Textured Materials
Jason Wolf

27-750
Texture, Microstructure & Anisotropy
A.D. (Tony) Rollett

Last revised: 7th Sep. 2009
Meaning of Texture

• Preferred Orientation of grains within a material.
• Crystallographic Preferred Orientation (to be more precise).

• Has nothing to do with surface roughness!
• Has everything to do with orientation of unit cells.
Textured Grass
X-Rays and Texture Analysis

• You can see grains under a microscope, but you cannot see the orientation of the unit cells within those grains.
• X-Rays and electrons can be diffracted from atomic planes.
• Varied arrangement of planes (texture) provides differences in diffraction patterns.
XRD Texture Analysis: Tools & Terminology

• X-Ray Diffraction
  – Bragg’s Law: \( \lambda = 2dsin \theta \)
  – Goniometer with several degrees of freedom

• Crystallography
  – Miller Indices: (hkl)

• Sample Microstructure
  – Grain Size
Conventional (Powder) Diffraction
Mostly used for phase analysis

Typical powder pattern. Contains many peaks.
Conventional Diffraction from Textured Materials

Grains are not randomly oriented.

Highly textured sample.
e.g. rolled sheet, sputtered film.

Perfectly textured sample;
e.g. single crystal, epitaxial film.
Very few peaks in the XRD scan. One peak dominates the scan. Other peaks of interest may be weak or absent from pattern.
XRD Pole Figure System

detector  goniometer  parallel optics  X-ray tube
Focusing Problem

Tilting the sample causes a focusing problem with conventional slit optics.

focused slits

slits out of focus due to specimen tilt
Parallel Optics

A solution to the focusing problem uses parallel optics.

A parallel x-ray beam can be achieved using a bank of parallel slits called a Soller slit. However, since the original x-ray source is divergent this results in a tremendous loss of intensity.

A better method for producing a parallel beam utilizes an x-ray lens.
Parallel Optics

X-ray lens:

An x-ray lens is a shaped bundle of millions of narrow glass capillaries. Divergent x-rays reflect along the inside walls of the capillaries until they emerge as a parallel beam. The same total external reflection effect is used in fiber optic cable.

The lens provides not only a parallel beam, but also an increase in overall intensity. X-rays that would have been blocked by a slit are now reflected toward the specimen.

Since the capillaries are round, the lens creates a circular beam that is cylindrically parallel. This permits diffraction for any direction of sample tilt.
X-Ray Pole Figures
Prepare sample

• Surface must be flat
• Polishing NOT always necessary
• Round sample face is best
  – square sample is OK
  – oblong sample should be cut square
• Larger area is better
  – 1x1 inch is good, 1x1 cm is minimum
X-Ray Diffractometer
θ/2θ Scan
PDF # 040787, Wavelength = 1.54056 (Å)

Aluminum

Ref: Swanson, Tatge, Natl. Bur. Stand. (U.S.), Circ. 539, I, 11 (1953)

fixed, slit intensity

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Pole Figure Scan

- Fix $\theta/2\theta$
- Vary psi and phi
  - Run a 360 degree phi scan at each psi step
  - 5 degrees steps
  - 1 or 2 second count time per step
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Converting to POPLA format

• Instruction sheet to be posted on the CMU 27-750 electronic black board.
What POPLA does

- Plots pole figures
- Applies corrections
- Calculates ODF’s and more
Background and Defocussing
Advantages over OIM

• Larger surface area examined
• No polishing needed
• Faster
Pole Figure Project Ideas

• Coins
• Soda can
• Soup can
• Razor blade
• Transformer plate
• Key
• Some metal that has been rolled
• Chocolate