Optimization of X-Ray Scattering for Characterization of Materials

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Small Angle X-ray Scattering (SAXS) is important and has a variety of real world applications

- Allows scientist and engineers to manipulate materials to our benefit
- Biological materials as a vehicle for drug delivery.
Interaction of X-Rays with matter provides useful information about the material

- Bragg Peak = Scattering
- X-Rays scatter off all materials, due to electron interaction.
  - undergo constructive interference in accordance to Bragg's law
- Precisely define incident X-Ray beam by controlling beam size and divergence

http://www.mrl.ucsb.edu/mrl/centralfacilities/xray/instruments/saxs.html
SAXS is a very powerful method in determining the **nanostructure** of materials.
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**SAXS Diffractometer Setup**

- **X-Ray Source**
- **Incident X-Ray**
- **Defining Blade**
- **Transmitted X-Ray**
- **Sample**
- **Scattered X-Rays**
- **Beam Stop**
- **Detector**

Incident beam before blade interaction

After blade moved into position

X-Ray Profile

Defining Blade

X-Ray Intensity vs Distance

X-Ray Intensity vs Distance
To optimize SAXS performance a better understanding of blade and beam interaction is necessary.
MRD PRO X’Pert Pro has no beam stop, thus allows for better view of defined X-Ray beam

X’Pert Pro not in vacuum!

Picture illustration in courtesy of National Nanotechnology Research Center, Bilkent University, UNAM, http://www.nano.org.tr/mrd.html
Candidate material for hybrid scatterless slit

Significant factors:

- **X-Ray Attenuation for slit and base**
  - Ability to stop X-Rays
  - Correlated to density

- **Strongest reflection angles (pitch angles)**
  - Angle on base tapered edge

### Candidate Materials Properties:

<table>
<thead>
<tr>
<th>Material</th>
<th>Tungsten</th>
<th>Silver</th>
<th>Germanium</th>
<th>Alumium</th>
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</thead>
<tbody>
<tr>
<td>Density [g/cm³]</td>
<td>19.3</td>
<td>10.49</td>
<td>5.32</td>
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<tr>
<td>X-Ray Attenuation Length [μm]</td>
<td>3.13</td>
<td>4.57</td>
<td>28.12</td>
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<tr>
<td>Crystal Structure</td>
<td>BCC</td>
<td>FCC</td>
<td>FCC</td>
<td>FCC</td>
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</tbody>
</table>
Newly designed scatterless slits have proven to drastically reduce slit scattering...
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Parasitic Scattering Plots

- Aluminum Blade
- Hybrid Single Crystal Blade

Where blade cuts incident X-Ray
MRD X’Pert Pro allows us to characterize the X-ray beam profile for optimal use.

- Scattering slightly detected
- Incident X-ray beam too intense to analyze any scattering
- Air scattering another issue
- Further data is being processed to bring about better results
Summer research has lend to much insight

• The MRD Pro setup is providing insight into X-ray beam profile
  – Further investigation into experimental setup necessary.

• Many candidate materials to analyze
  – X-Ray attenuation, crystal smoothness, pitch angle etc

• Plan on continuing my research in the Fall in hopes of achieving optimal beam definition.
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