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TIN WHISKERS AND THE LEAD FREE INITIATIVE

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There is a move currently underway in the electronics industry to use environmentally friendly materials. This includes removing lead (Pb) from electronic assemblies and solder alloys. It also involves removing certain types of flame retardant materials from plastic and encapsulated integrated circuits. The new alternative materials are commonly referred to as halogen free or green materials. Restrictions by environmentally friendly organizations and nations are pressuring electronic manufacturers to develop alternate surface finishes and solder alloys. More expensive solutions are to use nickel/gold/palladium (Ni/Au/Pd) or Ni/Au. Another more cost efficient alternative solution is to use pure tin (Sn) or alloys that are Sn rich [1], [2], [3], [4].

The use of pure Sn poses a serious reliability risk due to the potential for the Sn to form whiskers. Sn whiskers are electrically conductive filaments that can spontaneously grow from pure Sn surfaces. These filaments are single crystal structures whose growth mechanisms are not completely understood. The most compelling theory in the electronics industry is that Sn whisker growth is a compressive stress relief mechanism in the Sn plating. Some identified sources of stress in Sn are plating residual stress, compressive mechanical loading, scratches in the plating surface, intermetallic formation, and mismatches in the coefficient of thermal expansion between the plating and substrate [4], [5], [6]. Extensive studies are still being performed in the industry trying to understand the Sn whisker growth phenomenon.

Sn whiskers have been reported to commonly grow in lengths greater than 60 mils with diameters as much as 10 microns. Some studies report whiskers as long as 394 mils. The shape of the whiskers can vary dramatically from perfectly straight to bent or kinked. The initiation of whisker growth can occur soon after plating or lie dormant for years [3], [5], [6].

Sn whiskers can cause transient or long-term electrical shorts depending on the amount of current available. Metal vapor arcing can also occur in certain environmental and electrical conditions. Whiskers can also easily break loose in components and assemblies generating conductive debris [5], [6].

The Sn whisker issue is a serious reliability concern with space and military electronics. There are many documented cases where Sn whiskers have resulted in the failure of electronic assemblies. Two specific failure analysis cases will be discussed where the main failure mechanism was Sn whiskers. The first involves the failure of hybrid microcircuits when Sn whiskers formed on the Sn plated lids and broke off. The loose conductive whiskers caused electrical shorts to occur in the hybrid circuitry. The second failure to be discussed occurred on a rocket motor initiator when whiskers emanated from the Sn plated internal pins. The whiskers bridged a 10-mil spark gap causing test failures. Various other examples of Sn whisker growth will also be presented from internal experiments performed on Sn plated coupons. Another unique aspect of this paper involves Focused Ion Beam (FIB) cuts into Sn whiskers sites.

References:

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[5] Mosterman, M., *Mitigation Strategies for Tin Whiskers*. CALCE-EPSC, August 2002

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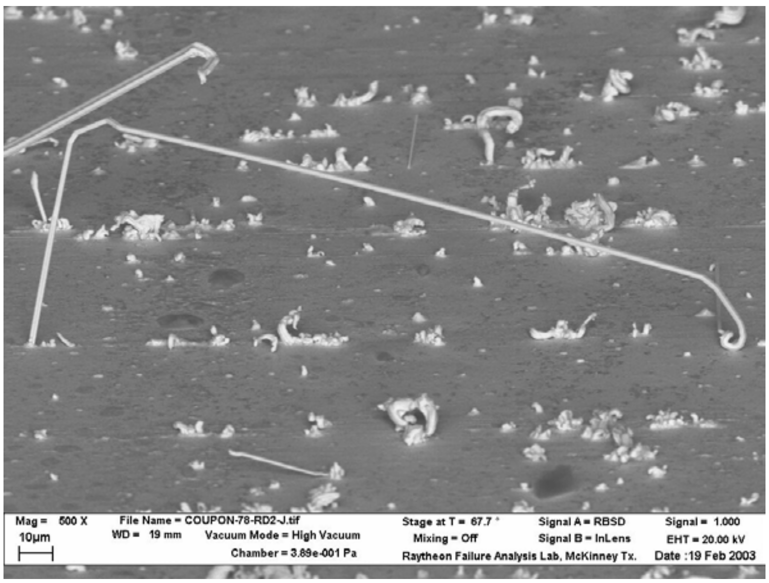

Figure 1: Dense coverage of Sn whisker initiation sites and whiskers varying in length and width.

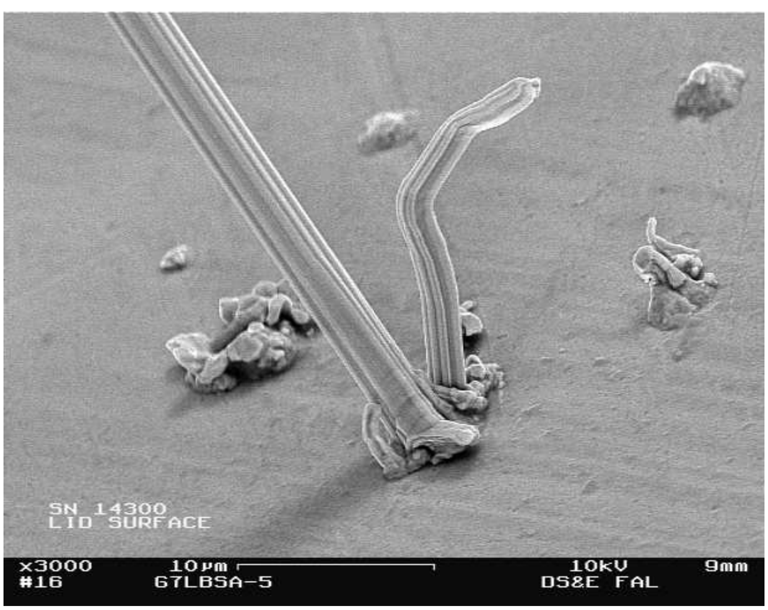

Figure 2: Sn whisker growing from the surface of a Sn plated lid on an electronic module.

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