【QS-09】

Isoelectronic Impurities in III-V Semiconductors

Hyeonsik Cheong
Department of Physics, Sogang University, Seoul, Korea

Nitrogen impurity in III-V semiconductors such as GaAs or GaP has a unique physical property that has attracted much attention in recent years. Being an isoelectronic impurity substituting the group-V ions (As or P), nitrogen does not create electrons or holes. However, because of the large differences between the host As or P atoms and N atoms in their sizes and atomic orbital energies, the effect of N substitution on the physical properties of these semiconductors is very different from that of normal alloys or impurities: adding a small amount of N causes a dramatic changes in the band structures of the host semiconductors.

GaAs1-xNx has been the subject of intense investigation in recent years because of its distinctive optical properties and its technological importance for application in multijunction high efficiency solar cells and optoelectronic devices in fiber-optic communications. Only 1 % nitrogen isoelectronic substitution in GaAs results in a fundamental bandgap reduction by ~200 meV, leading to the so-called giant bandgap bowing . Recently, a nitrogen-induced state, the so-called E+ state, above the conduction band minimum has been observed in electroreflectance and high-pressure measurements. In contrast to the red-shift of the bandgap energy with increasing nitrogen concentration (□ 3%), E+ exhibits a large blue-shift whose rate is roughly 2/3 of that of the red-shift of the bandgap energy.

The nature of the conduction band minimum and the E+ state of GaAs1-xNx is probed with resonant Raman scattering (RRS). Strong resonance enhancement of the longitudinal optical (LO) phonon Raman intensity is observed with excitation energies near the fundamental energy gap as well as the E+ transition. Near the E+ transition, various X and L-point Brillouin-zone-boundary phonons are relatively enhanced, which means that the state in resonance (E+) has strong L- and X-characters. In addition, a dramatic increase in the linewidth of the LO phonon mode is observed just below the E+ resonance, which is interpreted in terms of strongly localized states originating from the isolated nitrogen impurity levels. On the other hand, we have not observed any resonant LO phonon line width broadening or activation of sharp zone-boundary phonons near the fundamental bandgap energy. This result reveals that the conduction band minimum of GaAs1-xNx predominantly consists of the delocalized GaAs bulk-like states of G symmetry.