High pressure Raman and PL study of $In_xGa_{1-x}N$

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The direct bandgap of the $In_xGa_{1-x}N$ alloys ranging from UV to NIR renders these materials suitable for short wavelength laser diodes and photovoltaic devices. Raman and photoluminescence (PL) spectroscopies are non-destructive tools for the characterization of their structural quality and stress distribution. In this work, the pressure response of a polar $In_xGa_{1-x}N$ (x~0.37) film grown by MBE on a GaN/sapphire template was studied by combined Raman and PL mappings, allowing for the precise location of sample sites exhibiting different residual stress (Figure 1). In the Raman spectrum of the as-grown sample three Raman peaks appear at ~544, ~682 and ~706 cm^{-1}, attributed to the in-plane E_2 mode, an alloy disorder-activated shoulder (S-peak), and the A_1(LO) mode along the *c*-axis, respectively. The PL peak is located at ~1.97 eV, very close to the absorption edge energy, indicating that PL is unaffected by the presence of any defect states, composition fluctuations or In clustering. Breakage of the sample causes the significant softening of the Raman peaks and the redshift of the PL peak, indicative of position dependent relaxation of the epilayer due to random crack formation. Powdering of the sample further decreases the PL peak energy and the Raman frequencies with the latter approaching the strain-corrected values. [1]

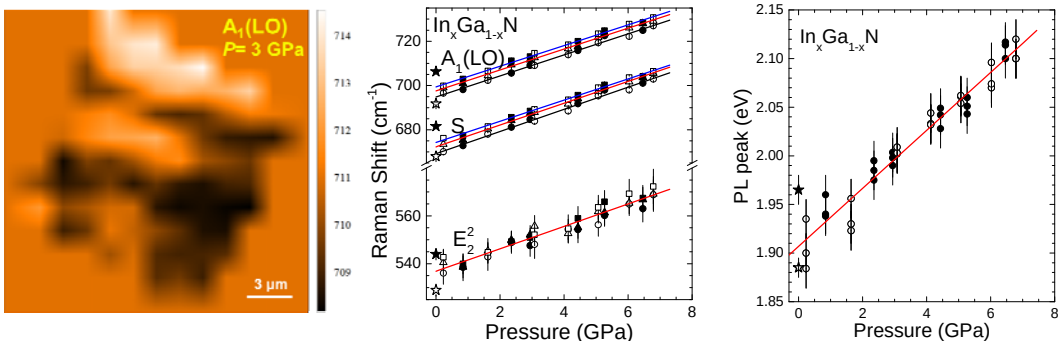

Figure 1: Raman mapping of the A_1(LO) frequency at *P*= 3GPa and pressure dependence of the Raman frequencies and the PL peak.

The analysis of our high pressure data demonstrates that in our experiments the residual stress state and the presence of the substrate do not affect the pressure response of the Raman and PL peaks. Pressure application causes blueshift of the Raman (~4.7 cm^{-1}/GPa for all modes and for different sample sites) and the PL peak (~30 meV/GPa). The pressure slopes for the Raman peaks are suggestive of the intermediate, between GaN and InN, stiffness of the alloy. The pressure slope of the PL peak obtained here is very similar to that of the bandgap energy (E_g) for x~0.4 from absorption measurements and that theoretically predicted assuming uniform arrangement of the In atoms. [2,3]

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