

NDnano Undergraduate Research Fellowship (NURF) 2011 Project Summary

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Project Title: Calculation of Dislocation Densities in GaN-based Heterostructures Using High Resolution X-ray Diffraction

In the leading edge of High Electron Mobility Transistor (HEMT) research, it is necessary to grow extremely thin layers of nitride based films including GaN and AlN. Unfortunately, due to the nature of the crystal structure of these compounds and the thickness of the layers required, defects that negatively impact device performance are common. If it would be possible to estimate the amount of defects in a particular sample, it would be easier and faster to develop the materials needed for the transistors. The main goal of this project was to develop a method to easily characterize and quantify the dislocation density in a given semiconductor crystal structure.

The main part of the method that was developed involves taking a series of specific x-ray diffraction scans. It is already known that imperfections in the crystal structure of a sample contribute to the broadening of the scan peaks. Through the use of a Williamson-Hall analysis, our method calculates an estimation of the actual dislocation density of the sample. The method is relatively quick, requires only few calculations and is repeatable on a number of different samples. It will provide extremely valuable information to researchers that otherwise would have been unknown, or at least difficult to obtain. Overall, the project was a success. The method gives relatively accurate estimations of dislocation densities in the semiconductors that are being used and will soon be implemented on a regular basis in current research and development.

The attached graph shows a plot of the Williamson-Hall analysis curves comparing samples of different dislocation densities against each other. The plots are generated using scan information and the dislocation densities and other crystal parameters can be extracted from the linear fits of the plots.

