NOVIKOV, SERGEY

(University of Nottingham)

Molecular Beam Epitaxy of GaNBi alloys

S. V. Novikov1,*, C. T. Foxon1, K. M. Yu2 and W. Walukiewicz2

1School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, UK 2Materials Sciences Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720-8197, USA *presenter e-mail: Sergei.Novikov@Nottingham.ac.uk

Abstract: Bismuth has previously been used extensively for the growth of high purity GaAs by liquid phase epitaxy (LPE) to improve the electrical properties of the layers [see reference [1] and references therein]. It was shown that at LPE growth temperatures of ~800oC there is no significant incorporation of Bi into III-V films [1].

Recently it was demonstrated that it is possible to grow GaAs1-xBix alloys with a limited Bi content by metal-organic vapour phase epitaxy (MOVPE) and by molecular beam epitaxy (MBE). In order to achieve a few percent of the Bi in GaAs-based alloys, growths by MBE were performed at extremely low temperatures, below 400oC, and with precise control over Ga to As ratios. The band gap bowing observed in GaAs1-xBix alloys can be explained within the band anticrossing (BAC) model [2].

It is more difficult to incorporate Bi into GaN layers than into GaAs layers, because the differences in atomic weight and radii between N and Bi are larger than between As and Bi. Therefore only limited information is currently available on the growth and properties of GaN1-xBix alloys. At normal GaN growth temperatures, in MOVPE and MBE there is no significant incorporation of the Bi into the bulk of the GaN layer. Previously, we have demonstrated that bismuth can be used as a surfactant to improve morphology and to decrease the surface roughness of GaN grown by MBE [3]. Furthermore we have succeeded for the first time, in growing GaN1-xBix alloys on sapphire substrates by MBE [4]. We were able to incorporate up to ~0.05 mol% of Bi into the GaN layer by decreasing the growth temperatures to ~500oC. Consequently, we observed a gradual shift of band edge emission peak in PL with decreasing growth temperature.

Recently we have studied the MBE growth of GaN1-xBix alloys at extremely low temperatures down to ~100oC. We have grown GaN layers on sapphire substrates under a wide range of the Bi fluxes and under different Ga:N ratios. In this talk we will review our prior efforts in using Bi as surfactant in MBE growth of GaN and compare Bi incorporation during the MBE growth of the GaN layers under Ga-rich and N-rich growth conditions.

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