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Optical constants of soft X-ray mirrors on board X-ray astronomy satellite ASTRO-E2

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High resolution spectroscopy of cosmic plasmas is one of the key features of Japan's X-ray astronomy satellite ASTRO-E2 due for launch in 2005. The X-ray Microcalorimeter(XRS) on board has the highest spectral resolution ever achieved as non-dispersive imaging detector, or even better than gratings in high energies above 3 keV. This area of research has great importance to investigate physical conditions of ionized plasmas in various states, and also to carry out dynamical study of matters falling into Black Holes by Doppler measurement.

The analysis of high resolution X-ray spectra requires intensive calibration of instruments. Since the energy resolution of XRS is about 6 eV, energy response needs to be understood with much finer energy steps. The Soft X-ray Telescope(XRT), which focuses X-rays onto XRS, has complex energy response in 2-4 keV range due to M absorption edge structures of gold, a material used for reflecting surface.

Structure of gold M edge in fine step, 1 eV or better, is not fully tabulated. Absolute values of optical constants, as well as exact locations and shape of edges, may depend on both physical and chemical conditions of a film. In addition it was found through ground calibration of Chandra X-ray Observatory that the M edge energies of gold are offset by a few tens of eVs from tabulated values. This result had already been emphasized by earlier measurement of ASCA reflectors, therefore the offset may be real and universal to this material.

The purpose of this experiment is to measure optical constants of gold in M edge region (2-4 keV) with energy resolution much improved from previous measurement. The requirement of energy step of a half to 1 eV has not been required nor achieved in the past experiment. BL15XU was chosen for its wide energy coverage and highly automated measurement setups.

Figure 1 shows a preliminary result of X-ray reflectivity measurement of flight ASTRO-E mirror, in 2-4 keV range at 0.3 deg. Comparison with previous measurement and latest available database is also shown. Shift of edge energies from old table values is confirmed with greater energy resolution. Owing to a superior stability of the beamline components, a wide-range energy coverage is achieved by single energy sweep with minimum systematic errors. This is quite valuable aspect since absolute reflectivity needs to be measured in our study. The measurement is so far performed at single incidence angle, therefore we cannot yet derive optical constants from the data alone. Continuation of the experiment has been proposed to the term 2005A.

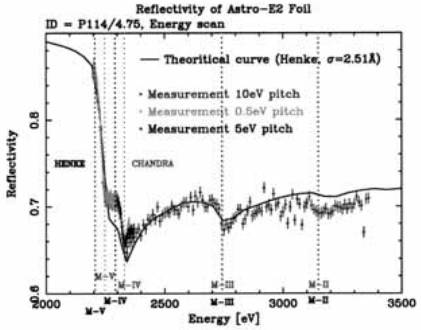

Figure 1: Measured reflectivity of ASTRO-E2 gold mirror at 0.3 deg.

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X-Ray Reflectivity Measurement of PFPE lube layer on Si (2)

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In a hard disk drive, magnetic write/read heads are flying with about 10nm spacing over the magnetic disk surface with very high speed. Therefore, direct contact between head and disk sometimes make irreversible damages on a disk surface. PFPE (perfluoro-poly-ether) liquid lubricant is widely used as protective coating against the fatal damage. Precise measurement of absolute thickness of liquid lubricant is important issue to understand the roll of lubricant layer. Based on our former study, we have established how to measure the absolute thicknesses of PFPE liquid lubricant on Si wafer by using SOR X-ray reflectivity spectra.

We used a multi-axis diffractmeter installed in the BL19B2 for the measurement. The sample coated on Si wafer was mounted in a chamber filled with He gas with a cover of Kapton film for reducing the background noise from air scattering. Reflectivity as a function of the reflection angle 2θ of Si substrate with lubricants.

We have measured additional samples that we could not measure in the former trial. Then we have calculated their absolute thicknesses by curve fitting method with computer simulation.

In this trial, we have gotten a thickness correlation between the absolute thicknesses by SOR X-ray reflectivity and thickness by Ellipsometry.

Fig.1 shows relationship between the method in this study and method by Ellipsometry.

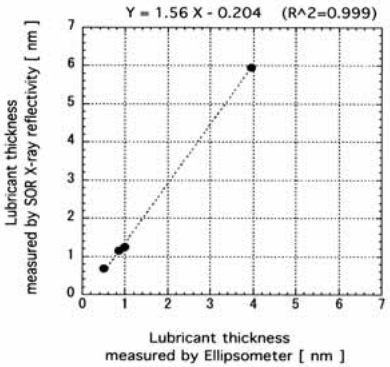

Fig.1 correlation between X-ray reflectivity method and Ellipsometry

The thicknesses measured by Ellipsometry are widely used as industry standard. In this study we have clarified that absolute thickness of thin PFPE lubricant on Si wafer is about 1.5 times thicker than that is measured by Ellipsometer. And the thinnest thickness value in this study is almost equal to the theoretical thickness of the PFPE monolayer.

We will try to establish how to measure the PFPE thickness on a real hard disk substrate in our future trial. To achieve this, we have to make specially smooth disk surface in order to prevent surface scattering that we observed in this trial.