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Report:

The aim of the experiment
was the characterisation of the strain behaviour in deep buried gratings in comparison with free *surface gratings* based on large *strained layers and multilayers*

The structures consist of (GaIn)(AsP)/InP superlattices grown by metalorganic vapor phase epitaxy (MOVPE), fabricated by CNET Bagneux, France Telecom. The composition is chosen in such a way that the strain in both sub-layers has the same amount but opposite sign. The symmetrically strained layer super-lattices have been laterally patterned by lithography and subsequent etching providing surface gratings with typical periods of 250 nm. Half of the samples were buried by InP after the etching step.

The aim of the experiment was the investigation of 6 multilayer gratings of different vertical compositional setup and grating shape in symmetrical and asymmetrical diffraction geometry.

A triple crystal diffractometer set-up was used. Behind the vertical double monochromator the set-up included a horizontal Si(11 I)-monochromator and a similar analyzer as well as slits to limit the extension of the analyzer streak. The experiments were performed at a wavelength of 1.55 Å in order to reach the asymmetric 224-reflection in non-grazing Bragg-geometry. In order to overcome the geometrical limitations of the diffractometer set-up for large momentum transfer (larger angles), the analyzer was mounted not on the third goniometer but directly on the detector arm of the second goniometer. The set-up made the asymmetric reflection accessible, but unfortunately it didn't have the required stability for precise scans along defined directions due to long vibrations of the detector arm after each movement. Therefore we could not scan the grating truncation rod profile of the structures by performing selected Q_z-scans. Instead, we had to map the whole intensity range (the maps were realized with the inner loop performed by the sample (ω)-rotation, which showed a far better stability). Thus the non-stable 2θ-vibration was damped in each (ω)-scan after some measuring points, and we obtained maps of acceptable precision. However, the amount of measuring time increased drastically. We could investigate two samples, one surface grating and one buried grating.

Fig. 1 shows the measured maps of the asymmetric 224-reflection for both the surface grating and the buried grating.

We observe well resolved grating truncation rods, proving the macroscopically homogeneous grating periodicity. Each truncation rod contains vertical satellite peaks, which represent the super-lattice periodicity. The position and form of the satellites corresponds to a nearly rectangular grating shape. The intensity of the superlattice satellites above and below the substrate is nearly symmetric. However, the shift between the superlattice main peak and the substrate position indicates a remaining averaged strain. The intensity pattern is slightly asymmetric with respect to the central crystal truncation rod (pronouncing the low Q_{II} side). This indicates a slight elastic strain relaxation in the grating. The asymmetry of the intensity decreases after burying, proving a partial restraining due to the counterbalancing effect of the substrate material. We are evaluating the results by comparison of the X-ray data with calculations based on elasticity theory.

Fig. 1: Measured 224-maps of a superlattice surface grating (right) and a buried grating (left)