Nanometer-scale structure and properties of dilute semiconductor alloys

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For many compound semiconductors, the addition of dilute concentrations of impurities leads to dramatic changes in the electronic, optical, and magnetic properties. For example, the introduction of a few percent nitrogen into GaAs leads to a band gap reduction of hundreds of meV. Furthermore, the incorporation of a few percent manganese into GaAs enables a combination of semiconducting and ferromagnetic behavior. The resulting narrow gap nitride and dilute magnetic semiconductors are promising for several applications ranging from long-wavelength light-emitters and high efficiency solar cells to spin-electronics and spin-optoelectronics. In both cases, the nanometer-scale details of impurity incorporation are critical to understanding and controlling the observed properties. In this talk, I will discuss our recent investigations of the growth, nanometer-scale structure, and properties of dilute GaAsN and GaMnAs alloys, using nuclear reaction analysis (NRA) and cross-sectional scanning tunneling microscopy (XSTM), in conjunction with several other measurements. In the case of GaAsN, I will discuss the incorporation of nitrogen into substitutional vs. interstitial lattice sites, and its effect on electronic and optical properties. In the case of GaMnAs, I will discuss clustering of MnGa and AsGa point defects, and its effect on electronic and magnetic properties.

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