DIFFUSE X-RAY REFLECTIVITY OF STRAINED SUPERLATTICES

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Perfect crystalline structure of a strained (non-relaxed) epitaxial superlattice influences substantially the morphology of its interfaces, so that the correlation properties of the roughness differ completely from the case of amorphous or polycrystalline multilayers.

The interface structure depends on the crystallographic orientation of the substrate surface. If the miscut of the surface (with respect to (001) crystallographic plane) is very small (few tenths of degree), the profile of the interface can be described by means of a random castellation (island-like model). In the case of larger miscut, a random staircase model is more appropriate. The actual interface structure lies somewhere between these two limiting cases.

The main difference between the roughness profile of an interface in a single crystalline superlattice and a polycrystalline (amorphous) multilayer consists in the spectral density of the roughness. In the former case, the spectral density exhibits maxima corresponding to the mean width of the islands (or terrace steps), while the latter structure exhibits no non-zero maxima of the spectral density. Moreover, the staircase-like structure is anisotropic and this anisotropy is related to the azimuthal direction of the substrate miscut.

Diffuse x-ray reflection is a suitable method for the study of the interface morphology since it probes the roughness spectral density. In particular, the above limiting models can easily be distinguished by measuring the x-ray scattering in several scattering planes with various azimuths. From the measurements, the basic parameters of the structure models can be determined.

Moreover, from the distribution of diffusely scattered intensity in reciprocal plane the correlation of the roughness profiles of different interfaces (roughness replication) in the multilayer can be stated. Usually, the staircase-like interface structure gives rise to an oblique roughness replication, i.e. the direction of the maximum replication is inclined from the growth direction by 40 – 60 deg. The reason for this feature lies in the growth mechanism. It can be explained using the concept of moving monolayer steps during the growth.

In the lecture, several examples will be presented demonstrating the island-like and staircase-like interface structures and the roughness replication in SiGe/Si, SiGe/SiC, and GaInAs/GaAsP/GaAs systems.