doi:10.1017/S1431927617009539
Microsc. Microanal. 23 (Suppl 1), 2017
© Microscopy Society of America 2017

Microscopic Analysis of Tin Whisker Growth on Tin Plated Copper Microchip Leads.

A. Rochester [1], D. Burdick[2], H. Aglan [1]

[1.] Tuskegee University, Tuskegee, AL, USA
[2.] The Boeing Company, St. Louis, MO USA

Tin whiskers are microscopic growths made of single crystals of pure tin that are formed on the surface of tin plated copper substrates or electronic circuit boards. Their growths are a current challenge in the aerospace, defense and high performance electronics industry as the reliability of electronics is in question due to the formation of bridging short circuits between two whiskers in high impedance electrical equipment. [1] They can grow spontaneously at room temperature with a diameter of a few microns and an elongation of up to few millimeters. The growth mechanisms have been discussed by many researchers resulting in a number of hypotheses. Tin (Sn) Whisker formation is promoted in regions where stress is applied which indicates their initiation is associated with dislocation behavior [2]. Stress accelerated growth of whiskers is caused by the diffusion of Cu into Sn to form grain boundary precipitates that cause compressive stresses [3]. Other growth mechanisms include residual stresses, externally applied stresses, stored energy, surface energy effects, thermal expansion mismatch, corrosion, electroplating, etc. [1-3].

The current study identifies tin whisker growth on a lead frame exposed to different environmental conditions. The tracking of the growth of these whiskers over periods of time was examined using SEM. The tin plated copper leads were supplied by The Boeing Company and were subjected to a) hygrothermal environment with 90% relative humidity at 90˚C and b) 5 wt% salt bath solution (suspended above liquid).

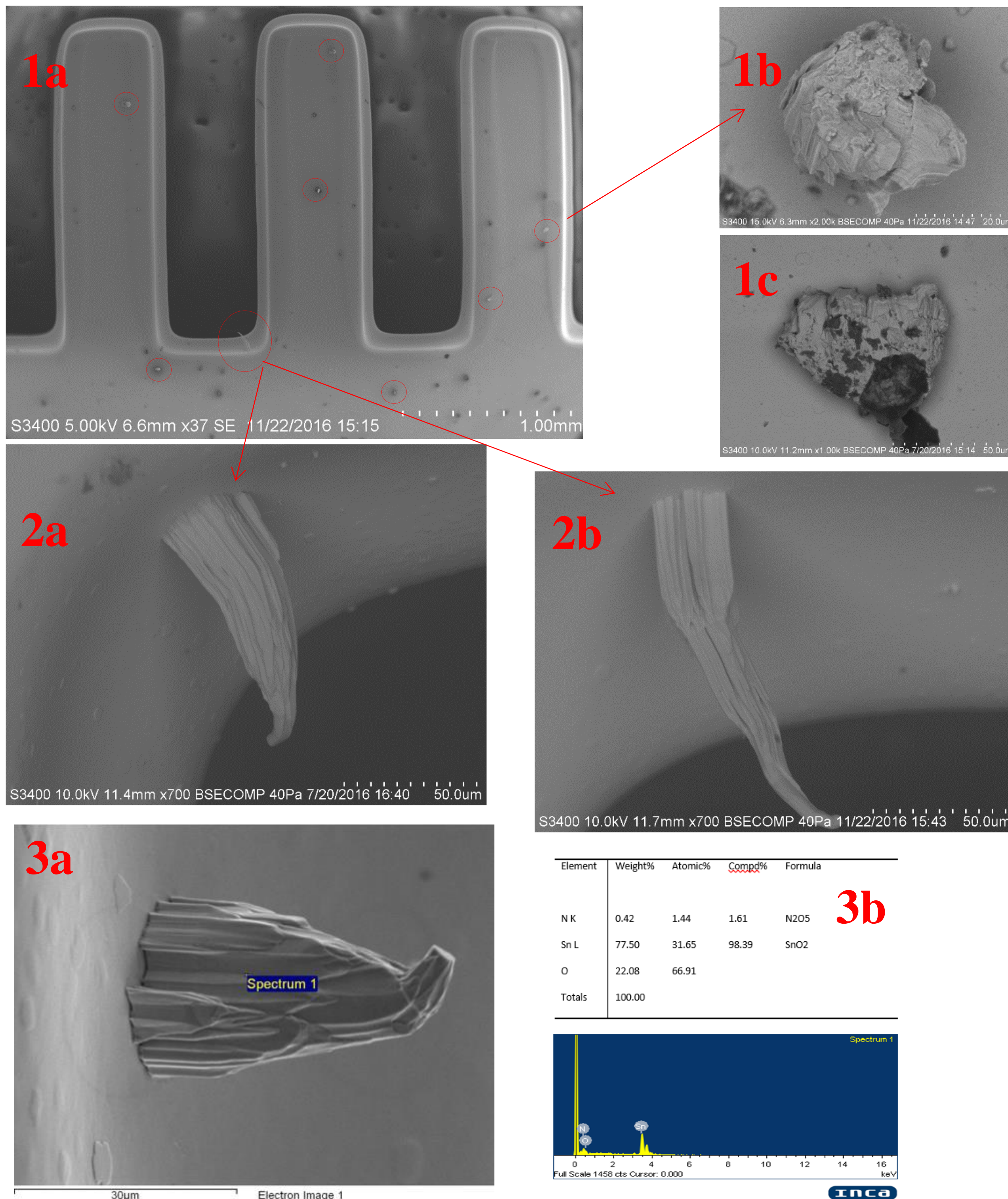
The identification and analysis of hillock formation and whisker growth was carried out using a Hitachi SN-3400 Scanning Electron Microscope (SEM). Figure 1a shows the early stage of whisker growth by hillocks formation, as well as isolated growth of whiskers. Figure 1b is a high magnification of one of the hillocks showing an early formation (indicated by an arrow). Figure 1c shows a hillock, with salt scale deposits, that was captured on a lead frame in the salt environment. Figure 2a shows a whisker in the corner of the lead that was captured July 20, 2016. After 4 months the same whisker was observed at the same magnification. The effect of time on the growth of Sn whiskers can be examined from Figures 2a &2b. The whiskers have grown in length and reduced in diameter by 42µm and 8 µm, respectively. This gives an elongation rate of 10.5 µm/month in length and reduction rate of 2 µm/month in diameter. Figure 3 shows a fully developed whisker from the surface of the lead frame. The facets can be vividly seen on the surface of the whisker and shows a change in direction of the growth. Energy Dispersive X-ray Spectroscopy (EDS) was conducted on the whisker in figure 3a to determine and confirm its composition. It was found that the composition was 98.39 % Sn.

In summary, SEM analysis has provided practical means to study the initiation and growth of tin whiskers on the surface of a lead frame. The composition of the whisker was determined to be almost pure tin. Based on this limited experiment, it was found that there is no significant difference between the frequency of hillock formation in the hygrothermal and salt environments.

References:

[1] H Aglan, K Prayakarao, M Rahman, and D Burdick, Engineering 7 (2015), p. 816-26.
[2] T Shibutani, J Wu, Q Yu and M Pecht, Microelectronics Reliability 48 (2008), 1613-27.
[3] K Nakai, *et al,* Journal of Physics: Conference Series (2009), p. 012089.

https://doi.org/10.1017/S1431927617009539 Published online by Cambridge University Press



Element	Weight%	Atomic%	Compd%	Formula
N K	0.42	1.44	1.61	N2O5
Sn L	77.50	31.65	98.39	SnO2
O	22.08	66.91		
Totals	100.00			

Figure 1: (a) Whisker with developed whiskers, hillocks and salt crystals. (b) hillocks and (c) hillocks and salt crystals

Figure 2: (a) Lead corner whisker (b) lead corner whisker 4 months later

Figure 3: Elemental analysis to identify composition of tin whisker

https://doi.org/10.1017/S1431927617009539 Published online by Cambridge University Press