from a point site. For the nodule to plate around such a filament and leave no nucleation site would suggest that the filament must be dissolved during the plating. This would lead to the conclusion that the filament is likely a naturally occurring organic filament of some sort.

Additions of extra brightener has been reported to help reduce the problem, but not eliminate it completely. This is probably due to the increase of the carrier content in the baths which is typically the second component in the brightener additive system. The carrier is a wetting agent. By increasing its concentration in the bath, any particulate that has contact with the panels is less likely to remain on the panels.

Acknowledgments

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