Characterizing Surface Roughness Using the Extreme Ultraviolet

REU Prospectus

Cody Petrie

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1 Introduction

I am doing my research in the extreme ultraviolet (EUV). There are many applications that utilize the EUV. One of those applications is photolithography. Photolithography is the process of etching a design into a substrate using light which is used in the production of computer chips. Currently it is possible to use visible and ultraviolet light in the process of photolithography. Using EUV in photolithography would enable us to make smaller computer chips than we are currently able to develop. In past years the field of astrophysics has grown to utilize many areas of the electromagnetic spectrum. The EUV has recently become a useful tool to astrophysicists. In March 2000 a satellite was launched as part of the IMAGE mission to image the magnetosphere of the earth in the EUV. One of the specific goals of this mission was to study the 30.4 nm line of the earth’s magnetosphere which is part of the EUV. This was only possible due to the development of carefully engineered mirrors that were able to reflect the 30.4 nm line and absorb other wavelengths [1]. This gave astrophysicists a new tool to study outer space. These are just a couple of the many applications of EUV research.

1.1 Non-Specular Reflection

Also known as diffuse scattering, non-specular reflection is reflection from a surface that does not follow Snell’s law as illustrated in figure 1a. When reflection obeys Snell’s law the reflected beam of light leaves a surface at the same angle that it was incident to the surface, \( \theta = \phi \) where \( \theta \) is the angle of incidence and \( \phi \) is the angle of reflection, as illustrated in figure 1b. I will be analyzing non-specular reflection data to determine the height of surface roughness of yttrium oxide (Y2O3) and possibly other thin films. A more detailed description of this process will be given later.
1.2 EUV

EUV light can be defined as being between 1 and 60 nm, which is about 10 to 100 times smaller than visible light. It is difficult to study this area because EUV light is absorbed strongly by most materials, including air. As a result, all of my research will be done under vacuum. All applications of EUV require that we understand the the roughness of the surfaces that we are working with. Variations in surface roughness that are comparable to the wavelength of light can cause non-specular scattering, and since the wavelength of EUV light is smaller than either visible or UV this effect is multiplied. My research will be to advance our ability to determine the rms surface roughness height of the materials that we are using to study the EUV.

2 My Research

I will be using reflection data to determine the size of the surface height variations of different thin films. I will assist David Allred and his students in growing the thin films that I will be using in my research. Using a vacuum reflectometer I will measure the non-specular reflection from these thin films in the EUV. I will be using a hollow cathode to create He and/or Ne plasmas. The hollow cathode that I will be using was designed after the model described in [2]. The light will leave the hollow cathode and reflect off of a grazing incidence monochrometer (GRIM) which has a resolution of about 0.1 nm. This resolution is smaller than the spacing of the wavelengths which will allow me to isolate the different wavelengths of light created by the He or Ne plasmas allowing me to use monochromatic light of known wavelength [3]. The light will then pass through a pinhole of diameter 0.3 mm to define the beam and then travel 17.4 cm to the sample surface, reflect from the surface and reach the detector. The detector I will be using is a channel electron multiplier that detects currents from single photons as they enter the entry aperture of 1mm diameter. The data that I collect will then be normalized with the incident beam to make the reflection data a percentage of the incident beam. Before I analyze the reflection data and try to determine the surface roughness of the samples I
will use an atomic force microscope (AFM) to see what the surfaces look like. This data will be used as a check to ensure that our roughness measurements are comparable to those of existing tools. At this point I will be able to determine the rms surface roughness height by using a method developed by Todd Doughty, Greg Hart and other students who work with Steve Turley. The method is similar to the Debye-Waller correction factor but has been modified to be better suited to determine surface roughness height. More about this method can be found in Todd Doughty’s paper [4].

3 Summary

This summer I plan to take reflection and AFM data on 2-10 Y$_2$O$_3$ thin films. Once this data is taken I will use the method developed by Steve Turley and his students to determine the surface roughness height of these surfaces and verify their accuracy by comparing then with the AFM data. My goal is to validate this new method of determining surface roughness based on non-specular reflection.

References