

## Progress in short period multilayer coatings for water window applications

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Multilayer coatings for normal incidence optics designed for the water window region ( $2.3 \text{ nm} < \lambda < 4.4 \text{ nm}$ ) are particularly challenging since a layer thickness below 1 nm is required. At normal incidence the roughness induced scattering increases as  $(\sigma/d)^2$  making it difficult to achieve high reflectivity as the period,  $d$ , is reduced. Recently, Cr/Sc multilayers have been fabricated<sup>1,2</sup> with normal incidence reflectivity in the vicinity of 20% for wavelengths near the Sc edge at 3.11 nm. Motivated by this success we have investigated the use of diffusion barriers for short period multilayers. Such diffusion barriers have been successfully applied to Mo/Si multilayers in the EUV.<sup>3,4</sup>

The multilayers were deposited by conventional magnetron sputtering. Using a B<sub>4</sub>C diffusion barrier layer a reflectivity of 32% was achieved at 3.11 nm at an angle of 10 deg from normal. The Cr/Ti and Cr/V multilayer systems have also been investigated. In the case of Cr/Ti a near normal incidence reflectivity of 17% was obtained near the Ti L edge at 2.73 nm. For Cr/V a near normal incidence reflectivity of 9% was obtained near the V L edge at 2.42 nm. These results are very encouraging for the possibility of more widespread applications of normal incidence optics in the water window range.

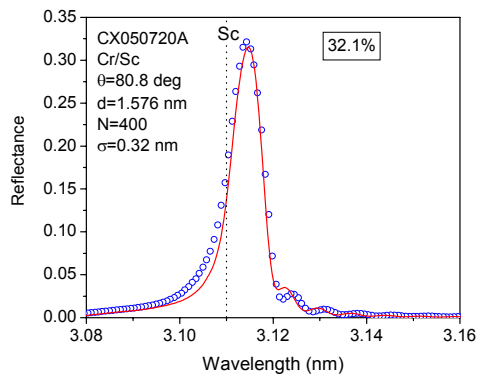


Fig. 1. The reflectivity measured for a Cr/Sc multilayer with B<sub>4</sub>C barrier layers at an angle of 9.2 degrees from normal incidence.

<sup>1</sup> F. Eriksson, GA Johansson, HM Hertz, EM Gullikson, U Kreissig, J. Birch, "14.5% near-normal incidence reflectance of Cr Sc x-ray multilayer mirrors for the water window," *Optics Letters*, Volume 28, 2494-2496 (December 2003).

<sup>2</sup> T Kuhlmann, Sergey Yulin, Torsten Feigl, Norbert Kaiser, Tatiana Gorelik, Ute Kaiser, Wolfgang Richter, "Chromium-Scandium Multilayer Mirrors for the Nitrogen K alpha Line in the Water Window Region," *Applied Optics*, Volume 41, Issue 10, 2048-2052 (April 2002).

<sup>3</sup> S. Bajt, JB Alameda, TW Barbee, MW Clift, JA Folta, B Kaufmann, E Spiller. "Improved reflectance and stability of Mo-Si multilayers." *Optical Engineering*, vol.41, no.8, Aug. 2002, pp.1797-804.

<sup>4</sup> S. Braun, H. Mai, M. Moss, R. Scholz, A. Leson, "Mo/Si multilayers with different barrier layers for applications as extreme ultraviolet mirrors," *Jpn. J. Appl. Phys.* Vol. 41, 4074 (2002).