Very thin layers for state-of-the-art x-ray mirrors

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State-of-the-art x-ray beamlines are equipped with x-ray mirrors according to their applications such as surface and materials science, chemical dynamics, photo emission spectroscopy, protein crystallography, x-ray microscopy [1]. In the case of free-electron lasers (FEL) and synchrotron radiation sources, total-reflection mirrors are an important optical element to guide and shape the beam. Such a mirror is often a single layer on a silicon substrate. The layer material is selected to its x-ray optical properties such as refractive index and micro-roughness. For the preparation of this layer material, it is important to achieve nearly bulk density, then the critical angle is perfect for its work. The typical layer thickness is in the range from 30 nm to 100 nm. At our Helmholtz-Zentrum Hereon, the most coated thin-film materials are B_4C, C, Ni, Pt, Ru, W in the last decades [2-4]. Two different magnetron sputtering facilities enable us to apply a wide range of different coatings with high precision and reproducibility up to a length of 1.5 m. Nowadays the interest in double and triple layer material systems has increased, because they can improve the overall mirror performance in terms of x-ray reflectivity and possibly extend its lifetime [5]. A bonding layer can support film adherence and stability. Furthermore, it can be used for chemical removal after a long operation time. After this, the substrate can most likely be re-coated. A top layer can prevent oxidation or any chemical reaction of the underlying layer. The different layer properties in this stack can also be used in different photon energy ranges. In sum the film thickness of the different layers is reduced that means some nanometers should be grown without any imperfections. We investigated some thin film materials in the range of some nanometers by means of x-ray reflectivity using our new diffractometer. With a special x-y stage it is now possible to measure a larger area of the mirrors. Furthermore, the micro-roughness of these layer systems has been measured by means of with light interferometry (WLI) and AFM to evaluate the impact of more interfaces in the layer stack.

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