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Seminar Series

Z-Contrast STEM Studies of Bismuth Incorporation in Epitaxial Ga($As_{1-x}Bi_x$)

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Recent interest in the controlled growth of Ga($As_{1-x}Bi_x$) semiconductor alloys has been stimulated by the sensitivity of the bandgap energy and valence band structure of these materials to the concentration of Bi solute they contain. The development of Ga($As_{1-x}Bi_x$) for applications requires detailed characterization of the materials that can be grown by the various deposition techniques that are used to produce devices. Specifically, it is critical to understand how Bi atoms are incorporated into a GaAs lattice in which they are essentially insoluble and how they ultimately are distributed within an epitaxial film or device structure into which they were coaxed by molecular beam (MBE) and metal-organic vapor phase epitaxy (MOVPE). Bi concentration as high as 10% have been report in films grown using MBE. Multilayer quantum GaAsBi/GaAs structures have been grown successfully by at least two groups with Bi concentrations up to 4.2%. Interestingly, incorporation of Bi into growing film appears to have been enhanced by pulsing the Bi flux into the reactor during MOCVD growth and by rotating the substrate through a Bi rich flux in MBE. Our subsequent work explored the distribution of Bi in a selection of structures grown by MBE and MOCVD methods using high-angle annular dark field (HAADF, or "Z-contrast") imaging methods in an aberration-corrected scanning transmission electron microscope (STEM). Complex Bi concentration profiles in the growth direction suggest that the Bi incorporation process is more complex than simply supply of Bi to the surface. A possible model for how and when Bi atoms are incorporated will be presented.

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