Tin Whisker and Surface Defect Formation on Electroplated Films and Reflowed Joints

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Research Funding from
Crane Naval Surface Warfare Center and Cisco
Definitions - Whiskers and Hillocks

• **What is a whisker?**
  – Metallic filament – grain diameter thick
  – Grows spontaneously
  – Electrical reliability risk

• **What is a hillock?**
  – Growing grain with surface uplift
  – Spontaneously grows
  – No electrical reliability risk
Defect Types and Morphologies:

- Hillock formation was promoted by generalized GB pinning with some mobile GBs (Boettinger et al, 2005).
- Hillock to whisker transition with ↑%Cu (Pedigo et al, 2008)
- Idealized hillock growth model (Pedigo et al, 2008)
  - Steps from vertical growth
  - Terraces from lateral GB migration
  - Ridges reveal triple line positions

Top-view schematics of a hillock showing traces of grain boundary movement

Side-view schematics of a hillock showing steps and terraces
Defect Morphology with increasing Cu concentration without Pb:

- Hillocks were found on all samples.
- Additional defect morphologies found with ↑%Cu
  - Hillocks (small, compact)
  - Hillocks with large initial vertical growth
  - Whiskers (composition as low as 0.2wt%Cu)
Defect Morphology with increasing Pb at constant Cu concentration:

- No ‘stand alone’ whiskers were observed on samples containing Pb.
- Increasing different morphologies of defect found with ↑%Pb
  - Hillocks with less defined steps and terraces...
    - gradual broadening of base.
  - Hillocks with secondary defects.
Defect ‘Phase Diagram’:

Defect Density (#/mm²) and Morphology, at 240 days after plating, as a function of Pb and Cu concentrations in films.

Defects:
- Large Hillocks with gradual broadening, irregular boundaries and secondary defects
- Medium Hillocks with gradual broadening
- Hillocks with large initial vertical growth
- Small, compact Hillocks
- Whiskers

Pure Sn 0

0 0.1 0.2 0.5

wt% Pb

wt% Cu

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