Reduction of Hazardous Substances (RoHS) **AN-105**

In 2002, the European Parliament promulgated what we at CineMag anticipate to be the first of a number of regulations to drastically reduce or eliminate certain substances which may be hazardous in the environment. They are known as 2002/95/EC or RoHS regulations. RoHS stands for Reduction of Hazardous Substances. These rules severely limit the amount of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) in most products sold in European Union countries. Because of our customers' need to meet these ever-growing environmental regulations, CineMag has committed to conversion of most of our production to the RoHS standards.

CineMag will provide written certification of RoHS compliance upon request when purchase orders are placed. Please be sure to specify this in your PO. If your application demands that it *not* comply with RoHS, mostly that lead-containing solders be used, be sure to specify this prominently and in writing.

There are a number of significant challenges which you will face if you use a lead-free solder to connect to our transformers and inductors, which you must do in order to maintain the RoHS standard. Use of a solder containing lead will obviously contaminate the product and it will no longer meet the RoHS standards.

1. Lead-free solders work at a higher temperature than the tin-lead alloys than you may be used to. This working temperature will be about 50° C higher than for Tin-Lead alloy solders. We recommend that you now maintain a soldering iron tip temperature of 335°C (about 665°F). This temperature can not be applied for more than 5 seconds to any pc bobbin pin without risking destruction of the device. Wire leads, similarly, will experience insulation breakdown if adequate care is not taken. The use of wave soldering or solder pots on pc pins is not recommended and will void all warranties.

2. The lead-free solders are less ductile. Solder joints will fail more readily when subjected to deformation which can occur with vibration or mechanical stress.

3. Solder joints will not have the same finishes that lead-tin alloys afford and may look granular. You should become proficient with what to expect and how to successfully solder with these lead-free alloys prior to soldering up your CineMag transformer or inductor. Otherwise, you can readily over-work the joint causing both a poor solder connection and damage to the part.

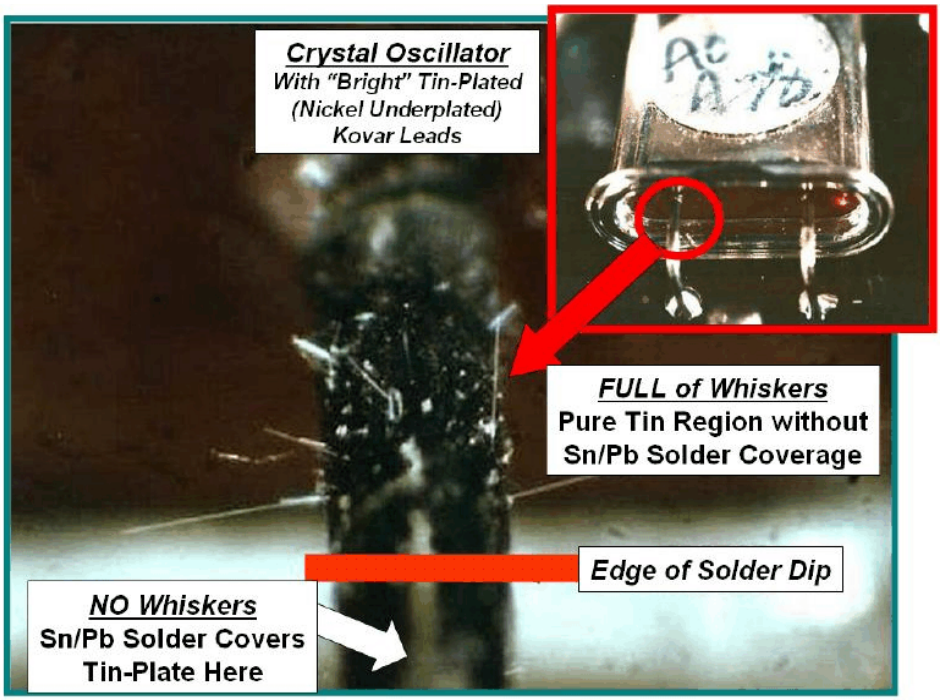
Solder whiskers are now a major concern in the electronics industry. They were virtually eliminated by the 1960s with the advent of modern lead-tin solders. With the advent of RoHS, these reliability issues have returned. By the time this Application Note is published it is expected that a number of US jurisdictions will undertake to enact similar hazardous substances mandates.

Generally, because of relatively large geometries and construction methods, transformers themselves should not experience major problems with whisker growth. However, CineMag does not recommend that RoHS compliant transformers be used where maximization of mean time between failures (MTBF) is critical.

Whiskers can grow to be many millimeters long. It is a good idea to keep this in mind when designing your product. Use of solder masks on pc boards may have some benefit but the whiskers are capable of undercutting or piercing weak areas in the mask. Keeping tin coated areas well separated as well as conformal coated may be helpful.

NASA reports that a number of satellites have failed because of Tin (Sn) whisker phenomena. Note that tin-lead solders significantly reduce this problem, as shown in these NASA photomicrographs.

Figure 1



Note that whisker growth is most aggressive at the bend in the leads coming from the crystal. Stress of Tin (Sn) accelerates whisker growth. Whisker growth is not limited to strained areas.

On April 17, 2005, the Millstone Power Station Unit 3 nuclear reactor located in Connecticut was automatically shut down when a tin whisker caused a short on a computer card. This gave the false indication that there was a major steam leak. This failure caused an automatic safe shutdown. It is feasible that a short could have disabled an automatic safety system and contributed to a "significant" reactor failure.

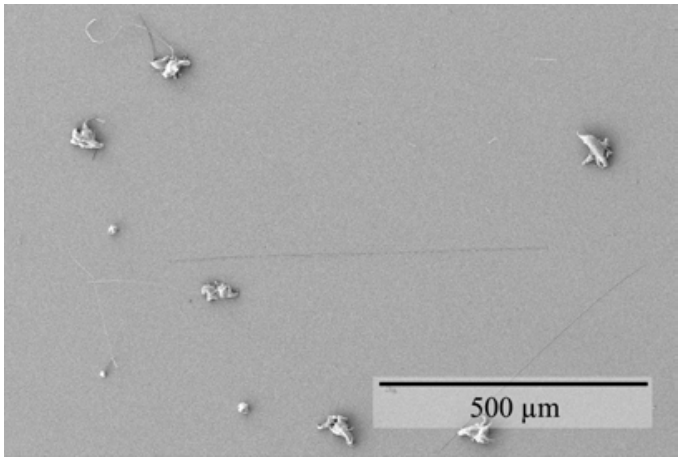
Whisker growth is not limited to Sn. Zinc (Zn) whiskers have shut down a major computer center before. Cadmium (Cd) and Silver (Ag) whisker growth in electronics have been well documented. Sn, though, is significantly more prone to developing whiskers.

Research indicates that Sn whiskers seem to erupt as a result of the release of inter-crystalline stresses. RoHS solders typically are an alloy of Sn, Copper (Cu) and Silver (Ag). These solders are very chemically active and dissolve Cu away much more rapidly that the Lead (Pb) based solders did. The rate materials are dissolved is a function of temperature. Be careful to regulate your working temperatures to the minimum which is practical thereby reducing the potential of damage to the component or pc board.

Again, do not be lulled into complacency because the Sn covered area has been conformal coated or because the most critical point is not a bent wire. Sn whiskers can undercut or pierce through weaknesses in conformal coatings. The conformal coating may enhance the MTBF rating, but this will not eliminate this failure mode. Sn whiskers will erupt anywhere there is Sn. Strain only accelerates the phenomena.

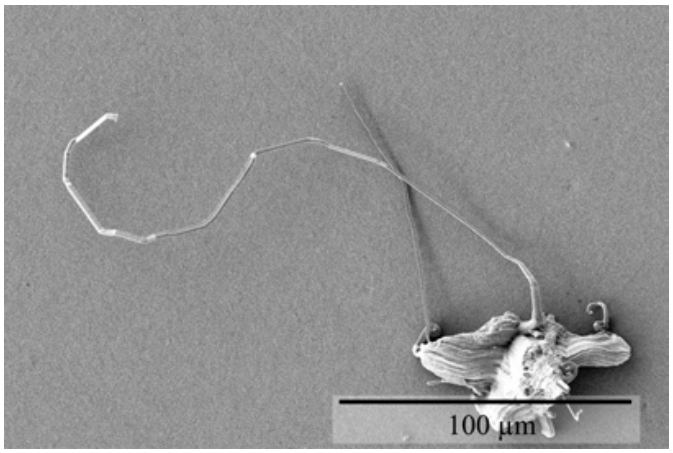
Work by Boettinger, Johnson, Bendersky, Moon, Williams and Stafford at the NIST in 2005 establish that these stresses result in the eruption of microscopic conical hillocks on the surface of the joint. Out of these hillocks are extruded very fine Sn whiskers. The following photomicrographs are of cantilevers upon which were electrodeposited a Sn-Cu alloy and subsequently strained.

Figure 2



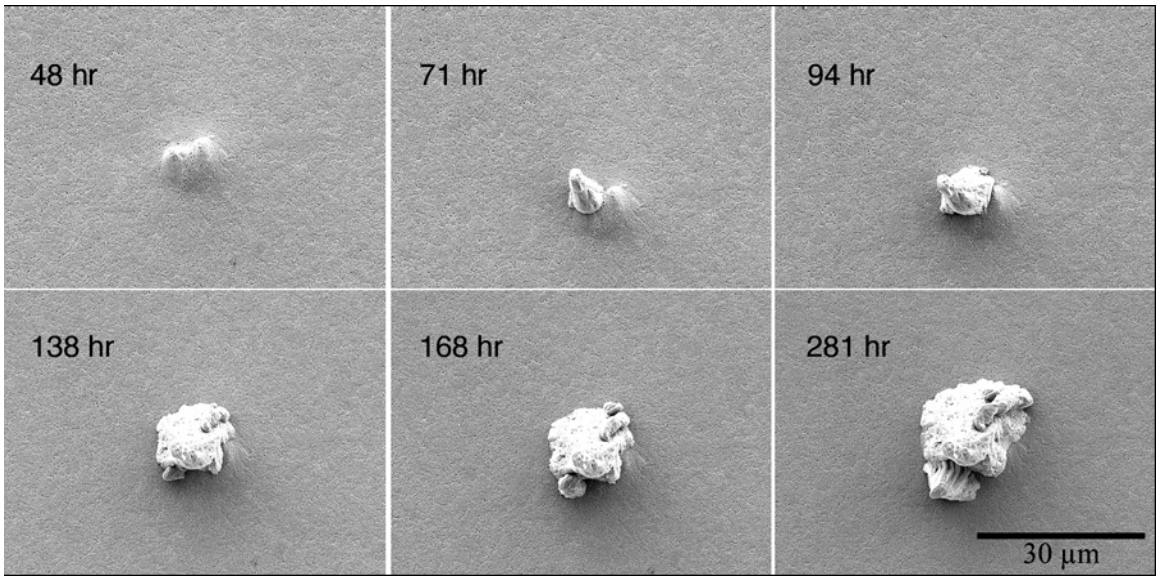
Note the whisker growing out of the hillock in the upper left-hand corner of this SEM micrograph of this Sn-Cu electrodeposited surface.

Figure 3



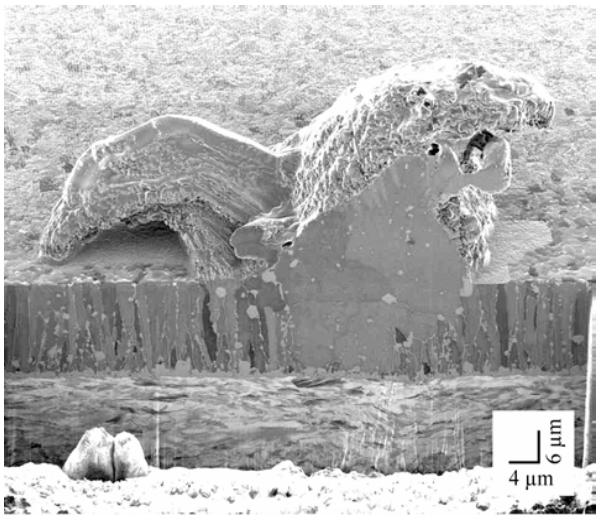
Close-up of the whisker in Figure 1

Figure 4



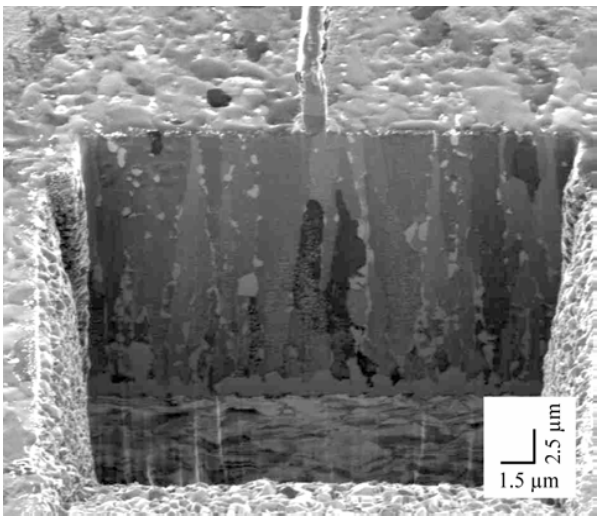
Growth of a hillock over the time period of less than 12 days.

Figure 5



Cross-section of a hillock.

Figure 6



Closeup of hillock. Note whisker erupting.

JIG-101

CineMag uses mu-metal alloys in most of its transformers as well as all of its shielding cases which are alloys containing a large proportion of Nickel (Ni). While not yet an issue with RoHS, Ni is not approved for extended contact with skin or tissues under the Joint Industry Guide JIG-101, as approved by the JEDEC Board of Directors.

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March 29, 2006