TIN WHISKERS ON LEAD-FREE PRINTED CIRCUIT BOARD AFTER FINISHING

R. Lange, U. Beck, M. Nowottnick

University of Rostock, Department of Informatics and Electrical Engineering, Albert-Einstein-Str. 2, 18051 Rostock, Germany

IUMRS-ICEM 2008

International Conference for Electronic Materials

28th Jul - 1st Aug 2008

Hilton Sydney, Australia

Introduction - technological background

Tin whiskers are posing a substantial problem for electronic assemblies. Especially with introduction of surface mount technologies in the 80th the distances between the components have shortened and structures on assemblies have become so cloth to each other, that whiskers are able to excite dangerous short circuits.
Nowadays the usual small outline components have pitch measures of 1.25 mm, so called 'flat packs', partially only of 0.5 mm. The insulating distances between neighboured wires are sometimes less than 0.2 mm. Whiskers on tin coatings have a growing rate up to 0.3 nm/s and can attain a length of some millimetres [Kle-98]. However the intensive growth occurs only for alloys with more than 70 % tin, therefore this problem was solved by using of corresponding alloys. Till 2006 the eutectic tin-lead-alloy with 37 % Pb was regarded as a standard solder, without dispose of whisker growing.
Since 2006 the European environmental legislation RoHS has come into effect, which bans the use of lead in electronic assemblies. An increasing implementation of solders containing high percentage of tin like SnAg3.5, SnCu1, SnAg3.5Cu0.5 or pure tin takes place. Comparable initiatives like RoHS have also caused a prohibition of lead in Japan, Korea or China, so that it has become a global phenomenon. Therefore the whisker problem is topical again.

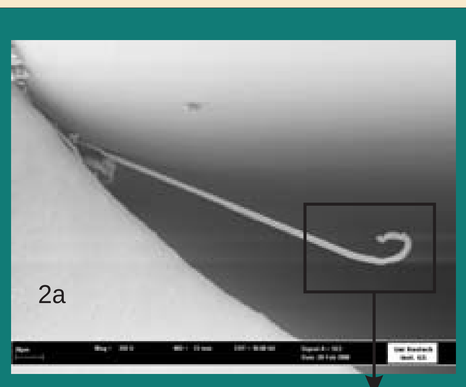
The aim of our contribution is to be a sign of the threat of whisker growth on lead-free solder and give a demonstration of this.

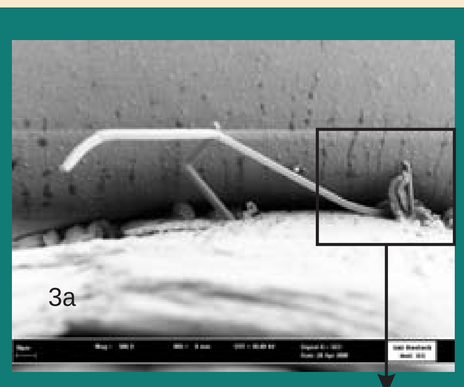
Material and methods

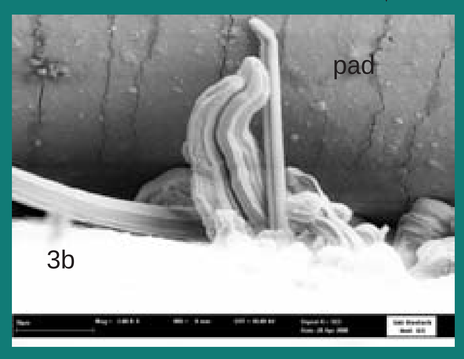
A printed circuit board coated with lead-free HASL and cold assembled by press-fit technology was analysed. The investigations were made by use of SEM (FESEM SUPRA 25, Zeiss, Germany) and EDX (X-flash + Quantax, Bruker AXS, Germany).

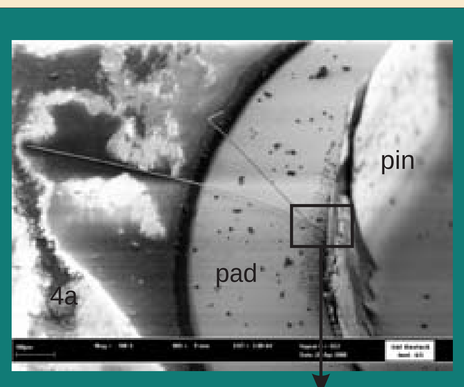
Fig.1: Connect assembly on printed circuit board cold assembled by press-fit technology.

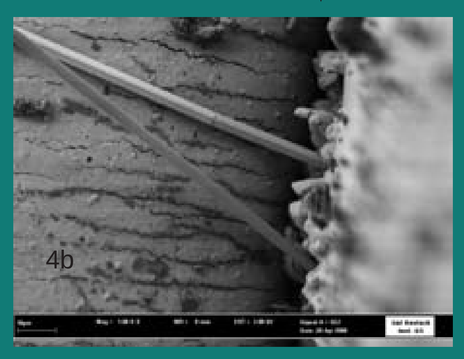
Fig.2-6: SEM-pictures of whiskers found in several regions of the connect assembly pictured in fig. 1. The whiskers are growing out of the mechanical stress region around the pin pressed in the lead-free solder coated pad. (several magnifications, see µ-bar)

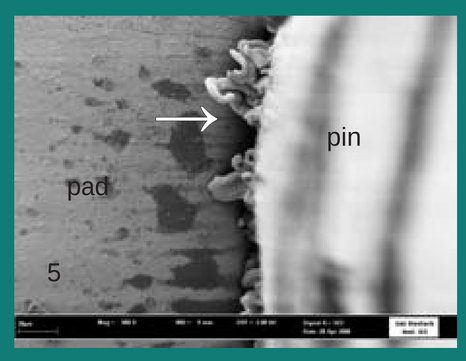


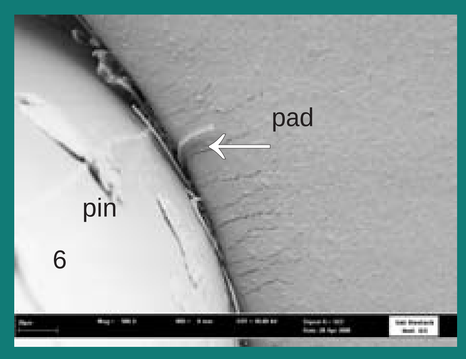


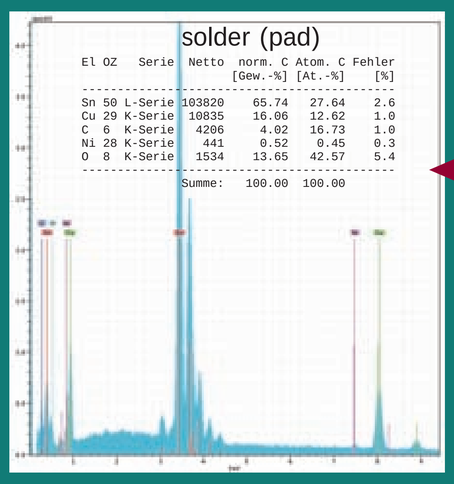


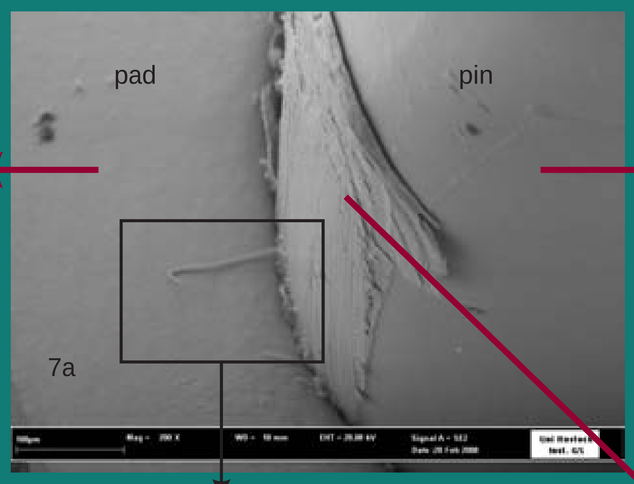












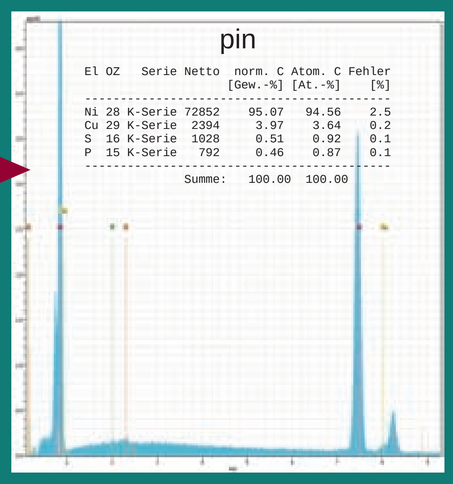
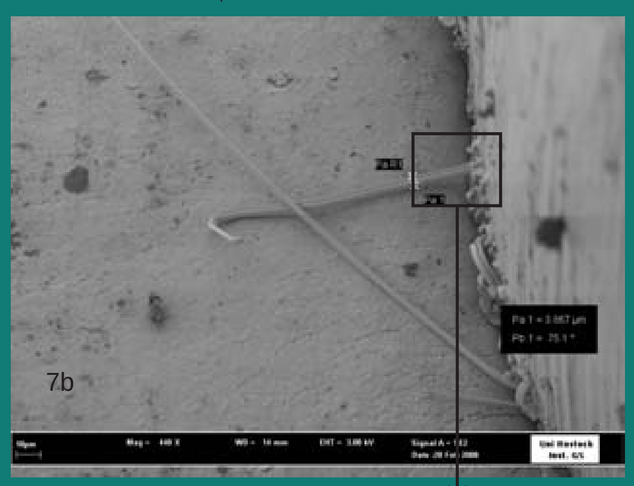
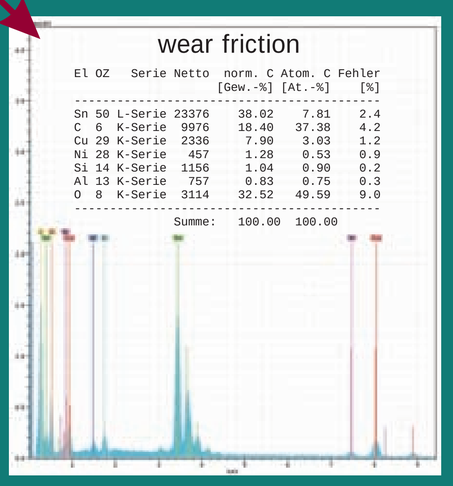
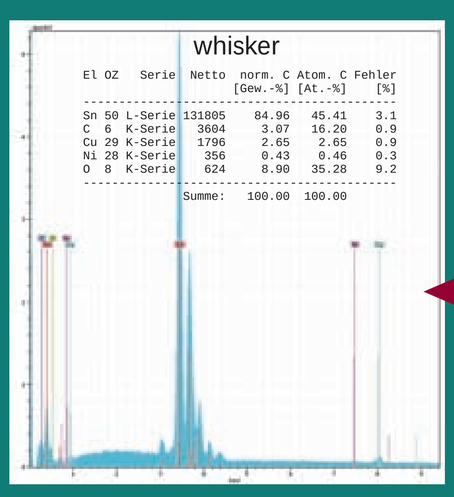


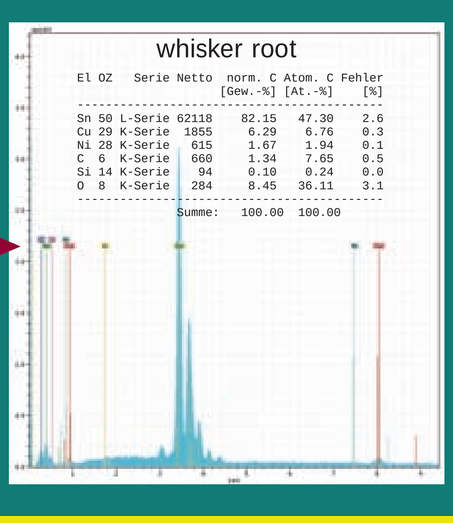
Fig. 7a-c: SEM pictures of whisker growth in three magnifications (see µ-bar). EDX-analysis for the three regions seen in figure 7a are assigned above and to the right: pad, pin and wear friction caused by mechanical stress due to the press-fit technology. As you can see the solder of the pad coating is mainly composed of Sn (66 w%) and Cu (16 w%). The pin mainly consists of Ni (95 w%) and some Cu (4 w%). The wear friction around the pin contains 38 w% Sn and also Cu and Ni.

The EDX-analysis of the whisker shown in fig 7c in high magnification (below) shows that it mainly consists of Sn (85 w%).









Results and discussion

The so called hot air solder levelling (HASL) coating with molten solder is the most popular surface finish today. This is also due to the very good solder ability, storability and low costs of HASL surface finish. The lead-free variant of HASL very often consists of a SnCuNi alloy with more than 98 % tin. Usually it is assumed, that lead-free HASL has no risk of whisker growing [Nih-05], but this is only true for whiskers caused by thermal or self induced stress.

For externally caused mechanical stress, which is inevitable for the press-fit technology, a whisker growing is also possible for lead-free HASL. But in particular the press-fit technology becomes more important because of the lead prohibition. Especially for plugs, which are very sensitive against the increasing soldering temperatures for lead-free solders, the cold assembling with press-fit technology is a reasonable alternative. The hard pins of the plugs will be pressed into to the soft coated undersized holes of the printed circuit board. Even this combination of lead-free HASL and press-fit technology causes a higher risk of whisker growth due to the high local mechanical stress.

Our pictures show a printed board connected through, coated with lead-free HASL and cold assembled by press-fit technology. The Tin-Whiskers grow out of the mechanical stress region between the pin pressed in and the lead-free solder and have a diameter of about 4 µm. The length of the whiskers is sufficient to cause a break on printed circuit boards. By EDX analysis it could be shown that the material of the whiskers is rather pure tin.

Conclusions

We could show that Tin-Whiskers can outgrow from the mechanical stress range between pressed in pin and lead-free solder coated on a printed circuit board. That is the combination of lead-free HASL and press-fit technology causes a very high risk of whisker growth due to the high local mechanical stress. The length of the whiskers is sufficient to cause breaks on printed circuit boards.

An alternative to this problematic combination could be either the soldering of plugs made of heat resistant materials or the application of tin-free coatings on the printed circuit boards like “immersion silver” [Han-99]. Certainly both solutions will cause additional costs.

References:

Klei-98 R.J. Klein Wassink, Soldering in Electronics; Electrochemical Publications Ltd., 2nd Edition; Ayr 1989
Nih-05 Nihon Superior; Engineering Dept.; Reliability of SN100C; 24. March 2005
Han-99 M. Hannemann; M. Nowottnick; R. Zajitschek: Lötbare Oberflächen für Leiterplatten; 1. Auflage, TGBZ Steinheim/Main 1999

Ulrich Beck
University of Rostock, Department of Informatics and Electrical Engineering
Albert-Einstein-Str. 2, D-18051 Rostock
+49 381 498 7233 Fax +49 381 498 118 7233
E-Mail: ulrich.beck@uni-rostock.de