Interfaces between nanometer thin films studied by x-ray standing waves in grazing incidence and grazing exit modes

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X-ray standing waves are produced when constructive interferences build inside a periodic structure of nanometer period. Then, in Bragg condition, *i.e.* when the period of the stack and the wavelength of the incident beam satisfy the Bragg law, a strong standing wave develops perpendicularly to the layers and has the period of the stack. This enables locating the maximum of the electric field at specific locations, particularly at the interfaces between the layers, by scanning the incident beam in an angular range around the Bragg angle. Thus, the intensity of a secondary process, x-ray fluorescence or photoemission, can be measured as a function of the grazing incident angle. The angular distribution of the intensity can be related to the depth distribution of the emitting element, which gives information on the interaction taking place at the interfaces between neighbouring layers.

The same is true if instead of considering the incident radiation, the emitted radiation generated by the multilayer stack itself is considered. In this case, the incident radiation can be of beam of x-rays, electrons or ions. Then, the intensity of the secondary process, x-ray fluorescence, is measured as a function of the grazing exit angle or detection angle. The same information is obtained regarding the depth distribution of the elements by working in grazing incidence or exit modes. Both modes can be also applied to the study of non-periodic multilayers such as x-ray planar waveguides.

We shall compare the advantages and drawbacks of both operation modes. Examples regarding periodic multilayers as well as waveguides, using x-ray fluorescence and x-ray photoemission will be presented. We shall show that, with respect to x-ray reflectivity which is the standard method to characterize nanoscale thin films, the use of fluorescence or photoemission in combination to x-ray standing waves brings the elemental information. This helps to get a better description of the multilayer stacks made of nanometer layers.

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