Posudek na doktorskou práci Mykhaila Barchuka

Diffuse x-ray scattering from GaN epitaxial layers

The thesis deals with the x-ray diffraction related methods of determination of dislocation types and densities and other defects in epitaxial GaN and (Al,Ga)N layers. This topic is actual and presents original results, which has been already published in respected journals. The simulation and analysis of x-ray diffuse scattering on the dislocations in the crystals is quite complicated, since the displacement field caused by the dislocations is long range and could not be treated within a standard approximations.

The thesis is divided in ten chapters. The first five chapters are devoted to the properties of gallium nitride, classification of the structural defects, growth method of the epitaxial layers, basic theory of x-ray scattering and overview of defect characterization method. The main part of the thesis is concentrated in later five chapters. The sixth chapter deals with measured data on two series of c-plane GaN and AlGaN epitaxial layers, chapter 7 with Monte Carlo simulations of these samples. The chapter 8 presents measurements on the series of a-plane GaN layers and the ninth chapter deals with a technique of determination stacking faults in the layers. The last chapter summarize the results obtained on all three series of samples.

The thesis, however, is not well organized. For instance, the growth conditions of the studied samples are presented in section 3.3 in the chapter 3 devoted mainly to the description of various growth techniques. The measured data of c-plane samples are presented in chapter 6, the chapter 7 shows the resulting fitted reciprocal space maps, while the corresponding values of the fitted parameters are presented in the last chapter 10. It would be better to sort the thesis with respect the sample series, since there are three series of samples independent of each other. The current arrangement is quite difficult for a reader to follow.

The thesis also includes number of minor typos and inconsistencies. I want to mention few of more visible imperfections:

- There is no reciprocal space map with shown scale or a contour step, except of figure 7.6 and 7.7. Only figure 8.3 on page 86 claims the isointensity levels to be $10^{0.5}$; however there are no visible contours in this graph.

- Cubic phase of GaN does not have a central symmetry, as is claimed on page 22.
- The definition of diffraction angles is inconsistent; on page 50 rocking scan is called Θ-scan, while few pages later (page 60) it is called ω-scan. The angles in the standard coplanar geometry are not defined at all.
- The table 6.2 contains fitted values from the x-ray reflection curves. The values do not have any error estimation, which is missing even more that they are written to incredible precision of 10^{-3} nm and the table headline contains forgotten double units.
- The discussion of the five fitted peaks in section 6.2.2 on pages 67-68 is a little bit confusing. One can also correspond peak 3 for sample A0 to peak 4 for sample A5, because the are at almost the same position. If the peak 3 in sample A0 should correspond to peak 4 in sample A5, what is the reason for the peak shifts between samples A5 and A0?
- The Monte Carlo simulation results can be better illustrated by few figures showing the effect of the individual simulation parameter results on the reciprocal space intensity distribution, for example the influence of the dislocation type on the resulting diffuse scattering.

M. Barchuk reached the main goal, which was to determine the densities of different dislocation types and stacking faults in wurtzite phase III-V semiconductor epitaxial layers with the accuracy of 15 %, which is a very good and novel result. The resulting fits are in an excellent agreement with the experimental data as well as the transmission electron microscopy results obtained for one series of samples.

According to the explicit request from the Charles University I can say M. Barchuk has shown his scientific creativeness and the doctoral thesis meets the required criteria.

Brno, 29. 10. 2012 Mgr. Ondřej Caha, Ph.D.