Determining Thin Film Roughness with Extreme Ultraviolet Reflection

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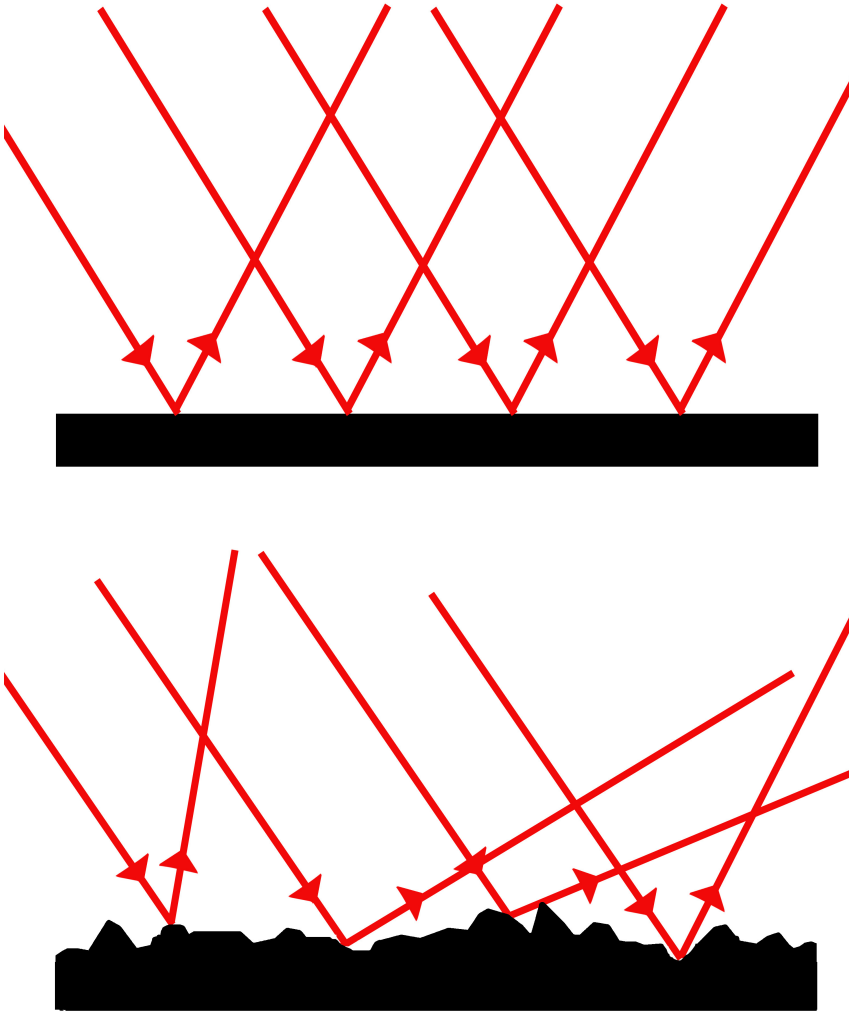
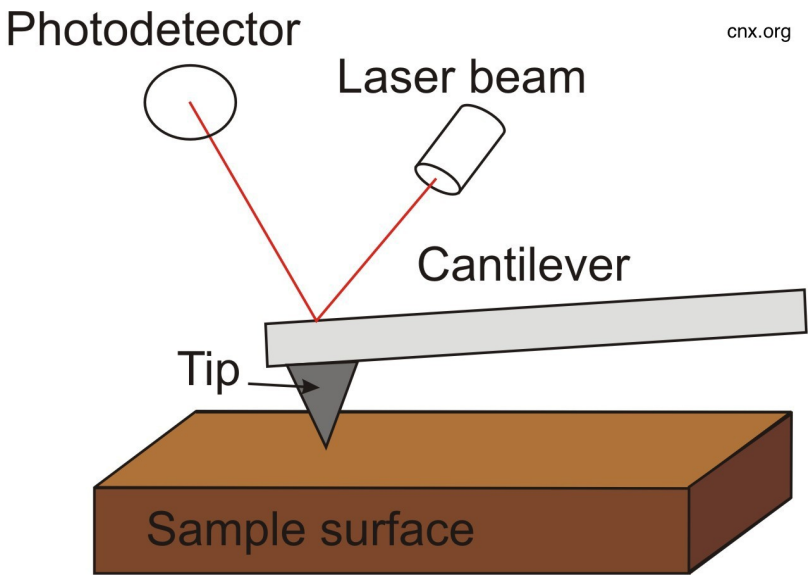
Introduction/Background

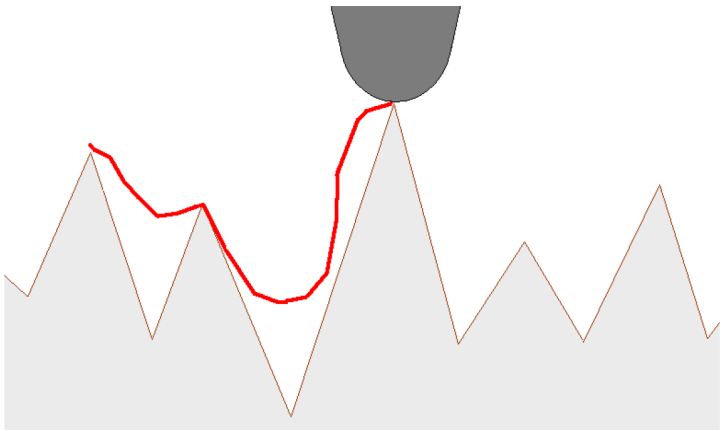
- Vacuum
- Wavelength: 1-100 nm
- Sensative to roughness on the scale of the wavelength
- Measuring thin film roughness allows us to make better optics for the EUV



Atomic Force Microscopy

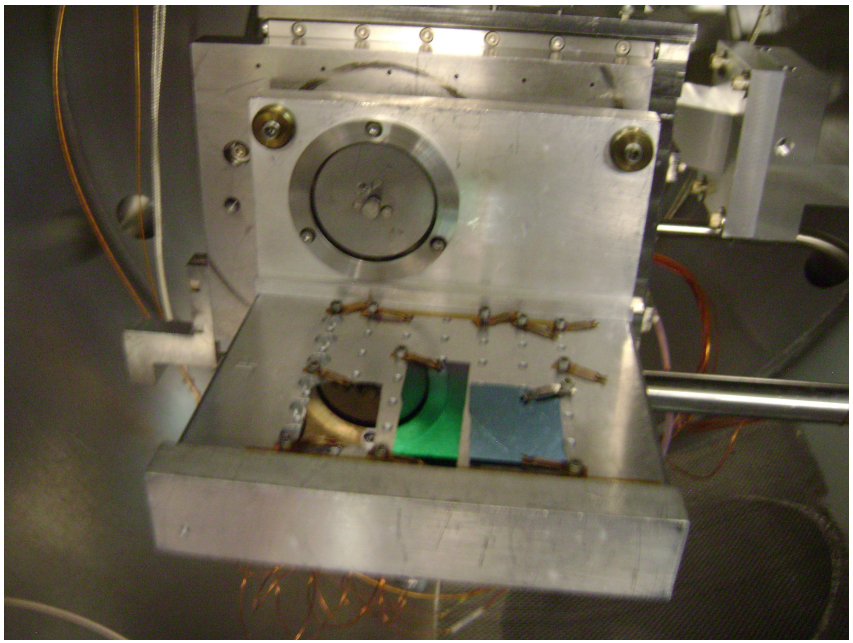
- AFM is the best existing method for measuring thin film roughness
- Limited by the size of tips





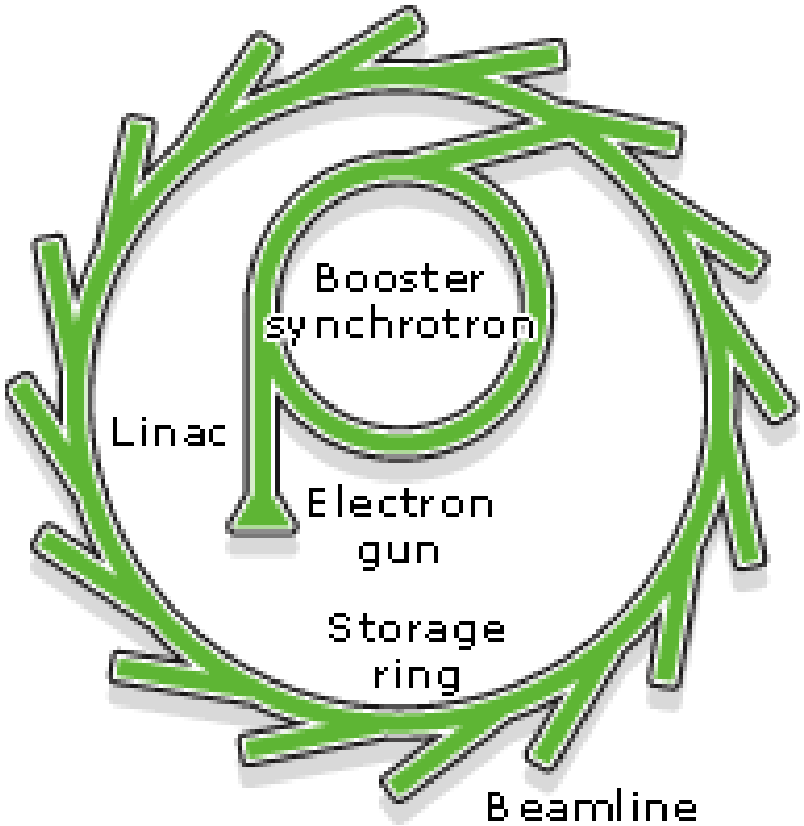
What we did

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



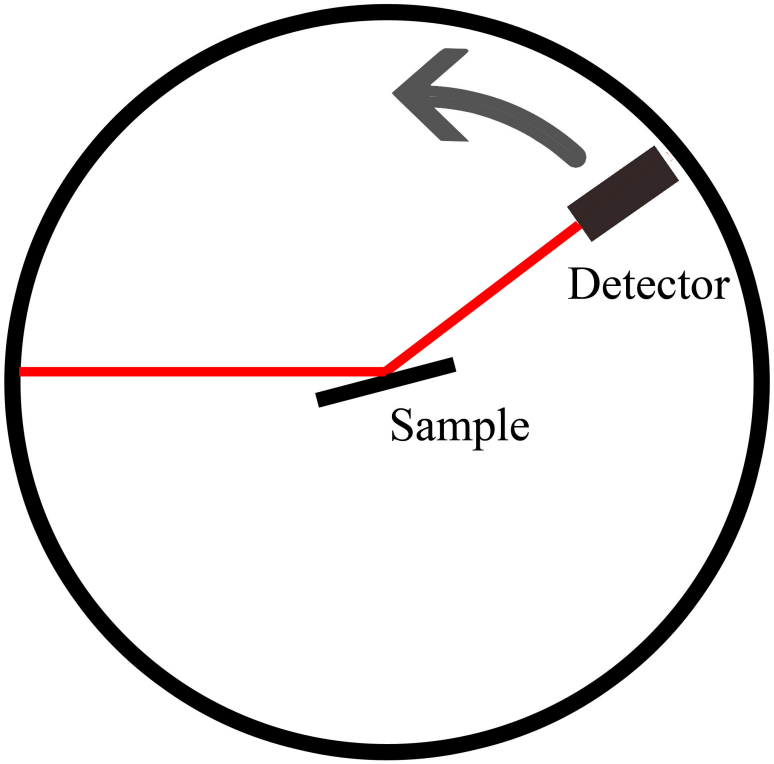
Reflection at the Advanced Light Source

- 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

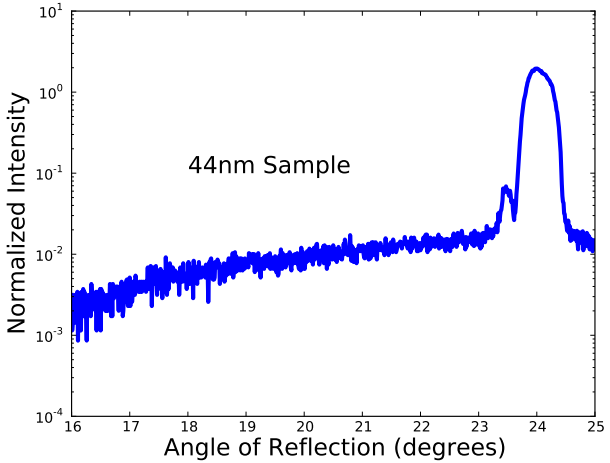


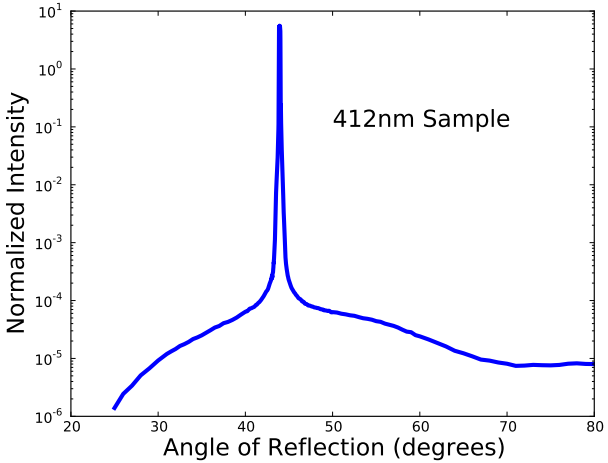
Reflection at the Advanced Light Source

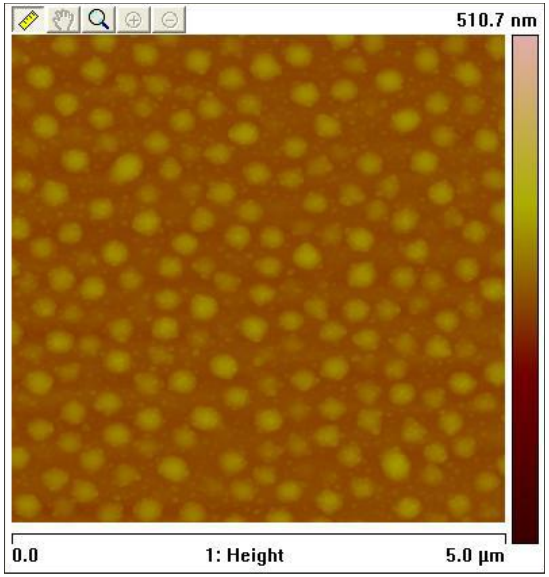
- Channeltron detector
- Reflection measurements in parts and stitched together

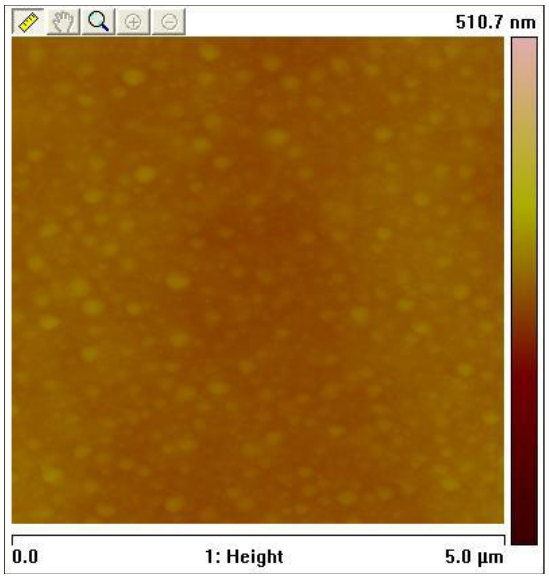


Reflection at the Advanced Light Source



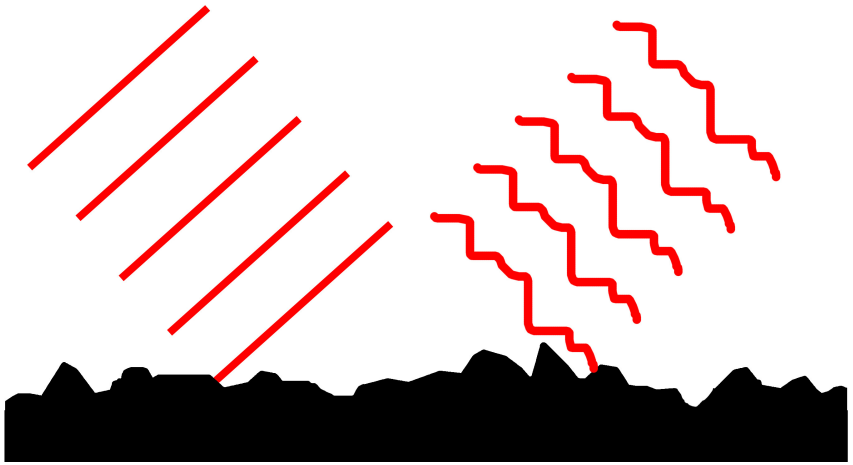




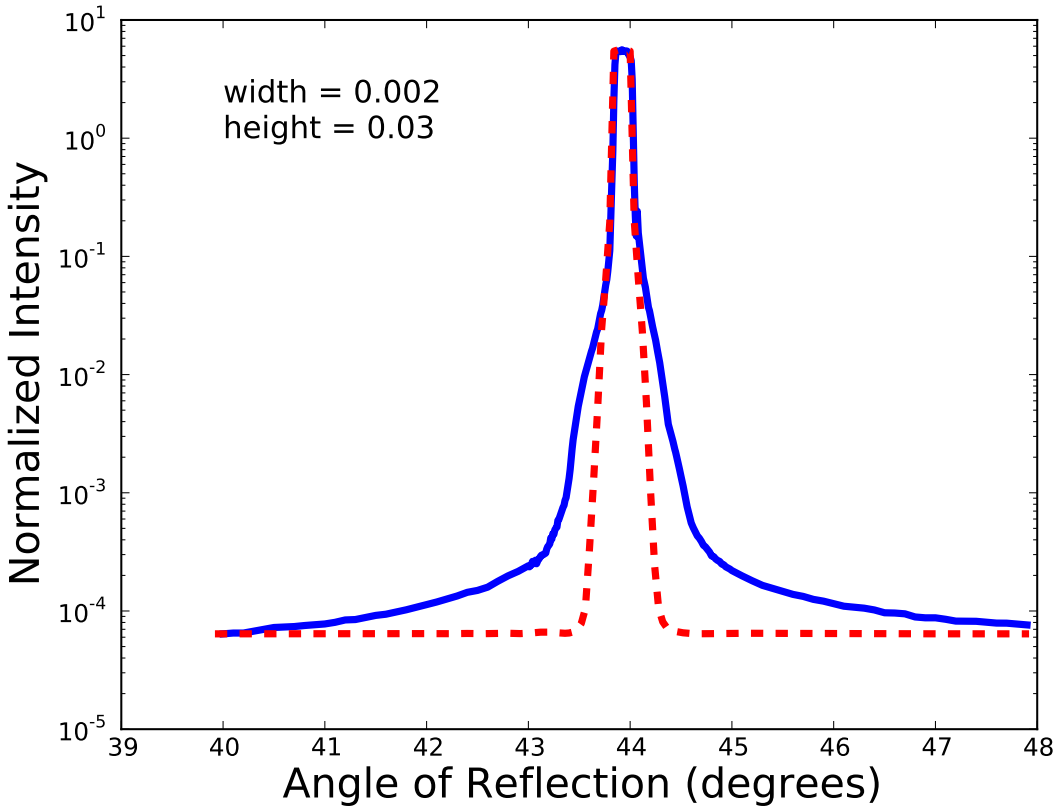


Physical Optics

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



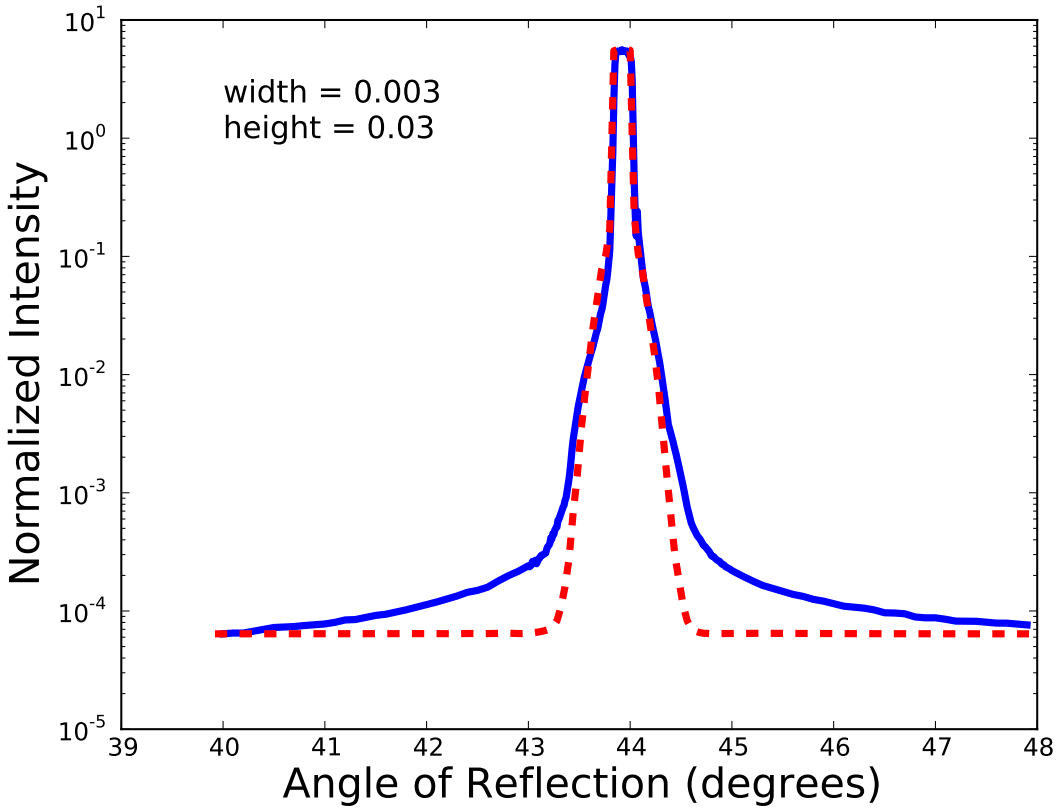
Comparison



width: related to the spatial frequency of the roughness

height: rms roughness height

Comparison



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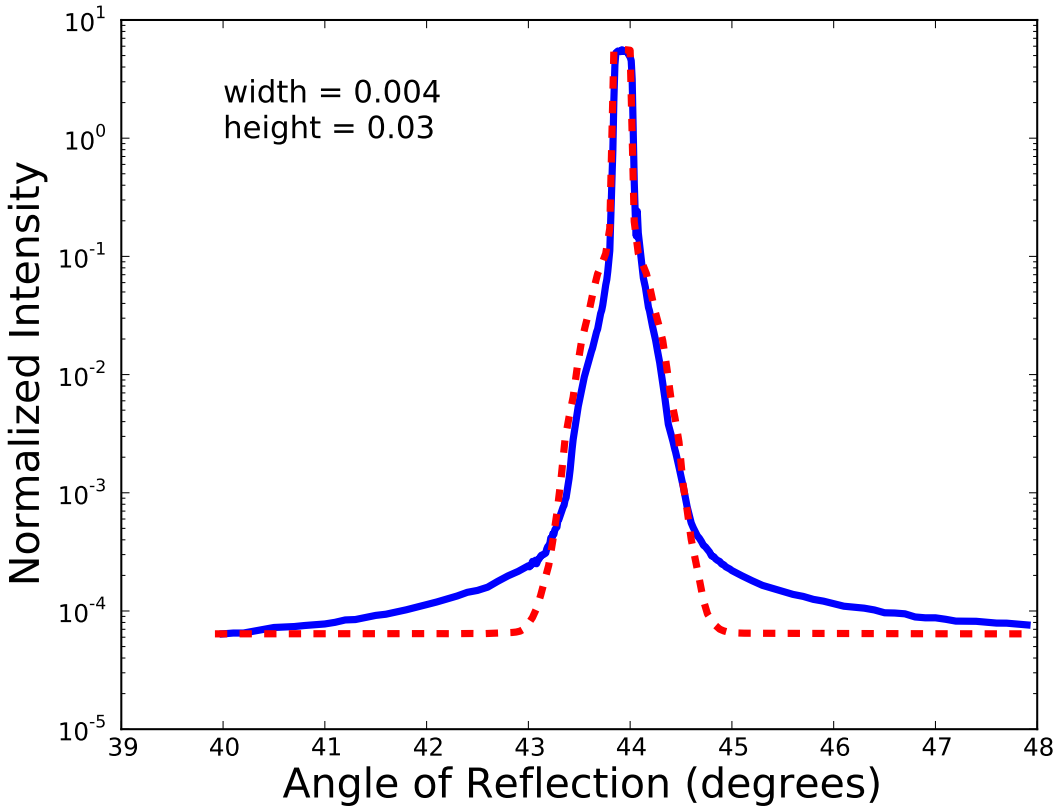
Comparison



width: related to the spatial frequency of the roughness

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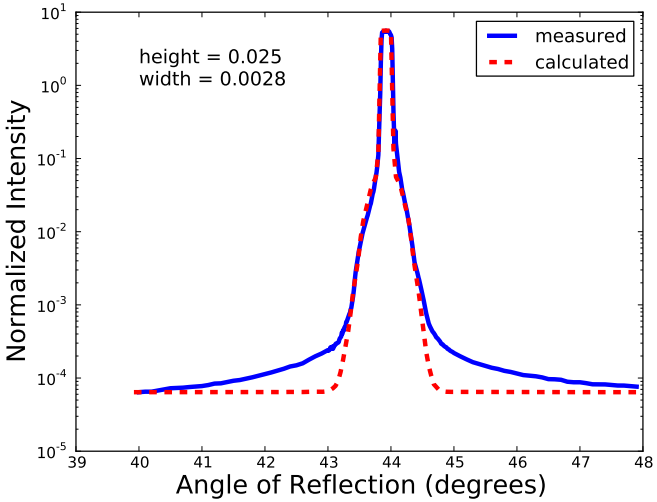
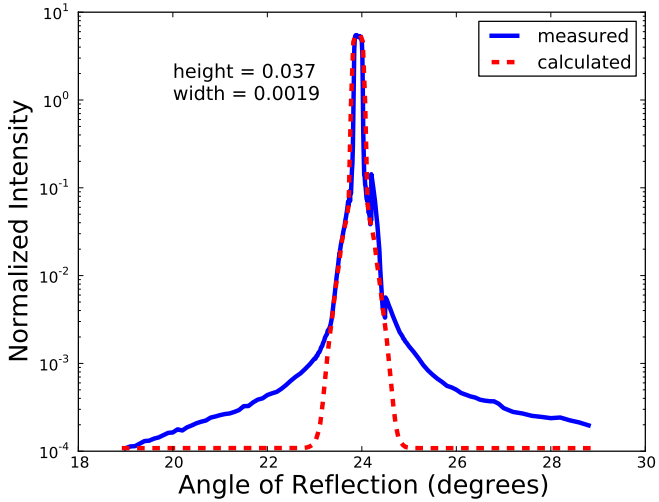
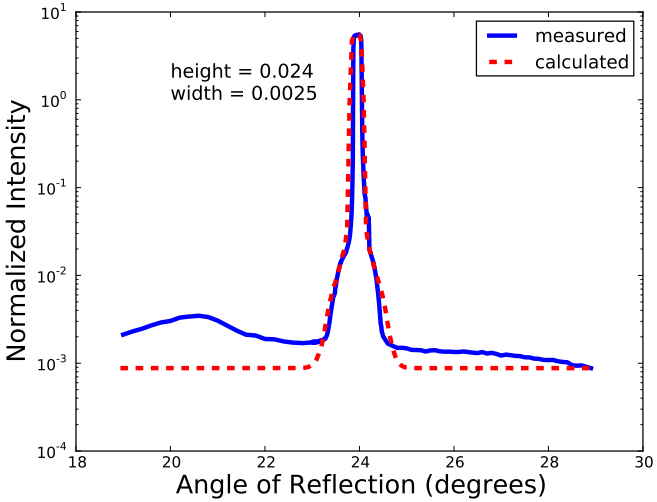


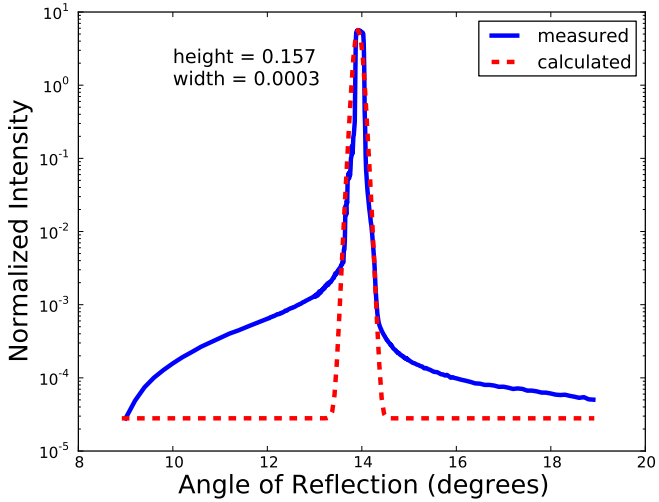
λ=25 nm, θ=22°
rms = 0.625±0.050 nm



λ=25 nm, θ=12°
rms = 0.925±0.175 nm

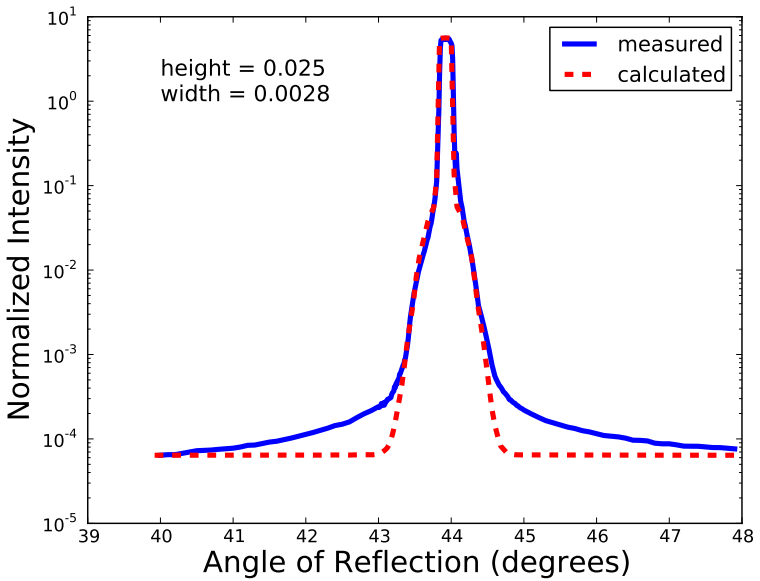


λ=5 nm, θ=12°
rms = 0.120±0.015 nm



λ=5 nm, θ=7°
rms = 0.785±0.045 nm

412 nm sample



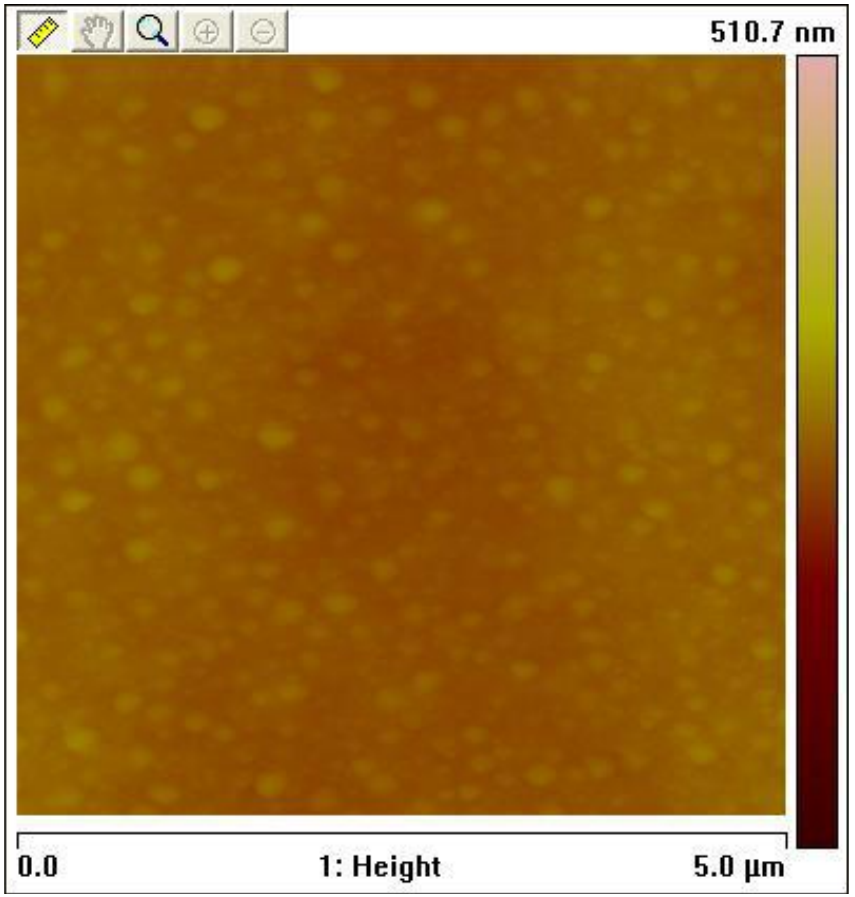
rms =

0.625±0.050 nm

0.925±0.175 nm

0.120±0.015 nm

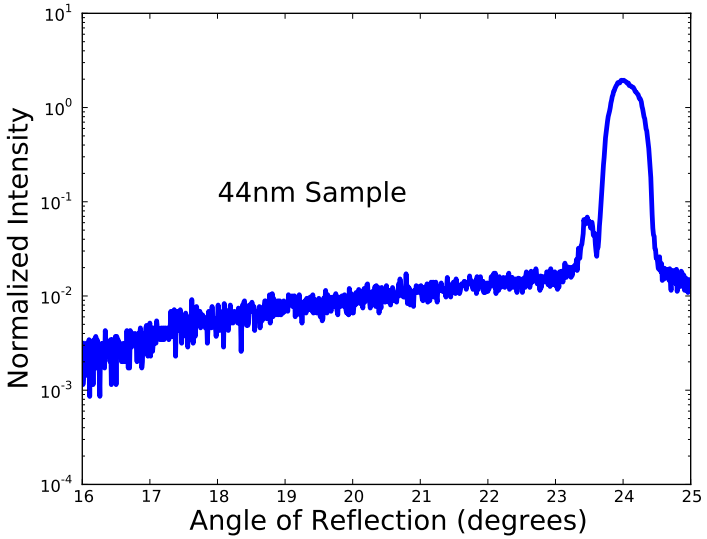
0.785±0.045 nm

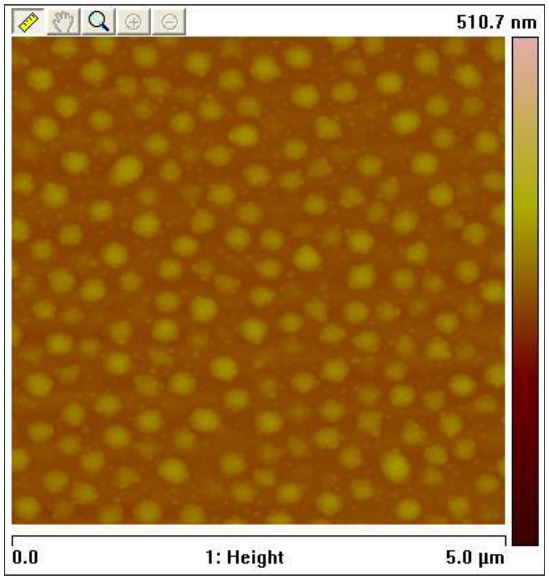


rms = 9.39 nm

44 nm sample

- We were not able to fit the 44nm thin film
- A different surface model is needed
- Based on AFM the model needs to include lower frequency roughness





Conclusion/Future Work

- Conclusion
  - We have come up with a method to measure surface roughness that involves EUV reflection
  - Different surface model is needed for 44 nm thin film
  - 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

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