The X-ray Standing Waves analysis of short period La/B- based multilayers

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Application of La/B_4C multilayer optics for λ = 6.7 nm, as can for instance be used at near normal incidence in a next generation photolithography equipment requires substantial improvement of both the reflectance and the bandwidth. La/B4C multilayers suffer from layer intermixing, diffusion and significant structural imperfections. In recent research we have shown that the formation of La-nitride by N-ion treatment of the La layers helps to reduce the compound formation, thus leading to an increase the multilayer mirror reflectivity. Here we present positive and negative influences of the N-ion treatment on the multilayer structure.

Using the Grazing Incidence X-ray Standing Waves technique for model waveguide structures, it was observed that, depending on the thickness of the La layer, the La density in a B_4C /La/B_4C stack is found to be reduced significantly with respect to the literature value for bulk La. This can be explained by LaB_6 interlayer formation. The density of LaN in B_4C /LaN/B_4C stack was found to be similar to the bulk LaN value.

To analyze the multilayer structure we combined the Grazing Incidence X-ray Reflectivity (GIXRR) technique with the analysis of the X-rays fluorescence from the La atoms excited with the X-ray Standing Wave (XSW) at the first order Bragg reflection. The analysis confirmed that nitridation of La significantly improves localization of the La atoms inside the multilayer period which significantly increases the optical contrast of the multilayer mirror. Analysis of the off-specular X-ray reflection however shows that depending on the nitridation process, interface roughness can be increased in LaN/B_4C multilayers.

In this presentation we will present details of the multilayer structural analysis and discuss the influence of interface intermixture and roughness on multilayer reflectivity.