Determining Thin Film Roughness with Extreme Ultraviolet Reflection

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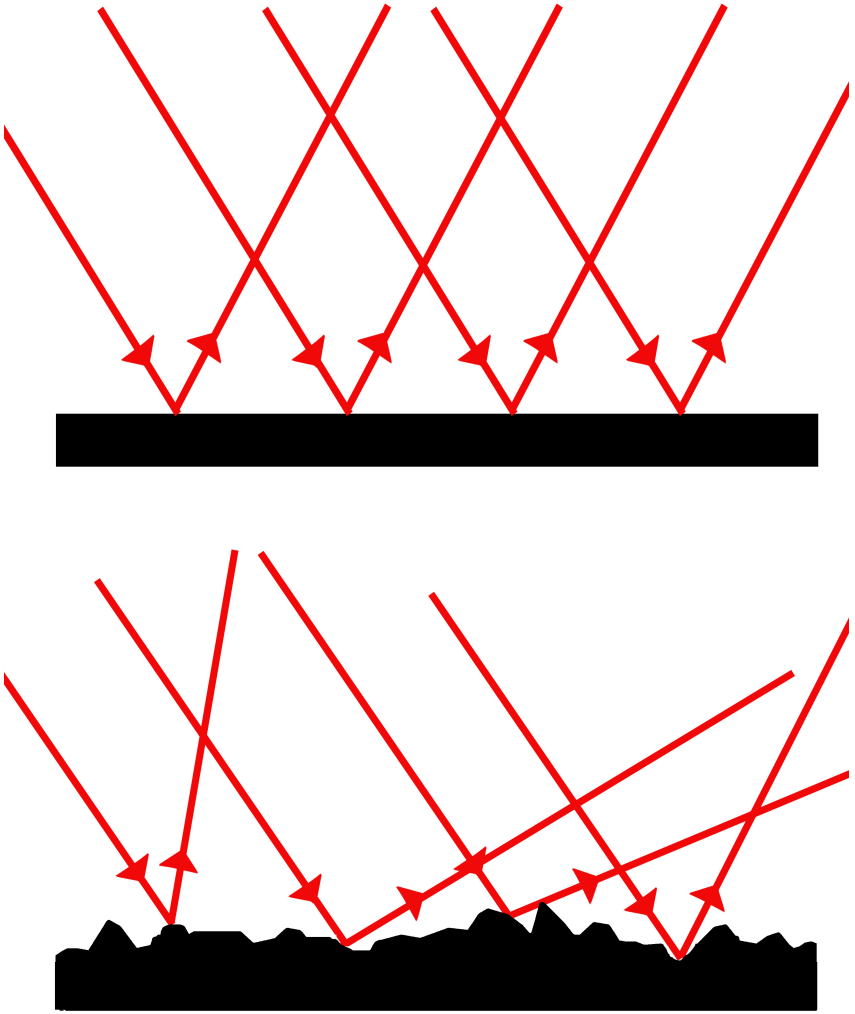
Student Research Conference

March 15, 2014

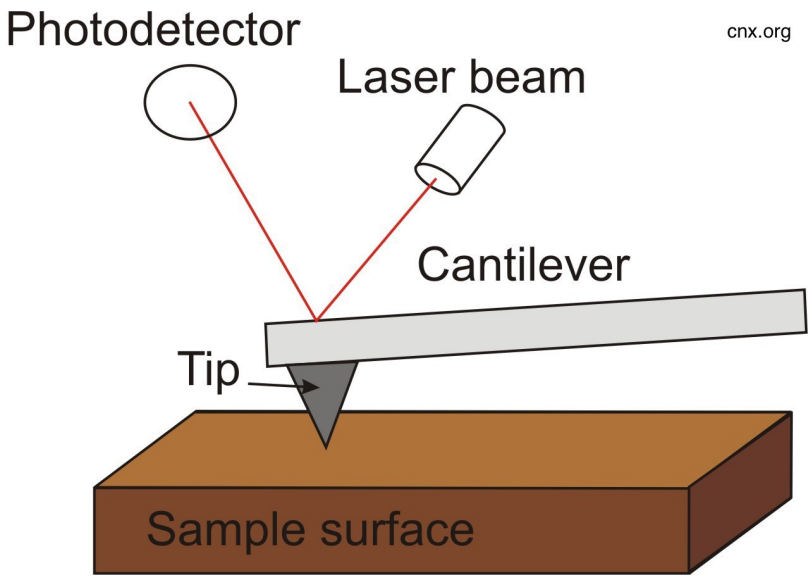
Introduction/Background

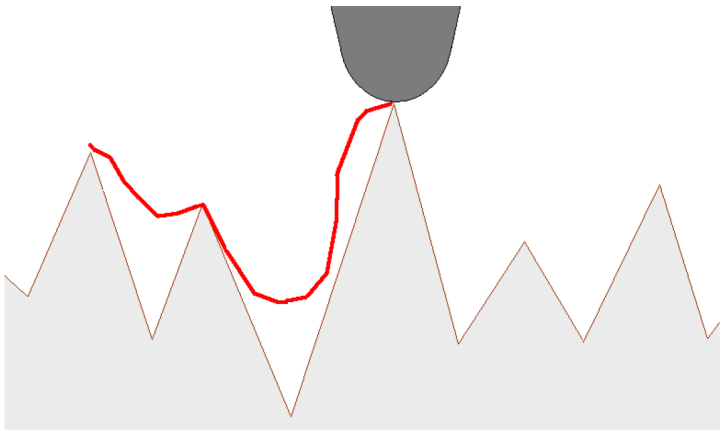
- Vacuum
- Wavelength: 1-100 nm
- Sensative to roughness on the scale of the wavelength
- Measuring thin film roughness allows us to make better optics for the EUV



Atomic Force Microscopy

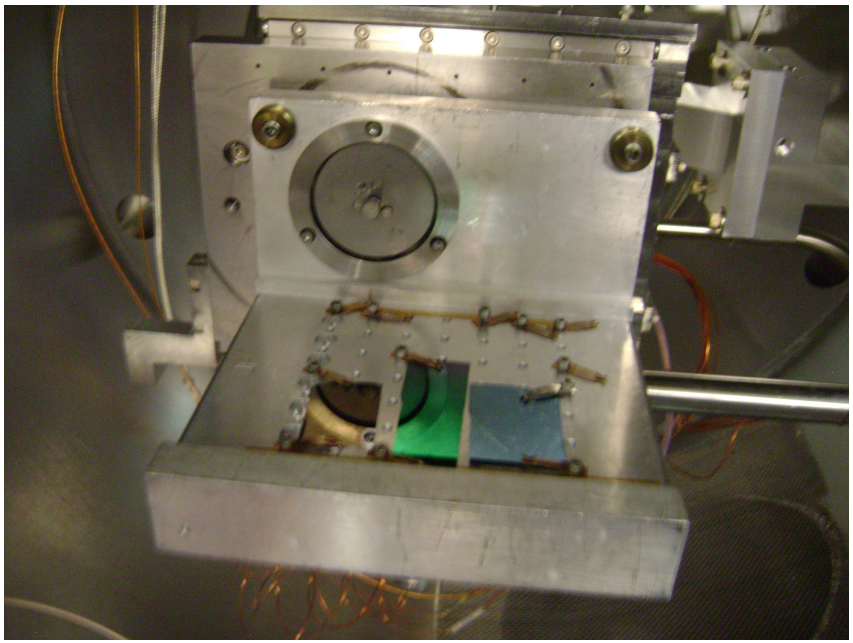
- AFM is the best existing method for measuring thin film roughness
- Limited by the size of tips





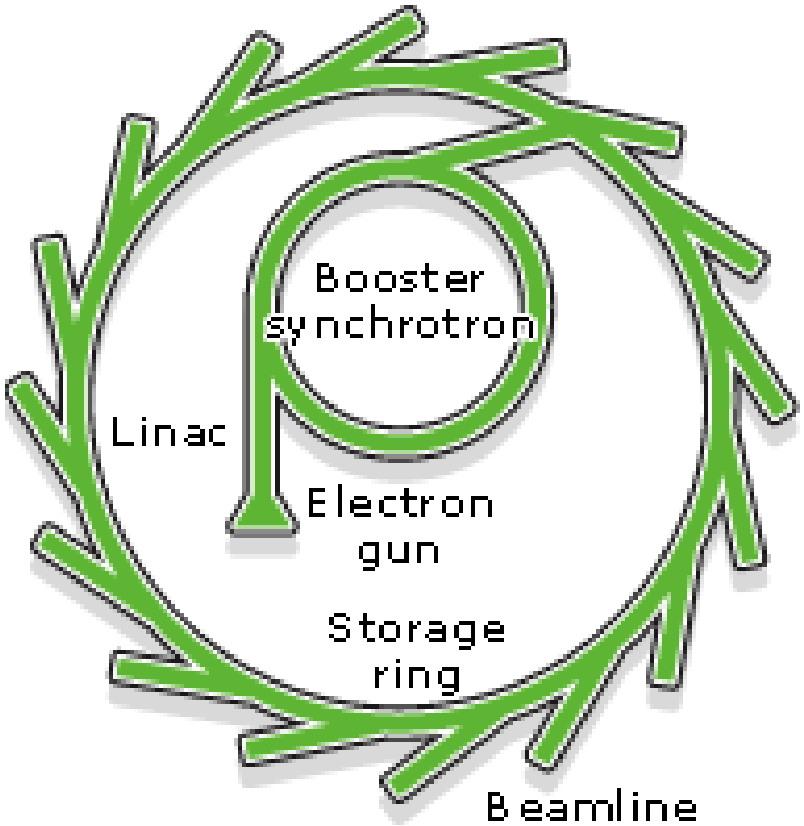
What we did

- Two UO_x thin films for measurements
- Use reflection of EUV light to determine roughness
- Compare reflection measurements with reflection calculations



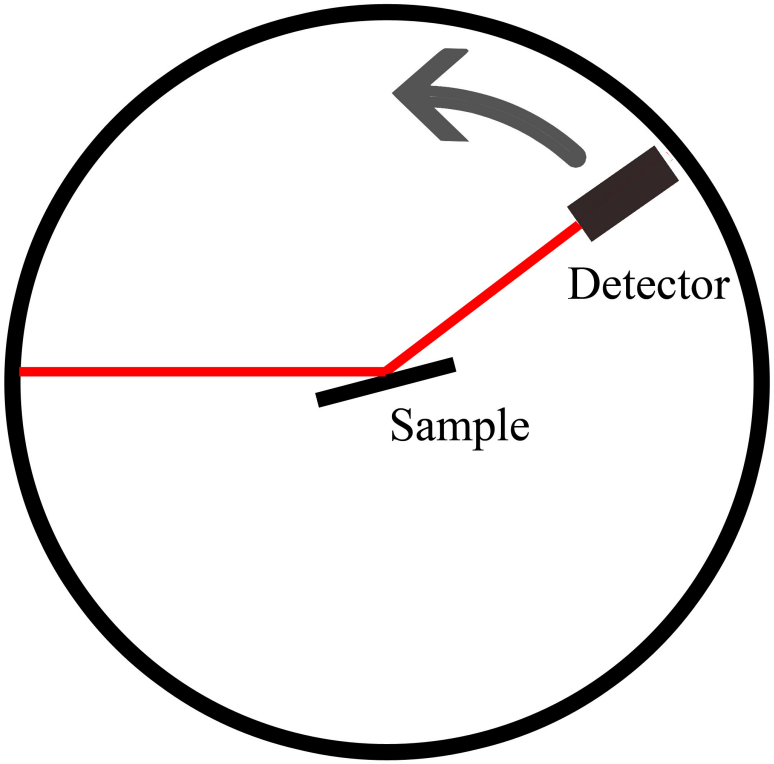
Reflection at the Advanced Light Source

- Advanced Light Source (ALS) consists of a third generation synchrotron
- Radiation come from accelerating electrons
- We use the radiated EUV light as a light source

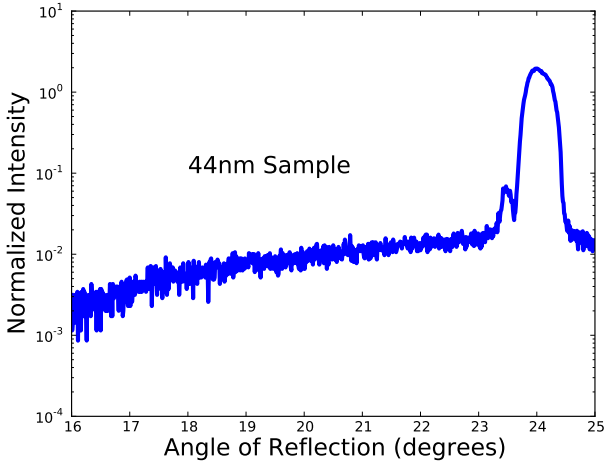


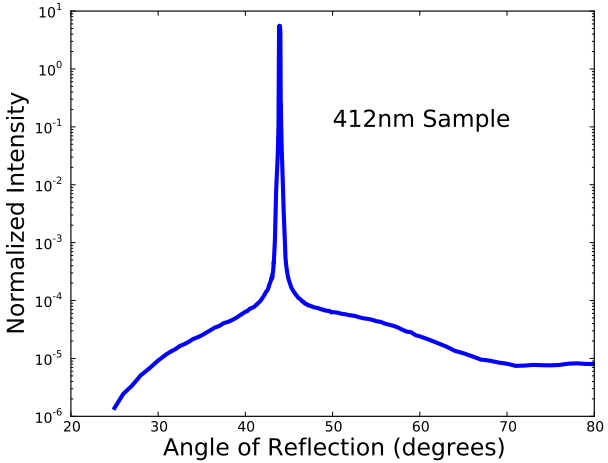
Reflection at the Advanced Light Source

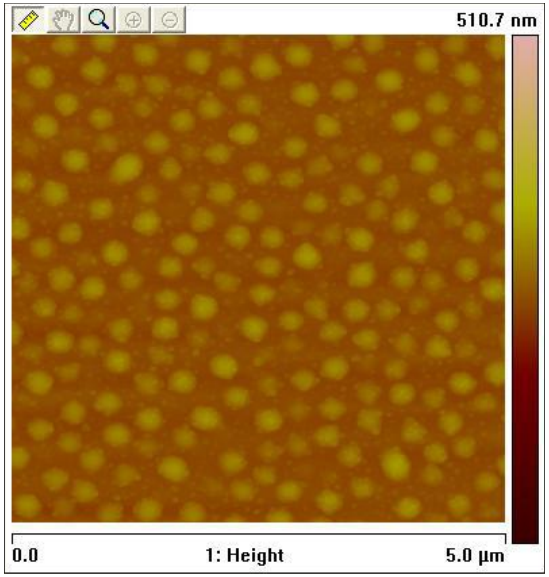
- Channeltron detector
- Reflection measurements in parts and stitched together

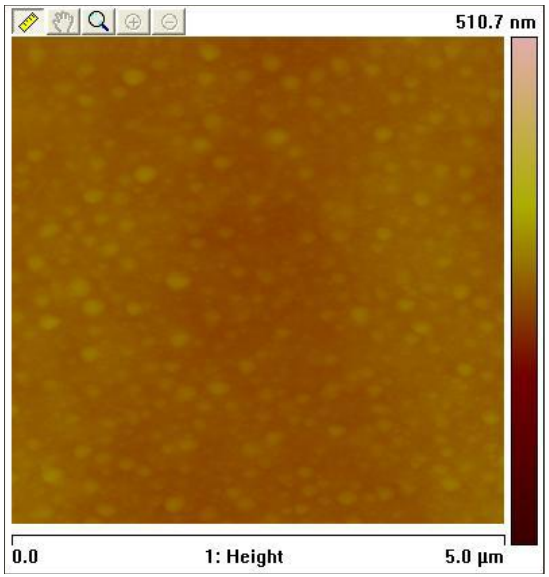


Reflection at the Advanced Light Source



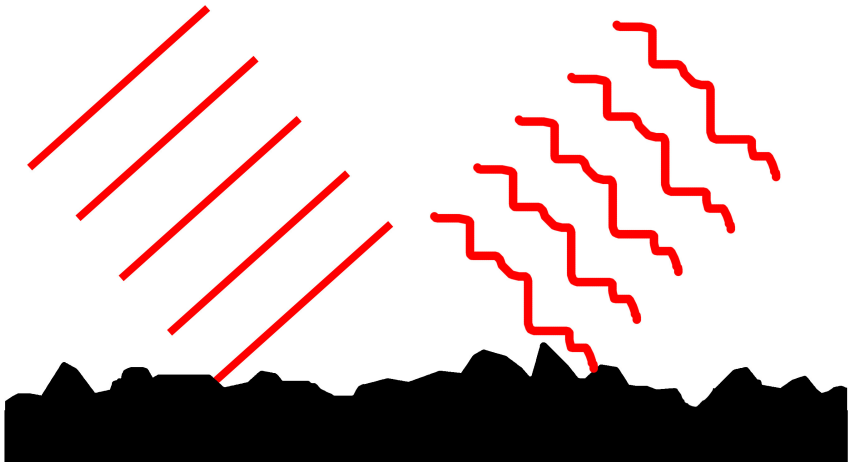




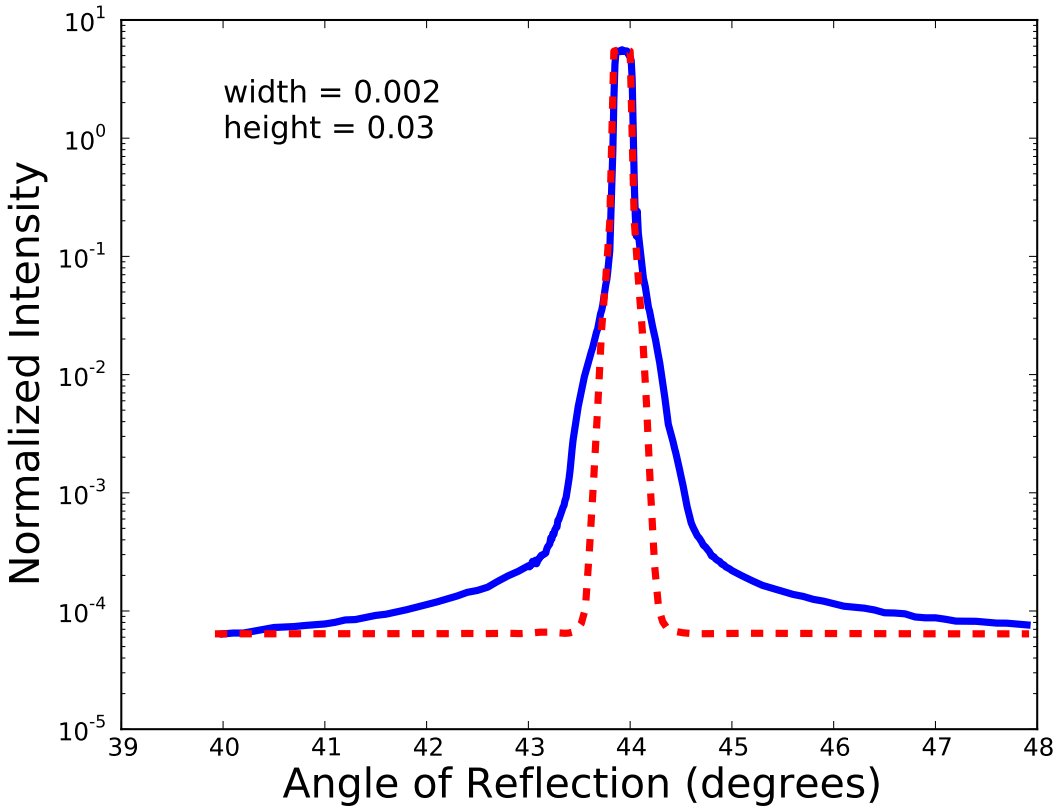


Physical Optics

- Calculate surface currents based on incident field
- Assume currents only come from field
- Generate surfaces with random rms heights and spatial frequencies



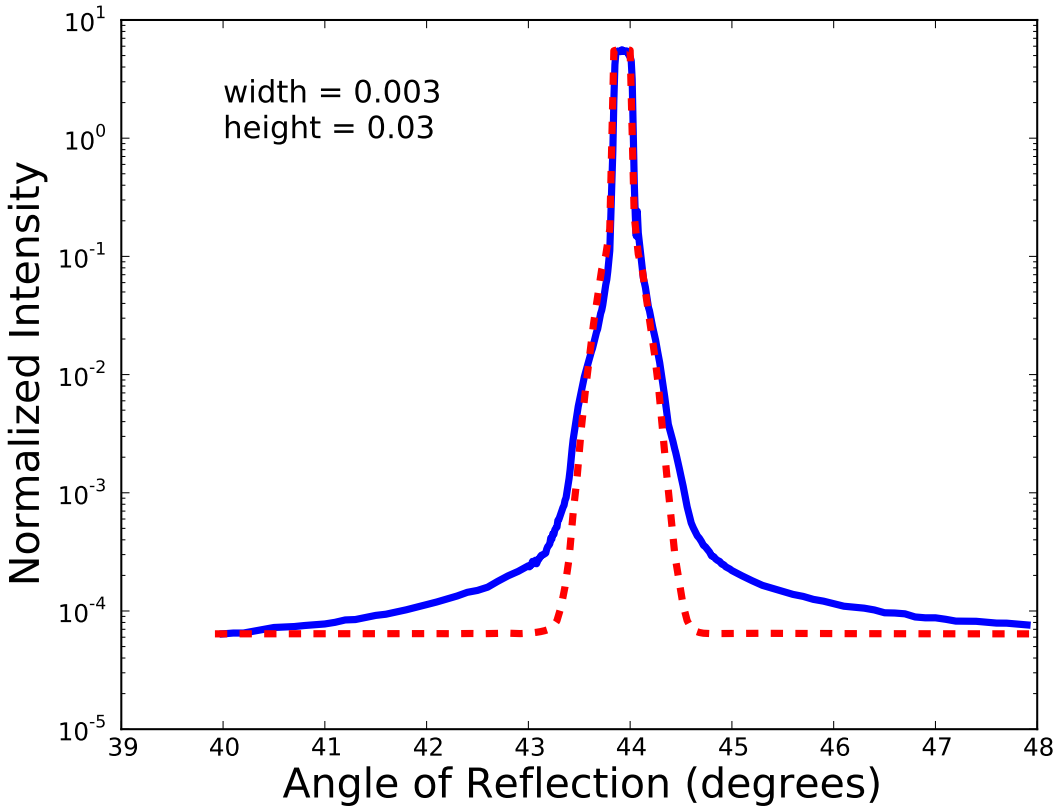
Comparison



width: related to the spatial frequency of the roughness

height: rms roughness height

Comparison



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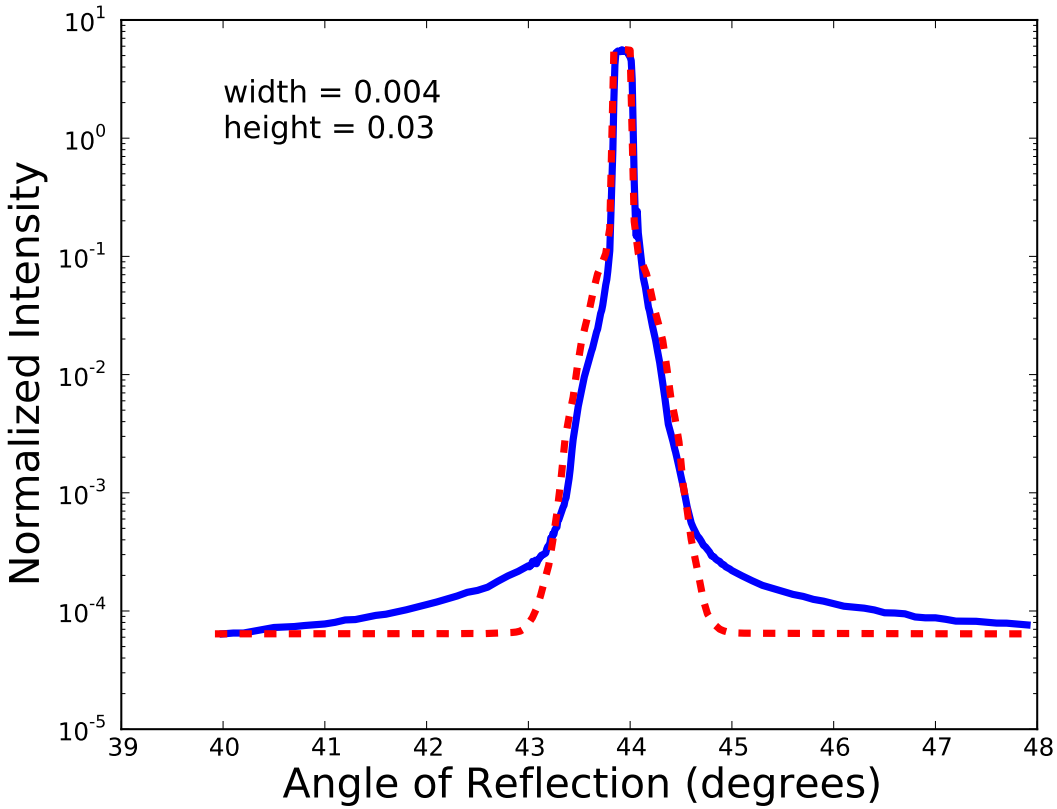

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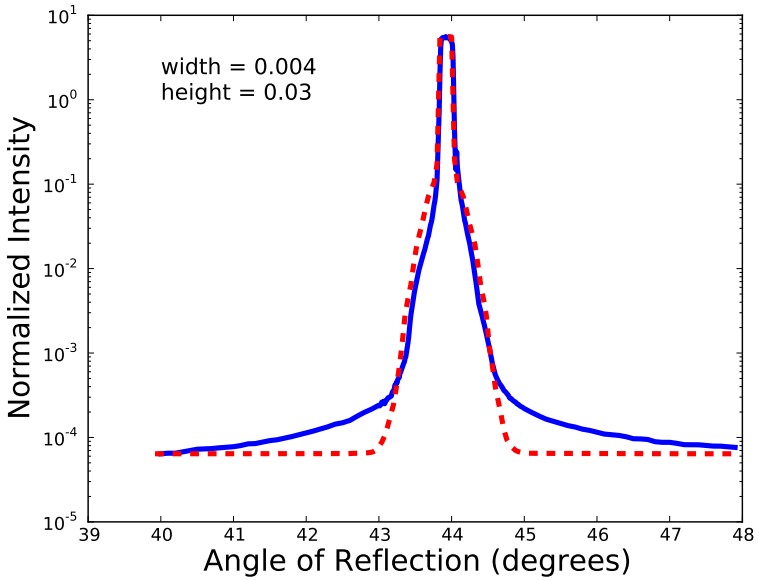
height: rms roughness height

Analysis

- The rms roughness of the 412 nm thin films was determined to be $25\text{nm} \times 0.03 = 0.75\text{nm}$
- Atomic force microscope said 9.39 nm
- Our method may have more sensativity than than the existing methods



Conclusion/Future Work

- Conclusion
  - We have come up with a method to measure surface roughness that involves EUV reflection
  - This method is sensative to roughness that methods like the AFM can't detect
- Future Work
  - Analytical model to connect reflection and roughness
  - Calculation that includes fields of sources on the surface

Acknowledgements

- Dr. Turley and Dr. Allred
- Army of Students
- NSF under the REU program
- DOE and the ALS
- BYU Department of Physics and Astronomy