

Analysis of strain state of semiconductor structures by large-angle convergent electron beam diffraction

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Convergent beam electron diffraction (CBED) of a sample in off-eucentric height provides information about both the lattice geometry as well as the structural peculiarities of the sample in one and the same experiment (Ronchigrams). Inside the central disc of the zero-order Laue zone the dark deficiency lines are visible corresponding to excess lines in higher order Laue zones (HOLZ). A shift of the position of HOLZ lines while crossing an interface indicates a variation of the local lattice parameters.

This method was applied to two different elastically strained layer systems.

First a 30 nm thick (Zn,Cd)Se layer embedded in ZnSe was investigated with respect to its strain state. The sample was grown by molecular beam epitaxy (MBE) at a temperature of 320 °C. The nominal Cd content was 20 %. Here, the lattice mismatch of about 1.4 % affects an elastic deformation of the ternary layer without formation of defects. Hence, the composition is directly correlated with the lattice constants. Owing to the different lattice parameters of ZnSe compared to (Zn,Cd)Se the HOLZ lines are curved when approaching the

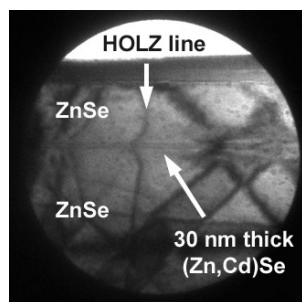


Fig. 1: LACBED pattern of a (Zn,Cd)Se layer embedded in ZnSe.

interfaces (see Fig. 1.) The dimension of the region where the HOLZ lines are curved clearly depends on the Cd diffusion length. The positions of the HOLZ lines with respect to composition and lattice parameters were simulated using the Electron Microscopy Image Simulation (EMS) software package. The results are in agreement with findings of TEM diffraction-contrast imaging and energy-dispersive X-ray spectroscopy.

A second sample was produced by combined use of metal organic vapour phase epitaxy and lithographic structuring of V-grooves. Multiple transitions of strain state from compressive to tensile and vice versa is introduced by materials of different lattice parameters. The aim of the growth experiments was to neutralize the total strain by capping the tensily strained V-grooved (In,Ga)P with compressively strained GaAs or (In,Ga)P. In Fig. 2 HOLZ lines crossing the different interfaces show an inversion of bending indicating a reversal from compressive to tensile and to compressive again.

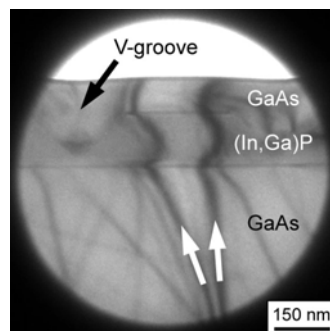


Fig. 2: Bent HOLZ lines in a V-grooved structure.