X-Ray Reflectometry Using Lower Energy Photons

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Introduction

X-ray reflectometry (XRR) is a tool of choice to non-destructively characterize the average geometrical dimensions, the density, and the interface roughness of multilayer systems. At SSLS, high resolution X-ray specular reflectivity experiments with lower energy photon beams at grazing incidence angles have been performed with an emphasis on thin films composed of light elements. We report measurements to determine layer parameters of highly porous poly-aniline (PANI) films for biosensors [1], parylene films as applied to light emission display devices [2], and lubrication layer on magnetic hard disk.

Methods and Materials

Lighter layers make less contribution to the reflectivity [3],[4], as electron number density is small. In general, parameters for such layers can not be well determined, particularly if they are grown on heavy element layers because the beam reflected off the heavy layer is too intense. However, the energy of the incident radiation may be chosen such that the absorption by the heavy layer is maximized while keeping the reflectivity of the light layer relatively high, thus enabling to distinguish the modulation of the intensity of the reflected light by the light layer on top of the strong reflection by the heavy layer. Successful examples of this optimization are presented using 3.998 and 5.000 keV photons.

XRR was measured in the X-ray demonstration and development (XDD) beam line at SSLS. The diffractometer is the Huber 4-circle system 90000-0216/0, with high-precision 0.0001° in step size for omega and two-theta circles. In the experiment, there was no influence of higher order energy impurity in the beam, as checked with a standard Si wafer.

Results

Fig. 1 shows X-ray reflectivities at lower wave vector transfer of a PS-*b*-P2VP template on a gold evaporated Si wafer after the growth of highly porous poly-aniline (PANI). XRR using 5.000 keV photons clearly reveals the existence of the top PANI layer, whereas the one using 8.048 keV photons shows nothing. Details of parameters can be found in [1].

Similarly, XRR using 3.998 keV photons in Fig. 2 shows better oscillation and indication of lube layer on hard disk substrate.

Besides, XRR using 3.998 keV photons results in better density determination for parylene films.

Discussion

XRR using lower energy photons (4 to 5 keV) is more effective for the determination of the layer parameters, particularly for lighter layers grown on heavy metal templates.

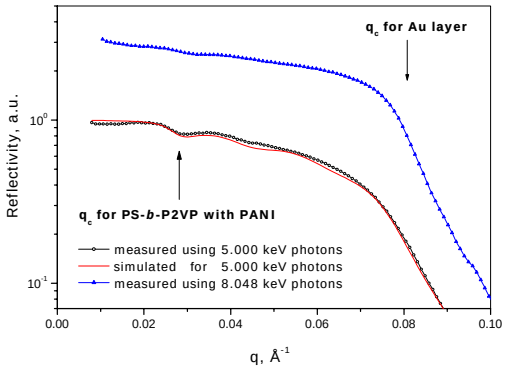

Fig. 1. X-ray reflectivity of a PS-b-P2VP template on a gold evaporated Si wafer after the growth of highly porous PANI.

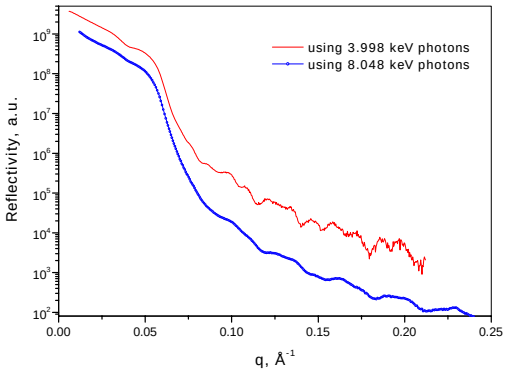

Fig. 2. X-ray reflectivity of harddisk layers. The lube layer (1.2 nm) is on Al/PNi/CrCoPtSi magnetic layer/DLC (4 nm).

References

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Acknowledgments

This work is supported by NUS Core Support C-380-003-003-001, A*STAR/MOE RP 3979908M, A*STAR 012 105 0038, A*STAR R144-000-053-303, A*STAR 0121050038, ARF R-144-000-53-107, and A*STAR 012 101 0131 grants. Thanks are to Kim Dongha, Zhang Jun and Low Hong Yee for offering samples.