X-ray Specular and Diffuse Scatter Characterization of Near Ideal Thin Film Multilayers on Various Substrates Produced by Dual Ion Beam Deposition.

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The scattering of x-rays from various surfaces and interfaces remains an active research area because of the technological implications and the interesting scientific questions it addresses. Many technical processes and devices depend upon material and structure properties of thin films and thin film multilayers. For many thin film optical and electronic devices, function and performance are greatly influenced by details of the substrates, surfaces and interfaces. In particular, when layer thickness is comparable to interface roughness and diffusion, both optical and electronic performance are greatly influenced by surface and interface details. X-ray specular and diffuse scattering measurements of highly repetitive multilayers combined with careful modeling provide understanding of the structure, material, and interface diffusion characteristics of the constituent films. Not only does this contribute to the understanding of structure-performance relationship, but provides insight into details of material interactions and behavior at interfaces.

The focus of this presentation is the measurement and modeling of x-ray specular and diffuse scattering from highly repetitive multilayers produced by dual ion beam deposition. The modeling will show good fits to measurement with stack descriptions containing the minimum number of structure, material and interface parameters. The characterization of several multilayers on various substrates and composed of various combinations of film materials will be presented. These multilayers have repeat spacings of 2-4 nm and are made on substrates ranging from epoxy replica to super polished fused silica. In this repeat spacing regime x-ray scattering measurements are highly sensitive to details of the transition region between adjacent materials and the modeling of these measurements yield the structure of this transition region.

The grazing incidence x-ray diffraction studies were made using a conventional x-ray source and multiaxis diffractometer/reflectometer with a crystal analyzer before the detector. Characterizations include both detailed specular and diffuse scatter measurements. The combination of near ideal multilayers, high resolution x-ray diffraction techniques, and careful modeling provides unique values for material properties, diffusion, and interface roughness. Generally, these measurements are reliably modeled by a very simple description of film and interface structure parameters. Analysis of both specular and diffuse scattering separates interface roughness from interface diffusion. For less perfect multilayers, stack variation must be accounted for and the total structure cannot be simply represented by a replicated bilayer. With this

loss of replication, a unique interface structure does not dominate the performance and the details of materials behavior may not be extractable from x-ray scattering measurements.