Application Report XRD 34

D8 DISCOVER Plus

Rapid Reciprocal Space Mapping on Thin Films

The D8 DISCOVER Plus equipped with the ATLAS™ goniometer and the high-efficiency turbo X-ray source (TXS-HE) is a diffraction solution designed to meet current and future analytical needs in research and production. In this report we present RapidRSM™, a technology that enables the measurement of Reciprocal Space Maps (RSM) in the shortest possible time.

The structural properties of epitaxial multilayer coatings are of paramount importance for the functionality of devices in semiconductors, optoelectronics, ferroelectrics and spintronics. Reciprocal Space Mapping (RSM) with XRD has become the de facto technique to characterize the structure of thin crystalline layers due to its ability to non-destructively measure both perpendicular and lateral strain, composition and domain effects. Typically, RSMs require a series of scans that allow the substrate and film diffraction intensity to be mapped in a shared planar slice of reciprocal space, a time consuming process which takes hours due to goniometric positioning.

With RapidRSM, the diffracted intensity is measured with a 1D detector which is actively read out as the scan is performed, leading to a dramatic reduction in scan time to just a few minutes or even seconds. Important for the fast measurement of RSM is an intense, highly parallel and monochromatic X-ray beam, a 1D-detector with high count rate and fast readout capability, making the D8 DISCOVER Plus with high intensity TXS-HE the superior solution.

A D8 DISCOVER Plus with Cu TXS-HE, Goebel mirror, 2xGe(004) monochromator, a 0.6 mm slit, Eulerian cradle and a LYNXEYE XE detector was used to measure RapidRSMs on asymmetric reflections of three compound semiconductor samples: around the (224+) reflection of two $In_xGa_{1-x}As$ films of 200 nm and 800 nm thickness on a GaAs substrate and the (105+) reflection of InGaN/GaN superlattice grown on a virtual GaN substrate.

With RapidRSM the total measurement time for each RSM was about 20 s.

The measurements were loaded into DIFFRAC.LEPTOS and converted to reciprocal space. The obtained RSMs are shown in figures 1 and 2. The differences between the two $In_xGa_{1-x}As$ films are clearly visible in peak both position and shape. The peak of the 200 nm film (Figure 1a) is horizontally aligned with the GaAs substrate indicating pseudomorphic growth. With the knowledge of the fully strained condition, the position of the InGaAs peak can be used to calculate the concentration of In, x=0.06 in this case, via a push button method in DIFFRAC.LEPTOS. The horizontal sharpness of the $In_{0,06}Ga_{0,94}As$ film and the GaAs substrate indicate a very high crystalline film quality with low dislocation density. In contrast, the (224) reflection of the 800 nm $In_{0,06}Ga_{0,94}As$ film is shifted horizontally and vertically (Figure 1b) towards the virtual peak position of a fully relaxed film $In_{0,06}Ga_{0,94}As$ film. The degree of relaxation is determined from the peak position to be 80% and the broadening of substrate and film peak indicate a high dislocation density due to the film relaxation.

Figure 2 shows the RSM of the (105+) reflection of the InGaN/GaN superlattice. Using the RSM tools of DIFFRAC.LEPTOS, the SL-Period was determined to be 15.3 nm. The perfect vertical alignment of the superlattice peaks indicates that the entire superlattice is grown fully strained on the GaN substrate while the narrow lateral broadening of the superlattice peaks indicates a low defect density.

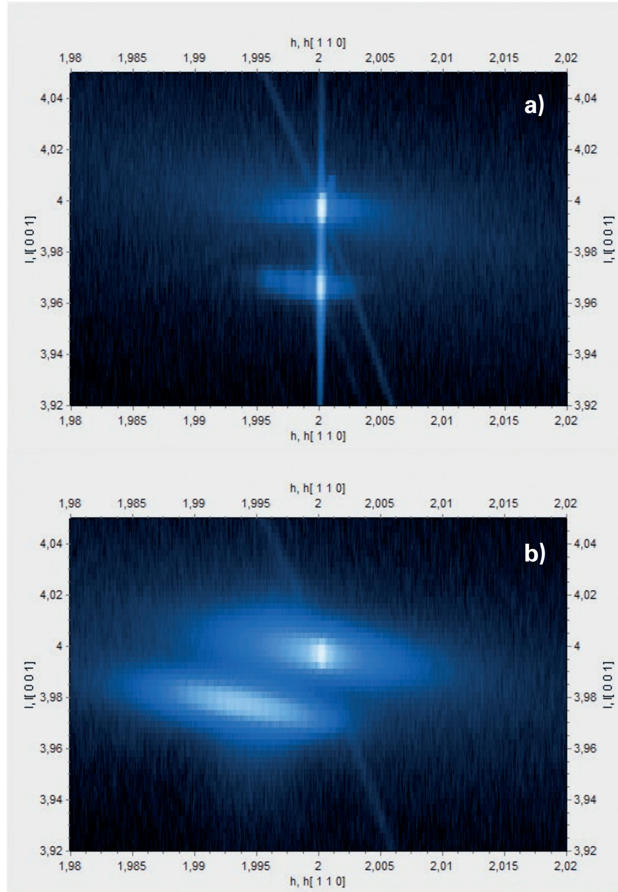

Figure 1: RSMs at the (224) reflection of a GaAs substrate with a $In_{0,06}Ga_{0,94}As$ film of thickness a) 200 nm (strained) and b) 800 nm (relaxed).

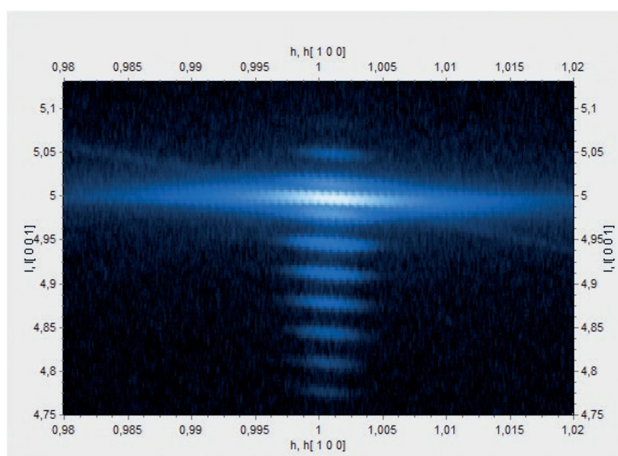

Figure 2: RSM of a InGaN/GaN superlattice on GaN taken at the (105) reflection.

Bruker AXS GmbH

info.baxs@bruker.com

www.bruker.com

Worldwide offices

bruker.com/baxs-offices