EUV Reflectometer Expansion and Refinement

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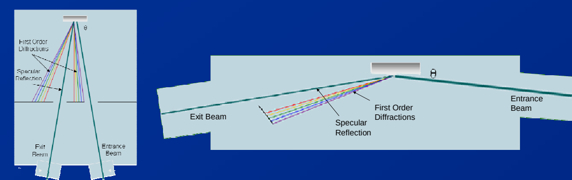
Abstract

Instrumentation used to measure reflectance in the extreme-ultraviolet on a wide variety of surfaces is being expanded through the addition of a grazing incidence monochromator. This extends the lower limit of measurements which can be done at BYU to 3 nm, and allows for faster turn around of sample creation to characterization. This will help to ensure the integrity of the samples. Measurement of source pressure is also being fed into the computer for normalization, and electronic systems are being updated and expanded to allow for the additional capabilities. These upgrades will be used for studies of oxide layers, roughness, cleaning procedures, and many other areas of interest at BYU.

The image above shows the EUV plasma source on the right connected to the new grazing incidence monochromator in the center. On the left is the entrance to the octagonal chamber.

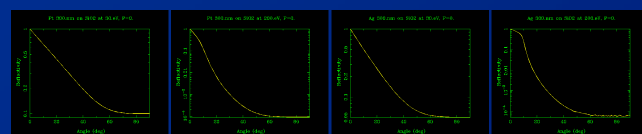
Control Requirements

- •Automation of stage control, detector control, and data acquisition
- •Protection interlocking of detector, venting system, and turbo molecular pumps
- •Real-time data acquisition from detector and vacuum gauges to normalize fluctuations in source intensity
- •Independent control of 5 control motors: x, y, and z translational stage control, stage angle (θ), and detector angle (2θ)
- •Alignment of sample mirror with beam and detector
- •Focus beam from diffraction grating
- •Maintain alignment during automated sweep of θ and 2θ.



The major change and why

The figures above illustrate the difference between our old and new monochromators. By reducing the incidence angle Θ, we can minimize the amount of light lost to imperfect reflection.



These figures show the change in reflectance as a function of incidence angle. We are able to keep far more light by reducing the angle of incidence. This becomes especially important with shorter wavelengths of light.

(calculations performed on the X-Ray Interaction with Matter Calculator from the Center for X-Ray Optics)
http://henke.lbl.gov/optical_constants/

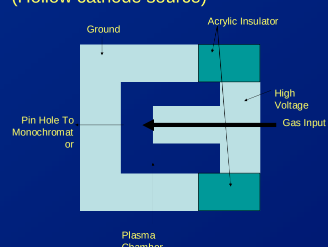
System Layout

EUV Plasma Light Source → Monochromator → Octagonal Chamber

This shows the path of the light through our system. After creation in the plasma source, it enters the monochromator where we select for a single wavelength of light. The octagonal chamber includes the sample and the detector which reads the actual data.

Plasma EUV Source

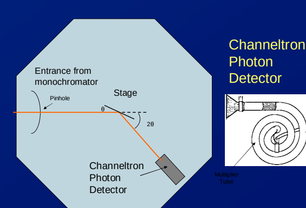
(Hollow cathode source)



The Plasma EUV source ionizes the gas fed into its chamber into a plasma. This emits along the various spectral lines of the given element. A variety of elements can be used to access different wavelengths.

Octagonal chamber

(Sampling chamber)



The octagonal chamber has been converted to allow the beam to enter from either monochromator.

Why is EUV light important?

Space applications:

- •The earths magnetosphere is of great interest to space exploration. One of the best ways to study it is by looking at the emissions of trapped ions. As singly ionized helium is the most abundant element in the ionosphere with an emission spectrum, it also produces the strongest emission lines. These lines lie in the EUV wavelength spectrum.
- •Observations of stellar bodies at different wavelengths tell us different things about the stars. The cooler exterior emits in the visible which our eyes can see. If we want to learn about the interior, we must look at the star with an EUV detector.
- •Black hole event horizons are characterized by high energy emissions in both the X-ray and EUV. Improving our capability to work in the EUV will improve our ability to study this astrophysical phenomenon.

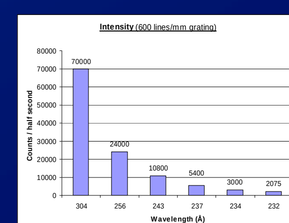
Other applications for this research

- •At present, options are limited as to where the EUV can be studied. Characterization of samples often requires costly trips to synchrotron emitters such as the Advanced Light Source in Berkeley California. These upgrades will allow for much more convenient and cost efficient measurements.
- •Many aspects of characterizing thin films in the EUV are presently not well understood. Roughness (imperfections on the surface), oxide layers, organic contamination, and aging can have dramatic effects on the reflective properties of the sample. This system will allow for testing of samples immediately after their creation to reduce these external effects on the samples.

Preliminary results and present status

Early tests of the grazing incidence monochromator have been encouraging. While we were able to get reflection at 30.4 nm with both systems, the normal incidence monochromator was unable to reflect appreciable amounts of any shorter wavelengths. We have also been able to isolate 23.2 nm light, and we hope to get shorter wavelengths with future adjustment of the light source. We expect that much of the drop off is probably due to the amount of light created rather than the drop off in reflection. Photon counts are summarized in the chart below.

We are continuing to work on meeting the control requirements we have set for the new system. Changes to the electrical system have been made to better interlock the various components, allow independent control of the driver motors, and to feed the pressure in the light source directly into the computer.



This chart shows photon count rates on the grazing incidence monochromator at different wavelengths corresponding to the emission lines of helium.