

# Extrusion Process

- Definitions

## Websters Dictionary –

- To force a metal, plastic, etc. through a die or very small die or small holes to give it shape. Websters Dictionary 3<sup>rd</sup> College ed. 1988

## Metallurgical Dictionary -

- The conversion of a ingot or billet into lengths of uniform cross section by forcing metal to flow plastically through a die orifice. ASM Materials Dictionary 1992
- A deformation processing technique in which a material is pushed through an opening in a die. The Science and Engineering of Materials, 4<sup>th</sup> ed., Askeland and Phule 2003
- The process by which a a block of metal is reduced in cross section by forcing it to flow through a die orifice under high pressure. Metallurgy, Dieter, 1961

- Effect on Microstructure

- Grains become elongated
- Increase in dislocation density
- Strain hardening (cold work)

## How does extrusion apply to Sn whiskers?

Sn whiskers growing by extrusion would need a

- Die or small hole to force the metal through
  - Surrounding pinned grain boundaries (by oxide film or IMC)
- Pressure source
  - Residual compressive plating stress

-> extrusion type whiskers (based on observations):

- thick diameter with striations (~3 - 5 micrometers diameter)
- odd shaped eruptions (OSEs) can be poly-crystalline

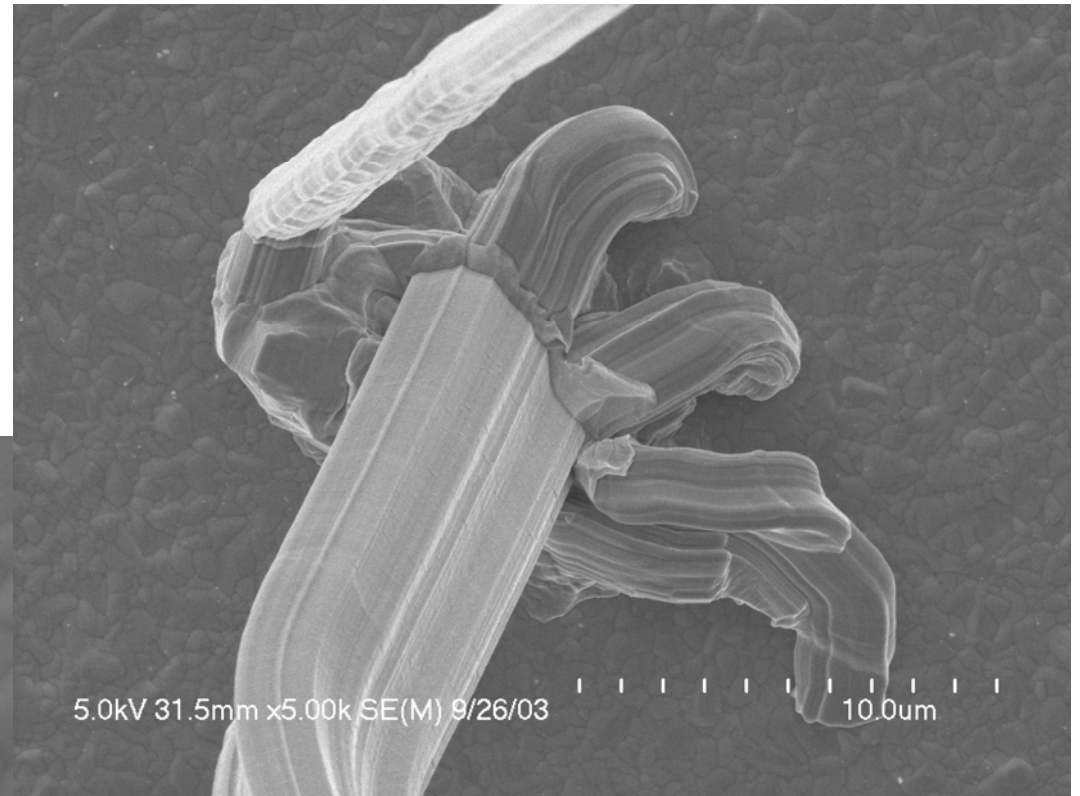
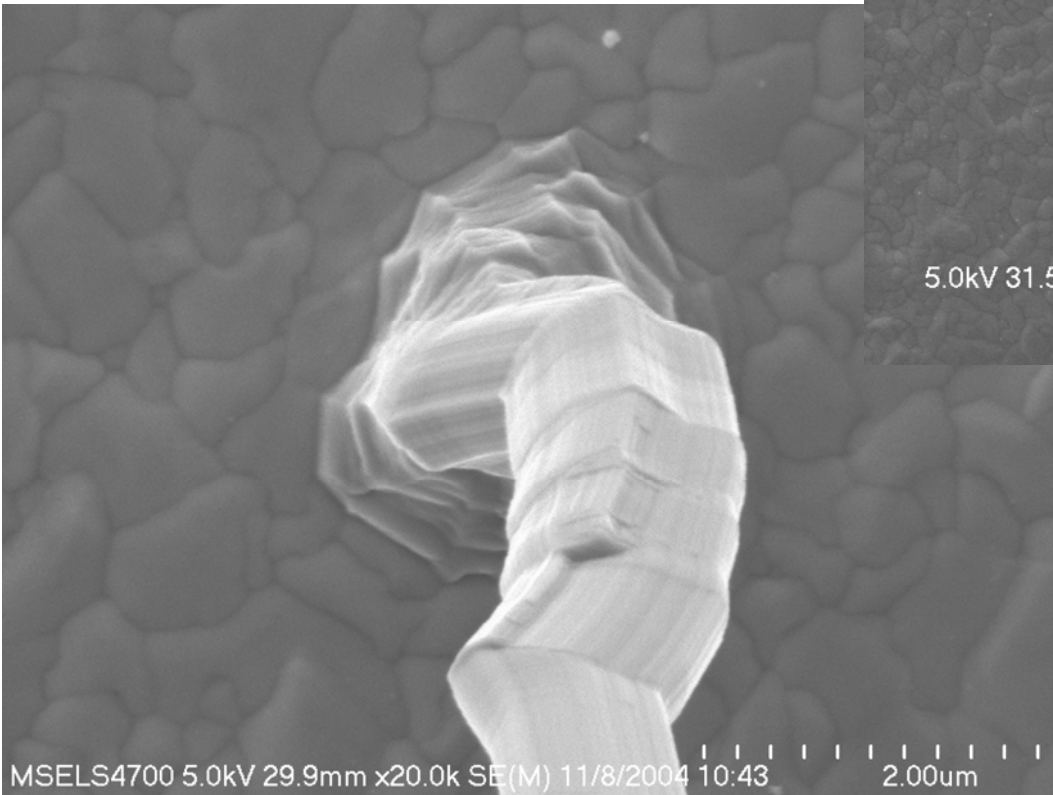
-> the same mechanism as squeezing toothpaste

---

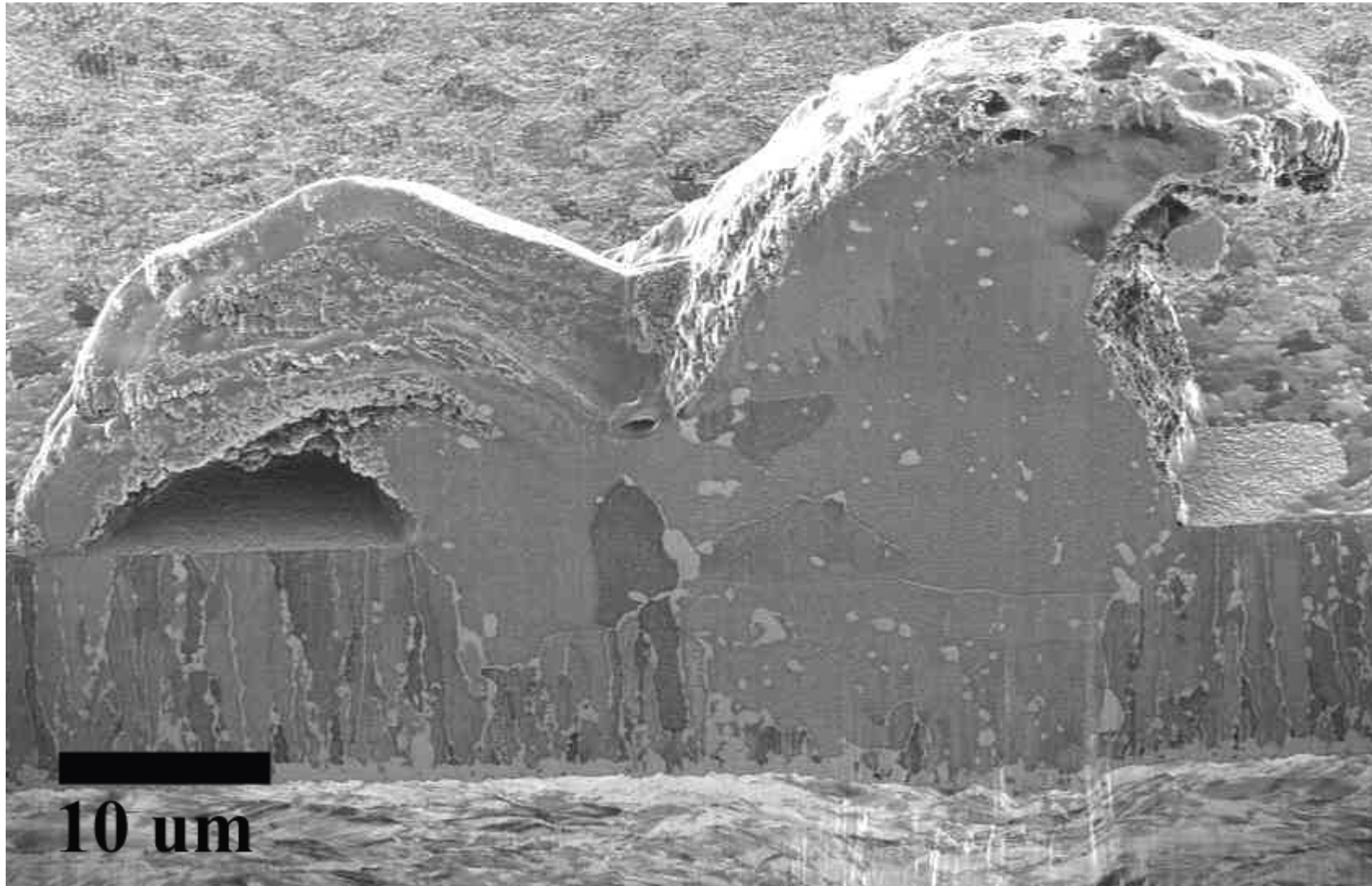
However, **UNLIKE** squeezing toothpaste out of a tube, there are Filament Type Whiskers

- They are growing from small grains near the surface
- Their diameters are 1 – 2 micrometers
- They are single crystals
- They may be free of defects

What is the growth mechanism?



Odd shaped eruption (OSE) on 15  $\mu\text{m}$  thick Sn-3wt%Cu electrodeposit on phosphor bronze substrate



FIB image courtesy of G. Galyon & M. Palmer, IBM

FIB cross section of small thick whisker (covered with Pt)  
the sample is 15  $\mu\text{m}$  thick Sn-3wt%Cu electrodeposit on a phosphor bronze substrate

