Nanoelectronics Undergraduate Research Fellowship (NURF)
2010 Project Summary

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Project title: Nanofabrication and characterization of semiconductor heterostructures

While high-efficiency solar cells are very desirable for both space and terrestrial applications, the current photovoltaic market is dominated by single-junction Si-based cells which have a maximum theoretical efficiency of just 31% under 1 sun. Multi-junction solar cells can cover a much larger range of the solar spectrum, and can thus convert a much higher percentage of the incoming solar energy. A four-junction monolithically-integrated III-V/II-VI semiconductor solar cell is currently being developed at the University of Notre Dame in collaboration with Arizona State University with a projected energy conversion efficiency of 40% under 1 sun and 48% under 1000 suns. The principal aim of my portion of the project was to determine the electrical and optical characteristics of ZnTe and ZnTe:N grown by molecular beam epitaxy on lattice-mismatched GaAs substrates, and ultimately to evaluate the feasibility of using such a junction in the solar cell.

The electrical characteristics of the p-type ZnTe:N layer were determined by magneto-transport measurements, which are dependent on the Hall effect. After placing the sample in a varying magnetic field, we would run a current through it and measure the voltage across the sample in the transverse and longitudinal directions to obtain the hole concentration and hole mobility. By doing this over a wide range of temperatures, we were also able to determine the temperature dependences of the two quantities. The optical characteristics were measured by photoluminescence spectroscopy. By directing light from a laser onto the sample, we would excite electrons from the valence band to the conduction band. The electrons would be unstable in the conduction band states, and fall back to the valence band, releasing photons with energy equal to the bandgap energy, which were detected and analyzed.

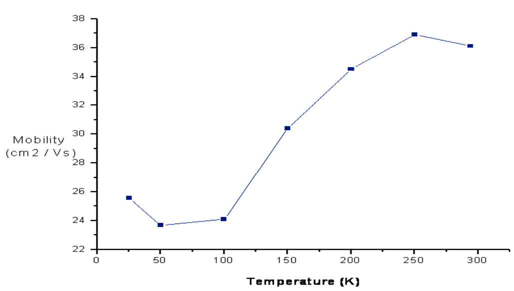

Figure 1: The temperature dependence of the hole mobility

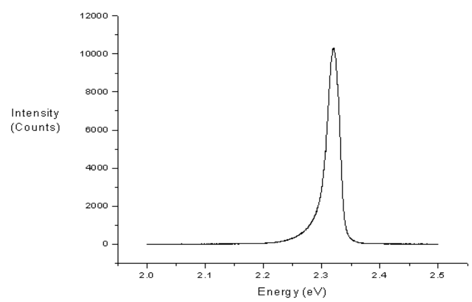

Figure 2: The photoluminescence spectrum for GaAs/ZnTe/ZnTe:N. The maximum intensity occurs at 2.32 eV.

By comparing the magneto-transport data and photoluminescence data obtained this summer at ND with transmission electron microscopy images taken by Prof. D.J. Smith's TEM group at ASU, we were able to conclude that GaAs is a suitable substrate for the solar cell project, and that the p-type doping of ZnTe:N in the MBE is highly effective. In light of these successes, the materials development group of the research team will now shift focus to the optimization of the n-type doping of ZnTe.

"MBE Growth and Characterization of ZnTe and Nitrogen-doped ZnTe on GaAs(100) Substrates," poster, presented at the 2010 Notre Dame REU Symposium.

"MBE Growth and Characterization of ZnTe and Nitrogen-doped ZnTe on GaAs(100) Substrates," paper, to be published online by the Notre Dame Physics REU.