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

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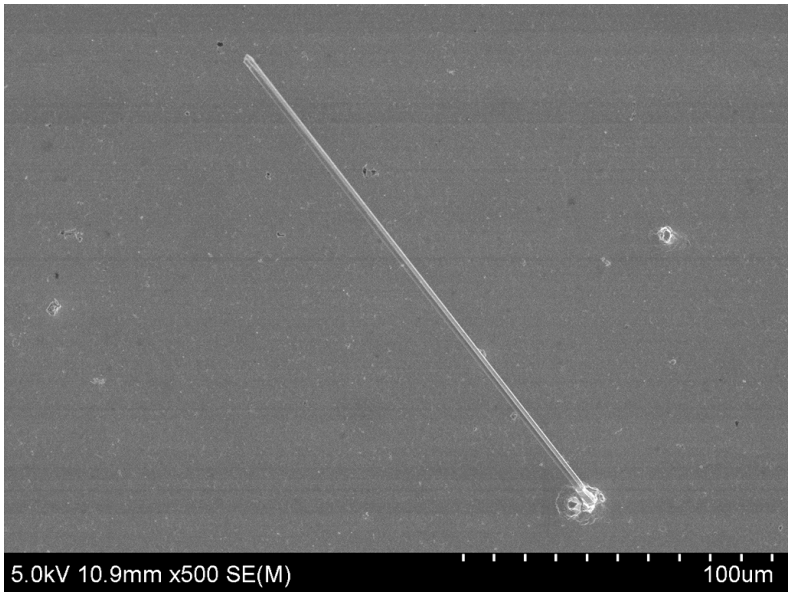
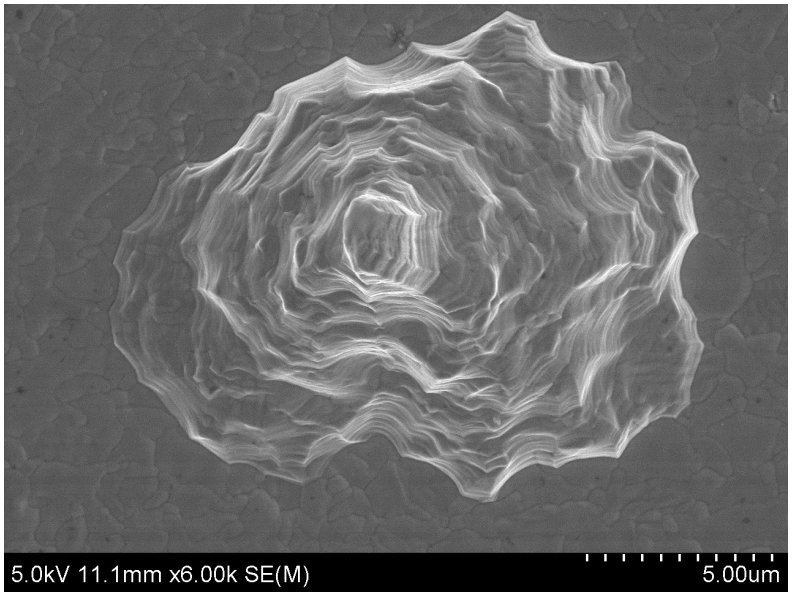
Research Funding from
Crane Naval Surface Warfare Center and Cisco

Definitions - Whiskers and Hillocks

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

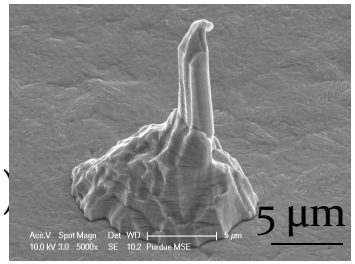


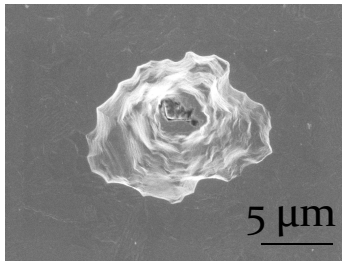
- What is a hillock?
  - Growing grain with surface uplift
  - Spontaneously grows
  - No electrical reliability risk

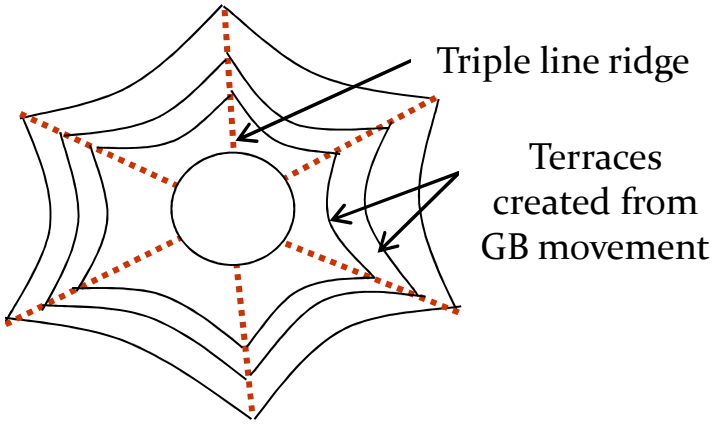


Defect Types and Morphologies:

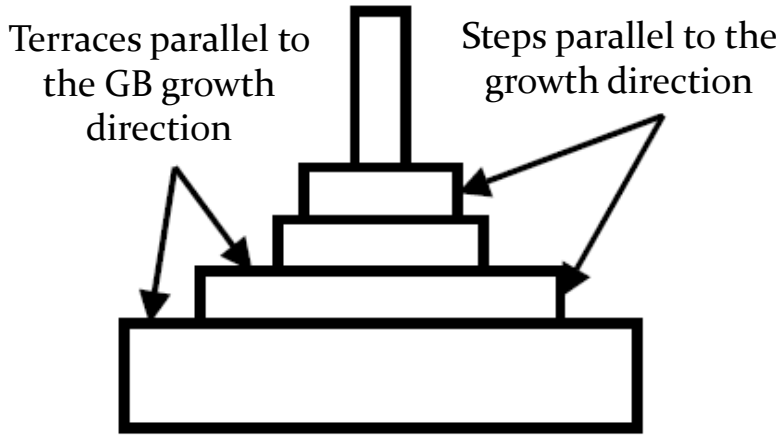
- Hillock formation was promoted by generalized GB pinning with some mobile GBs (Boettinger *et al*, 2005).
- Hillock to whisker transition with ↑%Cu (Pedigo *et al*, 2008)
- Idealized hillock growth model (Pedigo *et al*, 2008)
  - **Steps from vertical growth**
  - **Terraces from lateral GB migration**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







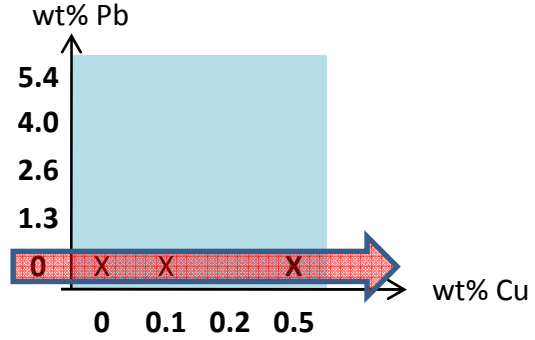
Top-view schematics of a hillock showing traces of grain boundary movement

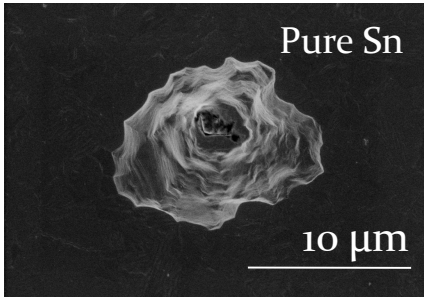


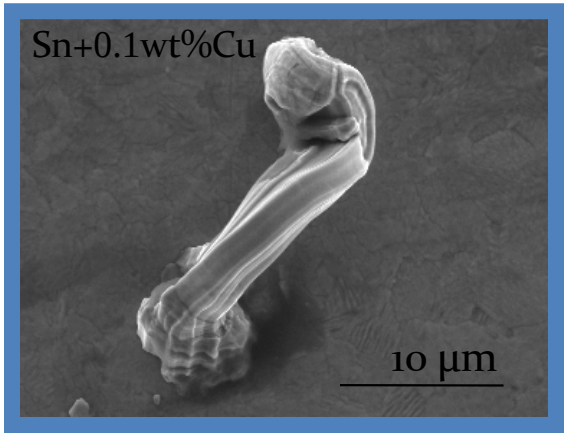
Side-view schematics of a hillock showing steps and terraces

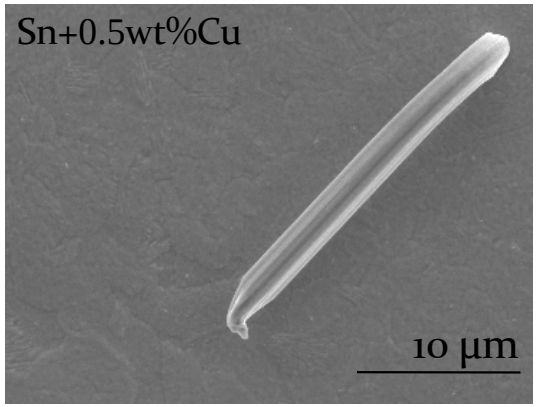
Defect Morphology with increasing Cu concentration without Pb:

- 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)



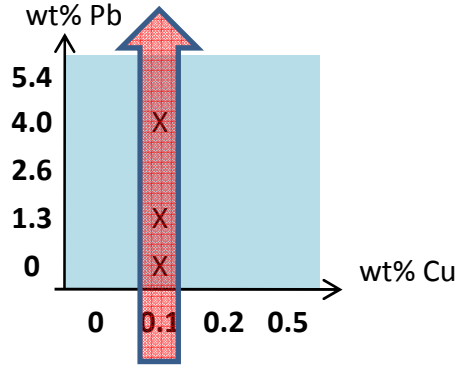


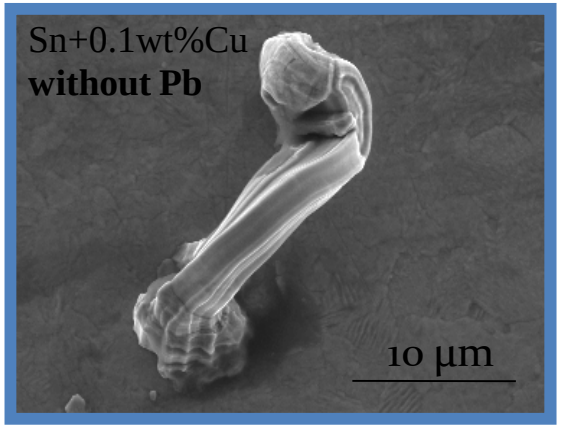


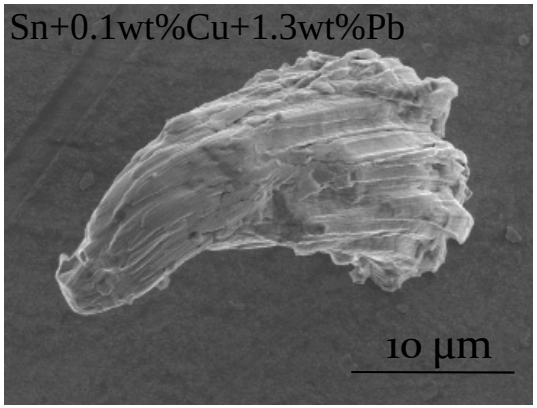


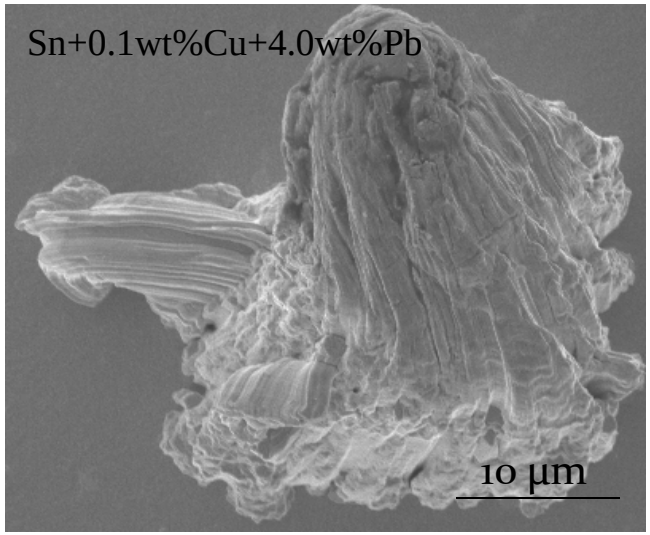
Defect Morphology with increasing Pb at constant Cu concentration:

- 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