

Tin Whisker Growth from Sn-In-Ag Solder

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The ubiquity of lead (Pb)-free solders in commercial electronics sometimes induces packaging engineers to include them in components used for high-reliability equipment. Unfortunately, in some lead-free solders, tin whiskers can form after reflow and threaten equipment reliability. While the literature does contain examples of tin whisker growth from assorted tin-based solder alloys the presence of ionic contamination [1] or in solders with small amounts of rare earth metals [2], the majority of reports of tin whisker-induced failures come from tin and tin-alloy plated materials with surface finishes that have not experienced heat treatment such as reflow or annealing of the plated finish. The exception seems to be tin-based solder with additives of rare earth elements [3].

During destructive failure analysis of an optoelectronic device in a hermetically-sealed package, we observed tin whiskers had grown from the reflowed Sn77.2-In20-Ag2.8 solder alloy used to join a gold-plated thermoelectric cooler (TEC) and a gold-plated package header. The tin whiskers grew in excess of 0.5mm in length over several years, bridged conductors at different electrical potentials, and caused resistive shorts on the order of ~100 to 400 ohms. Our analyses using XRF, SEM, EDS, and cross-sectioning confirmed that 1) the whiskers consisted of pure tin and 2) grew preferentially in areas near the perimeter of the solder joint. A recent study showed examples of whisker growth from a similar solder and pointed to the presence of Au-Sn intermetallics as a likely cause [4]. This paper points out that the presence and abundance of an assortment of intermetallic compounds (e.g., Au-In, Ag-In, Au-Sn) in various areas of the solder joint was seen to correlate with the presence and/or absence of tin whiskers.

[1] Snugovsky, Polina, et al. "Whisker formation induced by component and assembly ionic contamination." *Journal of electronic materials* 41.2 (2012): 204-223

[2] Jiang, B., and A-P. Xian. "Spontaneous growth of tin whiskers on tin– rare-earth alloys." *Philosophical magazine letters* 87.9 (2007): 657-662

[3] "Tin (and Other Metal) Whisker Induced Failures" NASA web site, <https://nepp.nasa.gov/whisker/failures/index.htm>

[4] Li, Qingqian, Y. C. Chan, and Zhong Chen. "Tin whiskers growth of SnAgIn solder on Kovar substrate with Au/Ni plating." *Journal of Materials Science: Materials in Electronics* 25.3 (2014): 1222-1227