| ESRF | **Experiment title:** Structural ordering and interface morphology in symmetrically strained superlattices grown on off-oriented substrates | **Experiment number:** SI 316 |
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Report: **Experimental report**

The aim of the experiment was the investigation of the strain and interface morphology in symmetrically strained superlattices, which are laterally patterned by strain induced growth.

We studied (GaIn)As/GaAs/Ga(AsP)/GaAs -superlattices grown on a 001 -GaAs substrate, nominally off-oriented by two degrees towards the [011] direction. The Iridium-content and the Phosphor-content are chosen in such a way that the lattice mismatch of both ternary compounds with respect to the GaAs substrate is of same magnitude but opposite sign (symmetrically strained layers). Depending on the strain in the ternary compounds and on the miscut the lateral period and the characteristics of the lateral ordering vary.

We have performed for the first time high resolution grazing incidence diffraction studies measuring the coherently diffracted and diffusely scattered intensity of the in-plane reciprocal lattice points (RLPs) HKO. Two samples of identical miscut but different strain have been studied using the in-plane RLPs 020 and 200.

In the 020-reflection the reciprocal lattice vector is perpendicular to the grating -induced lattice displacement vector, thus the reflection is insensitive to both the vertical and the lateral strain. The complementary 200-reflection detects the influence of the lateral lattice strain. In conclusion, measuring with scattering vectors nearly perpendicular and parallel to the in-plane lattice displacement vector respectively allows to separate the effect of the *pure "compositional" ordering* from additional *perturbation* due to *lattice distortion.*

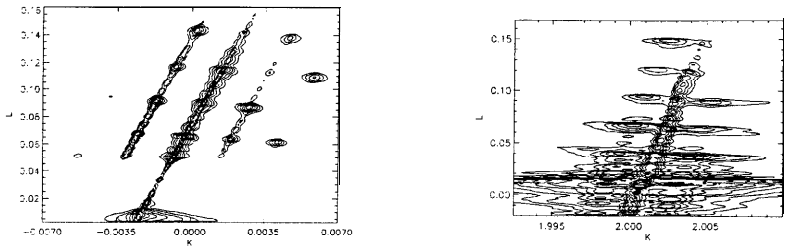


Fig. 1: Measured GID-maps of the 020 reflection (a - left) and the 200-reflection (b - right) of sample A

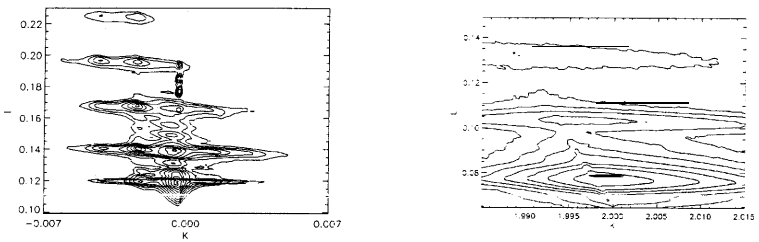


Fig. 1: Measured GID-maps of the 020 reflection (a - left) and the 200-reflection (b - right) of sample B

After monochromatization by a Si 111 double monochromator (wavelength $\lambda$=0. 12155 nm) the parallel undulator beam enables high angular resolution concerning the incident angles with respect to the sample surface $\alpha_i$ and the in-plane component of the diffraction angle $\theta_{0II}$. The direction of the scattered beam was determined by a system of narrow slits in front of the detector defining precisely $\alpha_f$. However, the use of an analyzer was prevented by an insufficient stability of the alignment. Thus the set-up allows to perform two dimensionally resolved measurements within a selected $Q_{II}, Q_z$ plane ( $Q_z$ is perpendicular to the surface). The detector integrates along the intersection line of the Ewald sphere with the $Q_x$ , $Q_y$ plane at $Q_z(\alpha_i, \alpha_f)$.

In Fig. 1 and 2 we plot experimental $Q_{II}, Q_z$ maps of the studied (GaIn)As/GaAs/Ga(AsP)/GaAs superlattices in the crystallographic frame of reference. The scattered intensity is concentrated in partially coherent stripes along the central crystal truncation rod (CTR) and the grating truncation rods (GTR). The existence of the GTRs and their widths indicates a remarkable lateral periodicity especially for sample A (fig. la). The GTRs are inclined with respect to the 001-direction by the miscut angle. The GTR contain superlattice satellites perpendicular to the surface normal. These superlattice satellites form branches inclined with respect to the sample horizon, where from we determine the replication angle of the stair like interface profile from interface to interface. Clouds of resonant diffuse scattering (RDS) around the GTRs are recorded in all maps. From the diffuse scattering we can deduce on the character of the laterally and vertically partially replicated fluctuations in the morphology of the structure.