Solid State Electronics Lab

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Exploiting Disorder in Ternary Heterovalent Semiconductors to Tune Across the Visible Spectrum

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ABSTRACT: The III-nitride family of GaN, InN, and AlN semiconductors has revolutionized multiple electronic industries, allowing us to access the spectrum from infrared to ultraviolet within one material system. Gallium and indium are rather expensive elements, however, and their long-term supply is of some concern – prompting many to explore potential alternatives for at least some applications. One such family is that of the II-IV-N_2 compounds, which are analogous to the III-Ns in that pairs of column three elements are "replaced" by a column II and a column IV pair. In the case of $ZnSnN_2$, which has been the subject of multiple studies in the past several years, estimates of the band gap energy have varied from approximately 1 to 2 eV (straddling the ideal single junction terrestrial solar cell gap).

It transpires that the cation sublattice tends to be less than perfectly ordered, which has a dramatic impact on the band gap energy. We have been able to quantify this ordering using the long-range order parameter S through a combination of synchrotron x-ray diffraction, in-situ electron diffraction, and Raman spectroscopy measurements. We observe a direct relationship between the order parameter and optical properties such as the band gap energy – allowing us to tune the band gap through controlled introduction of partial disorder through growth parameters – obviating the need for alloying. Further, we have demonstrated for the first time that $MgSnN_2$ can be synthesized, and has a band gap spanning the range of 1.9 to 3.4 eV (depending on the degree of cation ordering).

Consequently, these two materials span the visible spectrum, and provide an interesting alternative to (Al,Ga,In)N based alloys.

BIOGRAPHY: Steve Durbin received the BS, MS, and PhD degrees in Electrical Engineering from Purdue University. Prior to joining Western Michigan University in 2013, he taught at the Florida State University, the University of Canterbury (New Zealand), and the University at Buffalo (SUNY). He is a senior member of the IEEE, and a member of the American Physical Society, the Materials Research Society, and the Royal Society of New Zealand. His interests include novel semiconductors, oxide and nitride compounds, molecular beam epitaxy, pulsed laser deposition, and Schottky contact based devices.

Refreshments will be provided