Microstructure and the Optical Properties of $In_xGa_{1-x}N$ Alloys

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The optical properties of $In_xGa_{1-x}N$ layers have been studied using optical absorption and cathodoluminescence techniques. The layers were ~100nm thick and the indium composition *x* of the layers ranged from 0.03 to 0.17, as determined by Rutherford backscattering measurements [1]. The surface morphology of these films change significantly with composition, with highly visible features associated with dislocations intersecting the surface [2]. The Stokes shift – defined as difference between the band gap and the peak emission energy - was found to be considerably smaller than reported in the past for these alloys [3]. CL Spectra showed that for low indium compositions, the light emission follows a single mode Gaussian behavior. For higher indium compositions ($x \geq 0.8$) the CL emission changes to a bi-modal distribution with a main peak followed by second emission band observed at longer wavelengths (Shown in Fig. 1). Monochromatic images show that light emission associated with the main CL peak occurs from most of the film. This emission is homogeneous and is associated with a low Stokes shift. The second emission band originates from indium-rich regions in the vicinity of extended defects, and exhibits a larger Stokes shift, comparable to the previously reported values (See Fig. 2). Much of the past work on this material has been done on quantum wells. Thus, the previously-reported large Stokes shifts appear to be related to the strain fields in the vicinity of extended defects and interfaces. Our observations indicate that it is possible to grow InGaN epilayers with high indium composition, high homogeneity and lower Stokes shift.

[1] S. Srinivasan, R. Liu, F. Bertram, F. A. Ponce, S. Tanaka, H. Omiya, and Y. Nakagawa. *A comparison of Rutherford backscattering spectroscopy and X-Ray diffraction to determine the composition of thick InGaN epilayers*. Physica Status Solidi (b), 5 Nov. 2001, Vol. **228**, 41-45.

[2] F. Bertram, S. Srinivasan, L. Geng, F. A. Ponce, T. Riemann, J. Christen, S. Tanaka, H. Omiya, and Y. Nakagawa. *Spatial Variation of Luminescence of InGaN Alloys Measured by Highly-Spatially-Resolved Scanning Cathodoluminescence*. Physica Status Solidi (b), 5 Nov. 2001, Vol. **228**, 35-39.

[3] S. Srinivasan, F. Bertram, A. Bell, F. A. Ponce, S. Tanaka, H. Omiya, and Y. Nakagawa. *Low Stokes Shift in thick and homogeneous InGaN epilayers.* Applied Physics Letters, 21 Jan. 2002, Vol. **80** (3), in press.

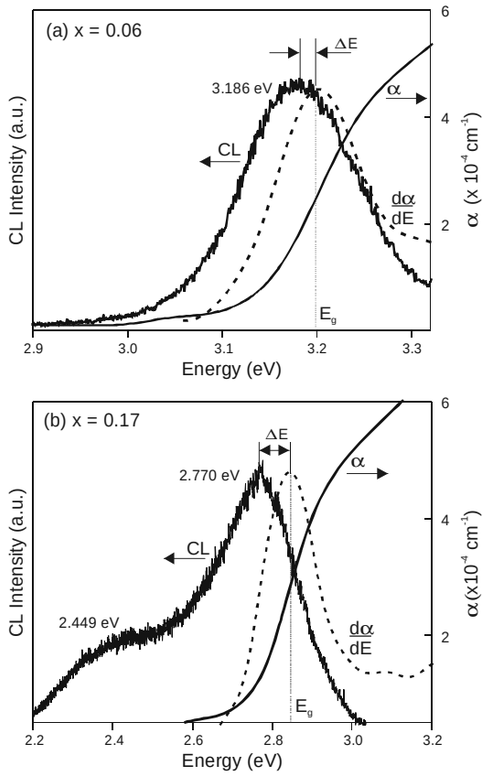

Fig. 1. Optical Absorption and CL spectra for (a) x=0.06 and (b) x=0.17.

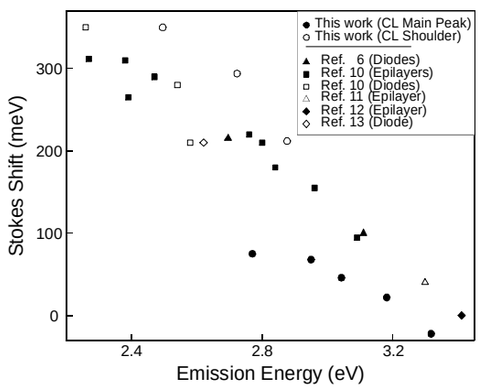

Fig.2. Stokes shift values from this work are compared with literature.

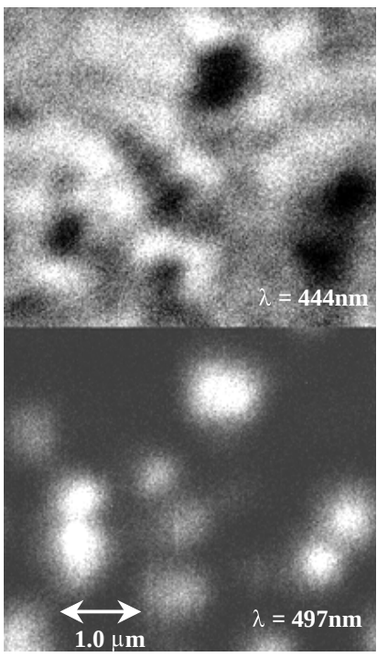

Fig. 3. 4K Monochromatic CL images at λ=444nm and λ=497 nm. The dark spots at 444 nm appear bright at 497 nm. These spots are related to defects in the material.