Contribution ID: **783** Type: **Oral (Student, In Competition) / Orale (Étudiant(e), inscrit à la compétition)**

Investigation of the effect of growth condition on defects in MBE grown GaAs1-xBix

Monday, 15 June 2015 16:45 (15 minutes)

Incorporation of Bismuth into GaAs causes an anomalous bandgap reduction (88 meV/%
for dilute alloys) with rather small lattice mismatch compared to ternary In or Sb alloys. The bandgap can be adjusted over a wide range of infrared wavelengths up to 2.5 μm by controlling the Bi content of the alloy which is useful for laser, detector and solar cell applications.

Semiconductor lasers are compact and efficient so they are the preferable choice in many applications. GaAs1-xBix can be used as the light emitting material for the 1-1.3 μm communication wavelengths. Another application is vertical-external-cavity surface-emitting- lasers (VECSEL) to generate high power infrared output and then doubling the frequency to achieve yellow laser light. The first step to make a laser is optimizing GaAs1-xBix growth parameters to realize the best material quality which cannot be achieved unless the defects in the crystal are understood.

The three requirements for MBE growth of GaAs1-xBix are: low growth temperature (compared to standard GaAs), small As2:Ga ratio and controlled Bi flux. In this research, we tried to understand the relation between the growth conditions and the crystal defects using photoluminescence (PL) and deep level transient spectroscopy (DLTS).

PL intensity is a good relative gauge for the number of defects as the defects are typically non-radiative recombination centres. Our results show that the reduction of growth temperature from 400℃ to 300℃ with all other growth conditions fixed causes the Bi concentration in the deposited films to increase from 1% to 5% but the PL intensity decreases by more than a factor of 1000. Changes in the other two growth conditions, As2:Ga ratio and Bi flux, affect the Bi incorporation but they are not as important factors in the PL intensity as the growth temperature. Two samples were grown at different temperatures (330℃ and 375℃) with approximately the same Bi concentration (˜2%) at a stoichiometric As:Ga flux ratio. The temperature dependence of the PL shows that the sample grown at higher temperature has less photoluminescence emission from shallow defect states and a stronger temperature dependence of the bandgap. We interpret the shallow defects as intrinsic localized states close to the valence band edge associated with Bi next nearest neighbour clusters. DLTS measurements on GaAs and GaAsBi samples show that the density of deep levels increases at low growth temperature and that a Bi surfactant reduces the density of deep levels. DLTS measurements on dilute GaAsBi samples grown at different temperatures will be presented.

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Session Classification: M2-2 Material growth and processing (DCMMP) / Croissance et traitement des matériaux (DPMCM)

Track Classification: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)