Probing the Basic Science of Polycrystals with Microfocused High Energy X-rays

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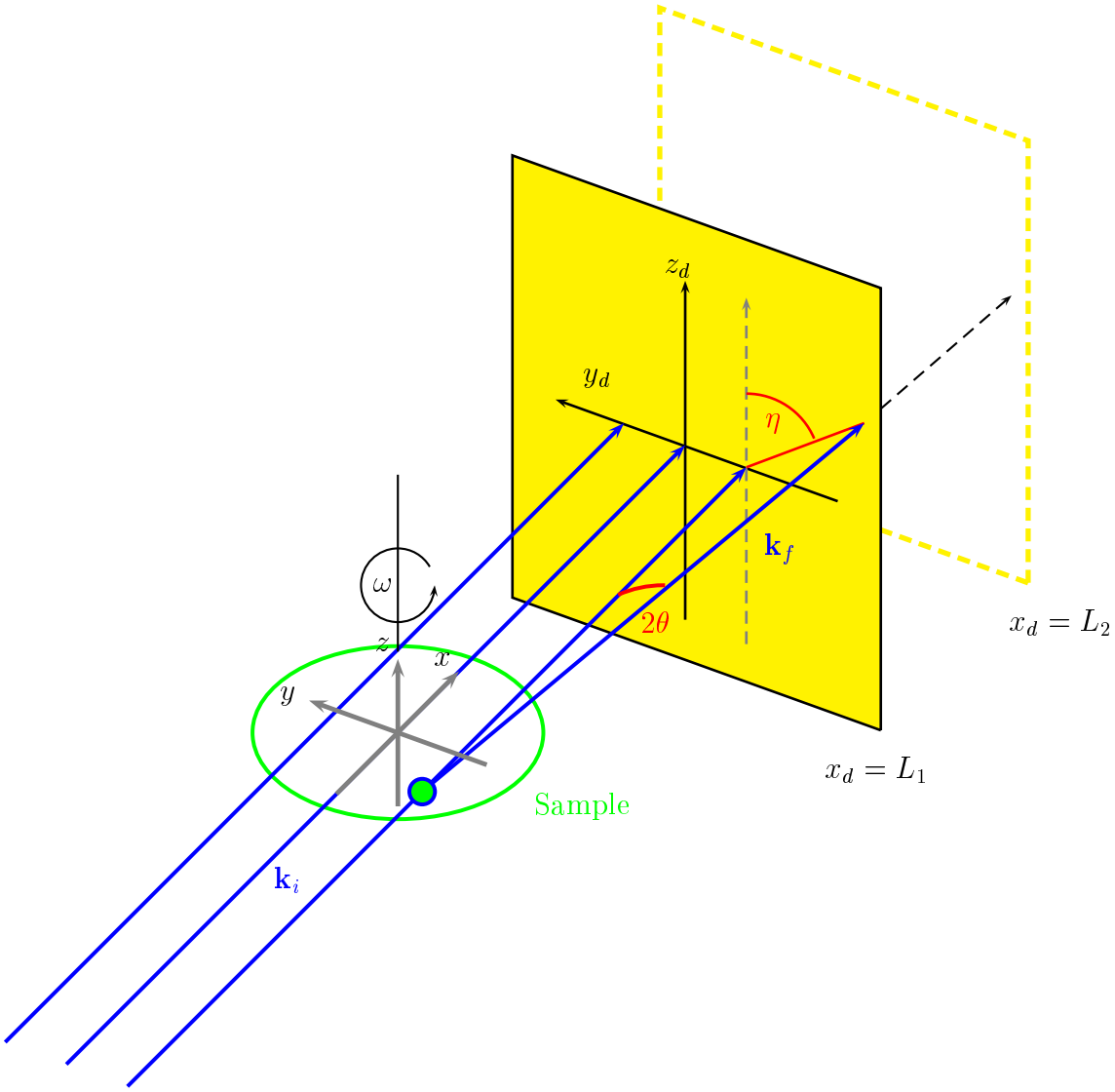
ESRF Beamline ID-11

- Mapping grains and grain boundary networks inside bulk materials
- 40 - 80 keV monochromatic (∼1%) photons
- Six dimensional mappings
  - 3 Euler angles as a function of
  - 3 spatial coordinates
- Watch dynamics: what are fundamental mechanisms under various driving forces?

ESRF ID-11: Grain mapping technique



- **Multiple detector $L_i \Rightarrow \mathbf{k}_f \Rightarrow \mathbf{G}_{hkl}$**
- **Scan $\omega \Rightarrow$ 3 Euler angles for each grain**
- **Detector spot shapes $\Rightarrow$ 2D Grain cross-sections**
- **Scan $z \Rightarrow$ all 6 dimensions**

The Numbers

- **Beam size:** $\sim 1\mu\text{m} \times 1\text{mm}$
- **Flux:** $\sim 10^{11} - 10^{12}$ **photons/sec**
- **Spatial resolution** $\sim 1\mu\text{m}$ **(not yet)**
- **Dynamics on minute time scale**

Limitations

1. **Large grains:** $\sim 100\mu\text{m}$
2. **Time scale**
3. **Not using intensities!**
4. **Incoherent: missing a million details**

ERL Based Microstructure Studies

1. Reduced line focus size $\Rightarrow$ better z-resolution
2. Sub-micron spot $\Rightarrow$
   (a) Illuminate a line
   (b) Additional raster dimension – slower
   (c) Defect sensitivity
   (d) Smaller grains
3. Coherence (?)
   (a) Exquisite defect sensitivity
   (b) Structure of non-crystalline regions near and within boundaries
   (c) Rapid dynamics inside individual grains

Many technologically important materials require small grains.

The dynamics mechanisms can be expected to be different from large grains.

These are complex materials: not trendy, but vital.

$\Rightarrow$ There is a large payoff for pushing resolution limits downwards!