Modifications of coherent hard X-rays beams induced by reflection on multilayer mirrors

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Compared with crystal lattice reflection, the use of Bragg reflection on a multilayer mirror as a monochromator for hard X-rays has the advantage of a higher photon flux density because of the larger spectral bandpass. The main disadvantage lies in the strong modulations in the reflected beam profile, see Figure 1. This is a major issue for micro-imaging applications, where multilayer-based monochromators are frequently employed to deliver high photon flux density [1, 2, 3]. A subject of particular interest is the origin of the beam profile modifications, namely the irregular stripe patterns, induced by the reflection on a multilayer. For multilayer coatings in general it is known that the substrate and its surface quality significantly influence the performance of such kind of mirrors as the coating reproduces to a certain degree roughness and shape of the substrate.

This presentation shall outline that the mid-spatial frequency roughness (MSFR), from 1 mm^{-1} to 1 μm^{-1} [5], of the multilayer substrate is of crucial importance for the beam profile modifications. A set of dedicated comparative experiments have been carried out, in which the influence of the finite X-ray source size, the surface profile as well as the surface roughness and the beamline geometry were studied. Hence, for the first time, a detailed description of the formation of the beam profile modifications can be introduced. Furthermore, different concepts for compensating the beam profile modifications will be discussed.

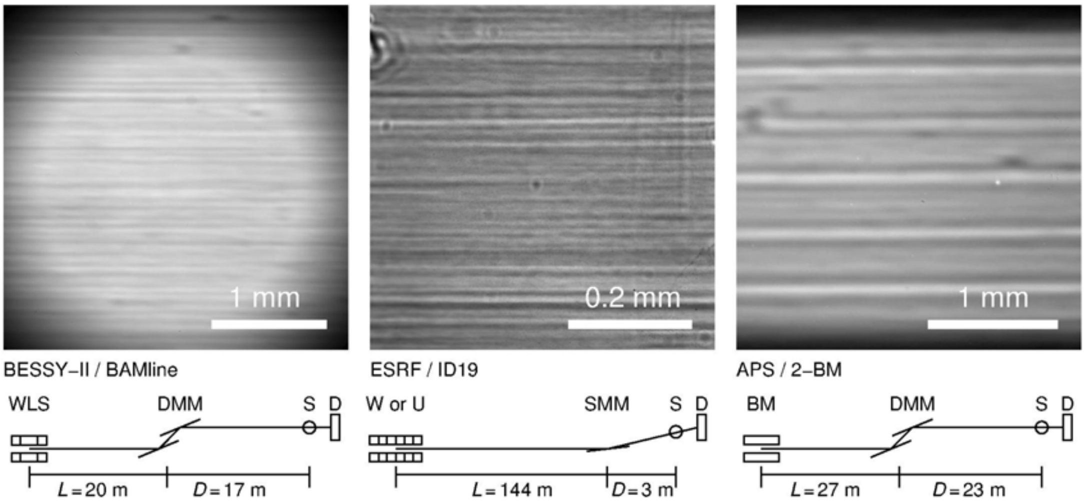

Figure 1: Examples of stripe modulations in the flat-field image after reflection by multilayer mirrors of different materials, period d and number N of bi-layers, in use at different beamlines around the globe [1]. The sketches below show the essential layout elements of each beamline: source (WLS: wavelength shifter; W: wiggler; U: undulator; BM: bending magnet), monochromator (DMM: double multilayer monochromator; SMM: single multilayer monochromator), and the distances L and D between source, multilayer and experimental station (S: sample; D: detector). The sketches do not show filters, windows, etc. Left: W/Si, N = 150, d = 2.88 nm at the BAMline, BESSY-II. Center: Ru/B_4C, N = 65, d = 3.92 nm, at ESRF beamline ID19. Right: W/B_4C, N = 200, d = 1.38 nm, at APS beamline 2-BM.

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