ROCKING CURVE IMAGING STUDIES OF LATERALLY OVERGROWN GaAs AND GaSb EPITAXIAL LAYERS

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The development of modern electronics requires fast techniques that allow precise analysis of the structural quality of crystalline materials starting from bare wafers up to complicated semiconductor structures. The aim of this work was to apply synchrotron radiation based technique of Rocking Curve Imaging (RCI) for detection and visualization of crystalline lattice microdefects in laterally overgrown epitaxial (ELO) layers. Since ELO layers consist of parallel monocrystalline layers regularly arranged on a template (see Fig. 1) they are perfectly suitable to demonstrate the potential of the RCI technique.

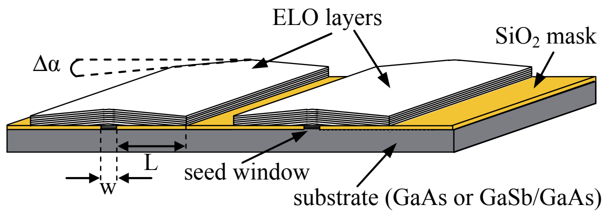

Figure 1. Schematic drawing of ELO structure. *L* and *w* denote widths of the ELO wing and of the seeding line, respectively. *Δα* is the maximal tilt angle of the ELO lattice planes.

Briefly, RCI is a technique which combines the features of X-ray imaging (very high spatial resolution) and X-ray diffractometry (very high angular resolution). The method is realized as follows (see Fig. 2): a wide, homogeneous and monochromatic synchrotron X-ray beam illuminates large parts of the sample. A precise goniometer allows rotating the sample close to the Bragg position with very small angular step around the axis perpendicular to the diffraction plane. Next, for each angular position series of local diffraction images are acquired by using very fast detector (Frelon camera - 2048×2048 pixels, pixel size equals to 1.4 μm). Finally, all digital images collected are used to create RCI maps of the sample that later on are visualized and analyzed with dedicated software [1].

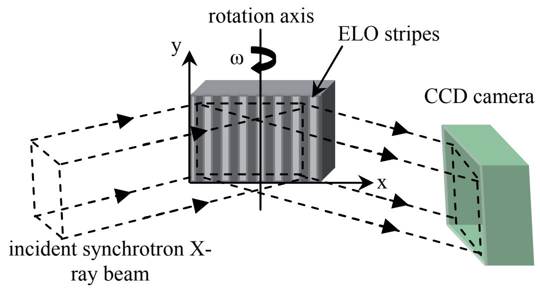

Figure 2. Schematic drawing of RCI setup. A wide beam of monochromatic X-rays is diffracted on ELO sample. Diffraction plane is oriented horizontally, perpendicular to ELO stripes.

First we focus on the RCI analysis of a single GaAs ELO stripe grown by liquid phase epitaxy on SiO_2-masked GaAs substrate. Details of the growth procedure can be found elsewhere [2]. Figure 3a shows the spatial distribution of Bragg peak position over a wide area of the sample. Signals coming from the substrate, from ELO wings and from the material grown vertically over the window in the mask are easily distinguishable.

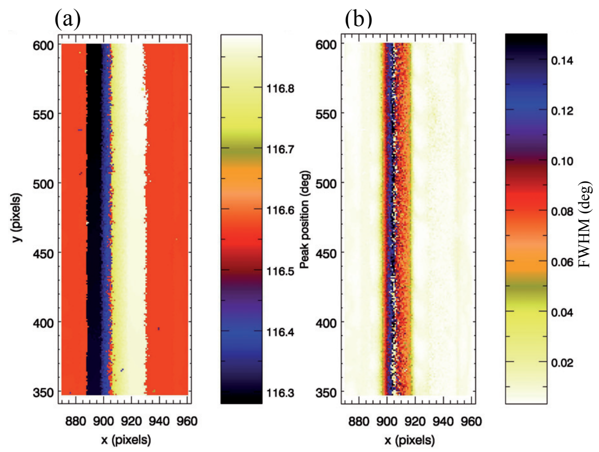

Figure 3. Spatial distribution of Bragg peak position (a) and map of local rocking curve FWHM values (b) in GaAs/GaAs single ELO stripe. Pixel size is 1.4 μm.

Figure 3b shows the spatial distribution of the full width at half maximum (FWHM) of the rocking curve. As seen, FWHM is largest in the central part of the layer. Note that the Bragg angle position changes continuously across the ELO stripe. This is even better visible in Figure 4 that shows a cross-section at the position y = 539 of the map in Figure 3a. Such distribution of Bragg peak position clearly indicates tilting of ELO wings towards the mask – a phenomenon commonly observed in many ELO systems [2]. As can be seen, the maximum wing tilt angle, denoted as $\Delta\alpha$ in Figure 1, equals ~0.3°. Figure 4 shows that the fastest changes of the Bragg angle take place in the central part of the layer. Thus, the crystal lattice there must be strongly strained, which explains enhanced values of FWHM in that part of the layer (compare Figure 3b). Note also that RCI maps show that homoepitaxial GaAs/GaAs ELO layers are uniform along the ELO stripe. This is not necessarily the case in heteroepitaxial ELO layers where lattice and thermal expansion mismatches lead to strongly stressed epilayers.

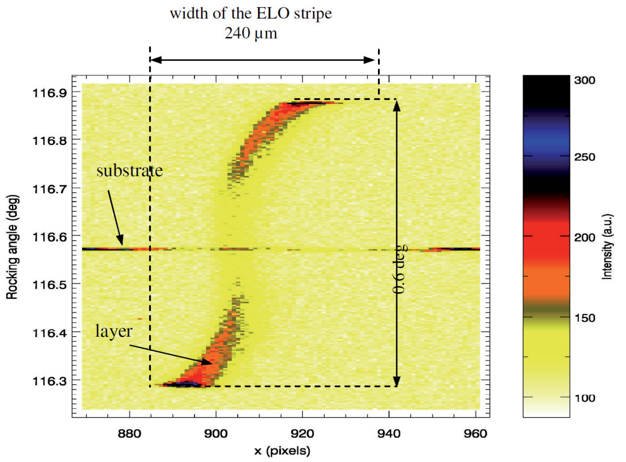

Figure 4. x-omega-map of the GaAs/GaAs single ELO stripe.

As an example Figure 5 shows a map of local diffraction intensity in a GaSb ELO stripe grown on a GaAs substrate coated by a planar GaSb buffer and SiO_2 mask. Local mosaicity in the wing area is clearly visible. Due to high spatial resolution of the RCI technique individual grains (microblocks) are visualized, so their sizes and relative misorientation can be readily determined.

Finally, results of RCI analysis of GaAs/GaAs and GaSb/GaAs ELO structures are compared with those obtained for the same samples by laboratory technique of spatially resolved X-ray diffraction (SRXRD) [3]. Due to more intense synchrotron X-ray beam and application of modern detectors, the spatial resolution of RCI is much higher, which makes this technique preferable for the detection of strongly localized strain fields in textured heteroepitaxial structures. On the other hand, analyzer crystals can be easily used in laboratory SRXRD technique allowing precise separation of overlapping signals in homoepitaxial ELO layers [4, 5].

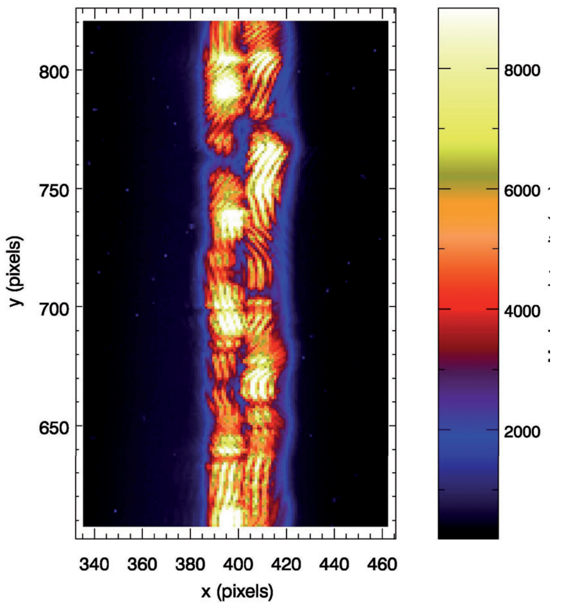

Figure 5. Spatial distribution of local diffraction intensity for GaSb/GaAs ELO layer. Pixel size is 1.4 μm. Microblock structure of the layer is visible.

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