Feasibility Study of “1 Minute” Reciprocal Space Mapping

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A lot of research effort is currently spent on the development and improvement of heterostructures grown by MBE (Molecular Beam Epitaxy) or MOVPE (Metal Organic Vapor Phase Epitaxy). Reciprocal space maps offer a direct way to measure peak position and shape in order to calculate mismatch and composition or to investigate peak broadening from defects, for example, using a Williamson-Hall plot (Fig. 1). For information about the homogeneity of heavily mismatched structures, reciprocal space maps are required on more than one point of the wafer (wafer mapping) to investigate possible yield losses before giving a wafer into processing. All of these measurements are required to be as rapid as possible without loss of information. Traditionally, typical 0D-detector based measurements with a crystal analyzer offer the highest accuracy, but are inherently slow, taking in excess of 12 hours to collect in some instances. For moderately complex structures, position sensitive detectors such as the PIXcel3D currently offer acquisition times more than one order of magnitude lower. In the present work, we present a feasibility study to further reduce the measurement time, exploiting the known qualities of the PIXcel3D such as count rate linearity of $13 \times 10^6$ cps per column and noise below 0.5 cps on the total detector (255x255 pixels). We present several examples of reciprocal space maps with acquisition times between 30 seconds and 5 minutes on current state-of-the-art nitride structures, to illustrate the further development of the application for X-ray analysis of nitride and other heterostructures.

Figure 1: (a) Williamson Hall plot of FWHM in two directions taken from 3 maps recorded in a total time of 3 minutes. (Right) (00.4) reciprocal lattice point of a GaN based heterostructure recorded in 1 minute on an X’Pert3 MRD with PIXcel3D.