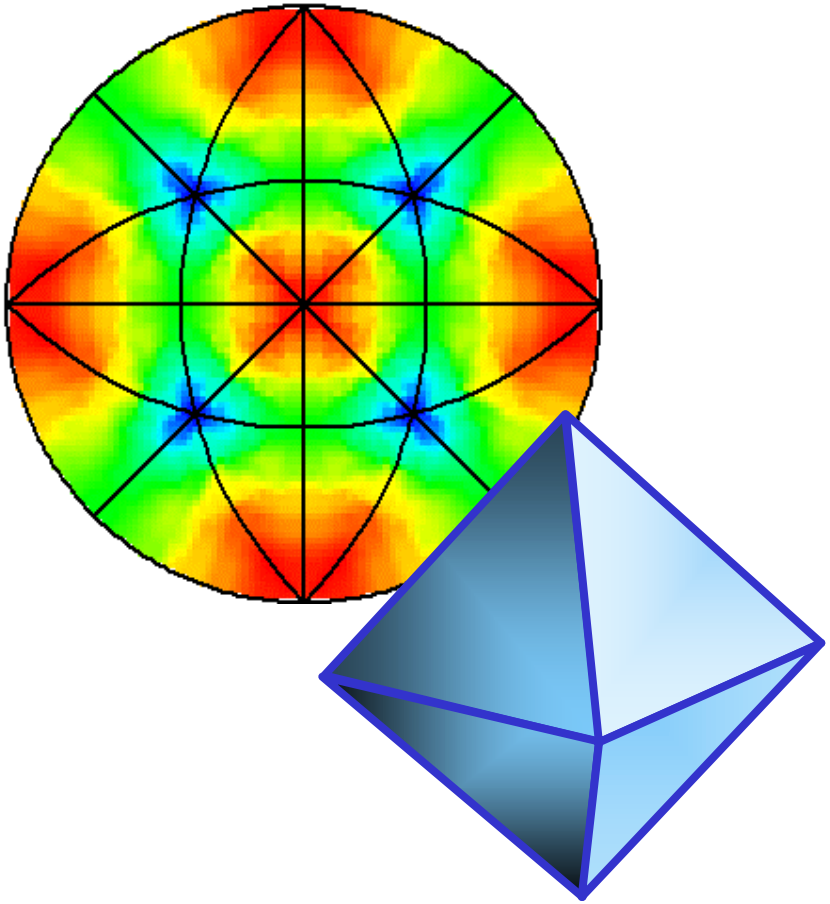
Polycrystals Have Good Habits

G. Rohrer/CMU MRSEC, Carnegie Mellon University, DMR-0079996

Most metallic and ceramic materials used in aircraft, automobiles, and devices such as computers are made up of many microscopic crystals held together by grain boundaries. These materials are referred to as polycrystals. We have found that the crystals in these materials have average shapes or "habits" analogous to the faceted shapes that are visible to the naked eye on specimens of certain minerals. This finding is important both as a simplifying principle in the study of polycrystals and because the properties of these materials depend on the shapes of the individual crystals and how they are held together.



Experimentally derived distribution of boundary planes in a commercial Al alloy (above) indicates that the average shape or habit of the crystals is dominated by octahedral facets, as illustrated schematically below.

Synchronized Transatlantic Synchrotron Research

R. Suter/CMU MRSEC, Carnegie Mellon University, DMR-0079996

Scientists in Carnegie Mellon's MRSEC are collaborating with scientists at Risoe National Laboratory (Denmark) on the development of a new technique for probing the internal microstructure of polycrystals. Using high energy synchrotron x-rays that penetrate through centimeters of solid samples, the technique can nondestructively measure the shapes and orientations of individual grains and how they change with time. This information is needed to understand how to control the properties of advanced ceramic and metallic materials. Henning Poulsen's group at Risoe built the first facility at the European Synchrotron Radiation Facility in Grenoble. Together we are working to develop a second generation facility at the Advanced Photon Source.

ESRF ID-11 dedicated facility

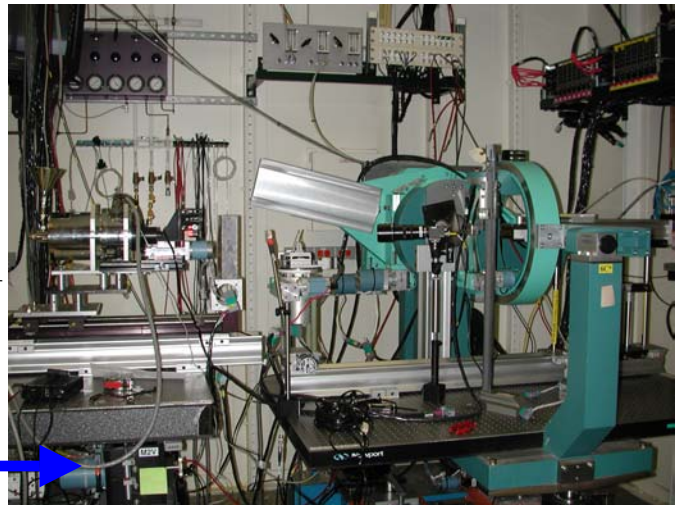
Carnegie Mellon University MRSEC Collaboration with Risoe National Laboratory, Denmark

Development of the Three Dimensional X-ray Diffraction Microscope:

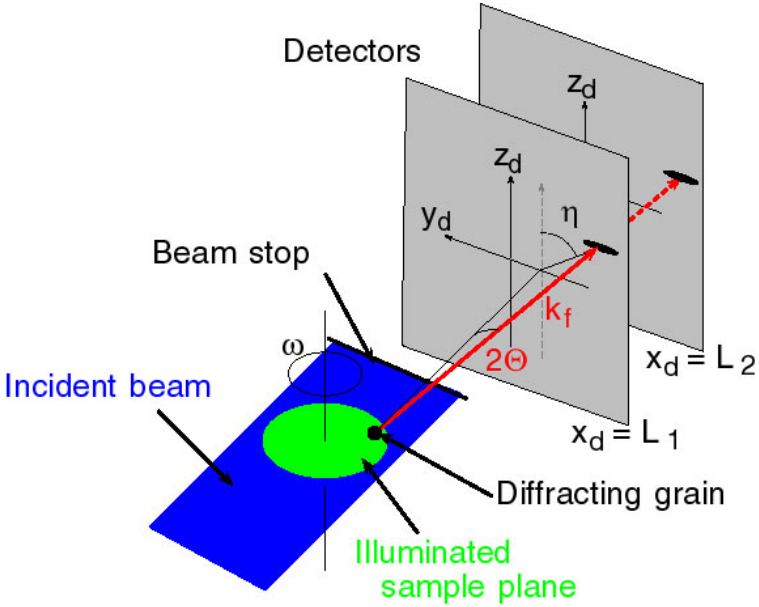
- Fundamental science of polycrystals
- Non-destructive probe of internal bulk microstructure
- Watch microstructure dynamics deep inside bulk materials

ESRF ID-11 dedicated facility

APS XOR-1 general purpose high energy x-ray beamline



Overview of the Technique

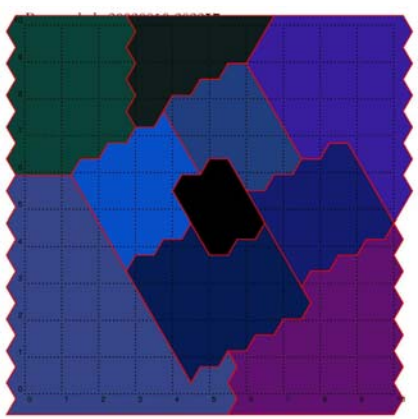


- ~ 2 μm spatial resolution
- < 1 degree orientation resolution

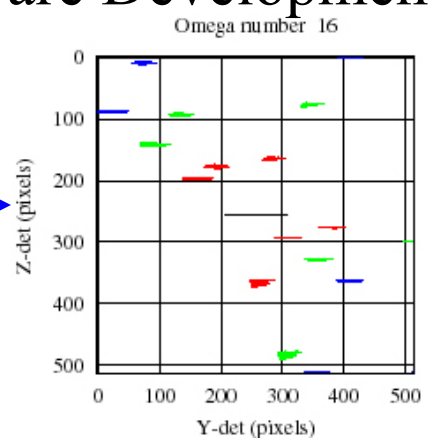
Requires:

- Over 100 CCD images per plane
- Precision rotation
- High resolution detector

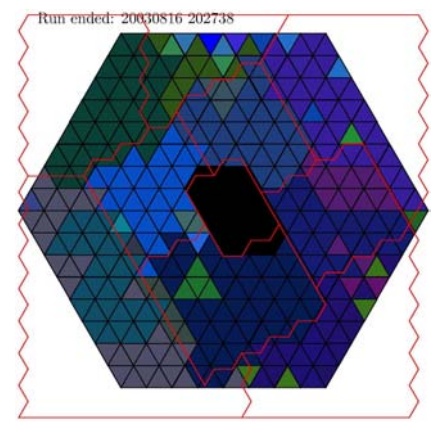
Software Development Test



Simulated microstructure



Diffraction images L1, L2, L3



Ab-inito reconstruction of microstructure

Collaboration Activities

- Group meeting in Roskilde
  - Progress reports
  - Software strategies
  - Division of labor
- Two trips to ESRF
  - Data collection, hands-on
- Trip to High Energy X-ray Scattering Workshop, Hamburg
- Submission of APS "Partner User Proposal" for additional beamtime
- CMU Purchase of precision rotation stage for collaboration users