New Properties for InN Grown by Molecular Beam Epitaxy

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The basic properties of InN are becoming understood due to advancement in growth by molecular beam epitaxy. The InN bandgap is now found to be 0.65eV, in contrast[1] to the decades-old assignment at 1.9eV. Photoluminescence, absorption and ellipsometry confirm the 0.65eV bandgap. Undoped InN remains n-type. Quantitative mobility spectrum analysis shows low mobility electron transport in defective regions near the lattice mismatched interface with sapphire substrates, while low defect regions have mobility exceeding 2000 $cm^2/Vsec$ and non-degenerate transport is now seen[2].

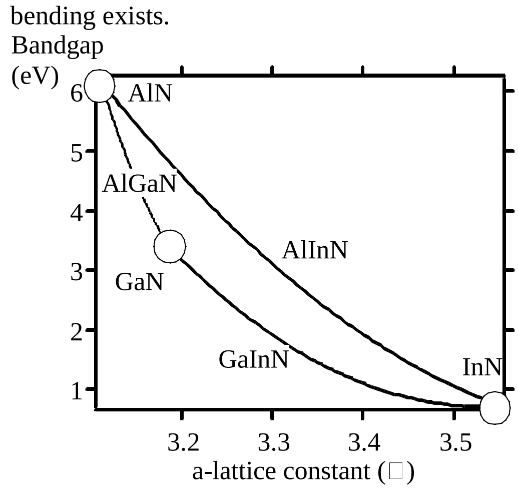
Critical points in band structure are deduced from ellipsometry in agreement with the LDA-DFT model[3]. Solar cells with high efficiency and long operating lifetime are expected from the GaInN alloys, where strong proton radiation resistance is observed. Electron effective mass is 0.045m0 in the minimum of a non-parabolic gamma conduction band[4]. The energy separation of the next lowest conduction band minima is almost 4eV higher. Such a large inter-valley separation leads to the question of negative electrical resistance applications. Breakdown electric field strength in InN is not known. Velocity-field relations from single particle spectroscopy show velocity overshoot and negative differential mobility[5]. THz wavelength radiation from short pulse laser excitation has now been seen from the surface of InN and GaN/InN interfaces. The first InN electro-chemical sensor has been demonstrated by surface chemical interaction with InN surface electron accumulation.

InN exhibits large surface electron accumulation accompanied by a large surface electric field. This leads to 2 sensing mechanisms. First, the electron density is strongly dependent on exposure to polar solvents such as methanol and water. Resistivity drops by around 30% following these exposures more than one hour elapses to re-establish equilibrium resistivity. There are a number of questions that are being studied to explain this response including identification of specific surface/chemical interactions response for the resistance change[6].

The equilibrium resistivity is dominated by the surface electron accumulation density[7] of $3\text{-}5 \times 10^{13}$ cm^{-2}. Efforts are underway to explain how the band structure of InN controls this behavior, or how defect states could lead to such high sheet densities.

The surface accumulation leads to, or results from, a large electric field of more than 1MV/cm. The conduction and valence bands are bent down away from the Fermi level at the surface. The valence to Fermi level energy difference is near 1.2 (XPS)[8] to 1.5 (EELS,CV) eV.

The large field over just 1-2nm depth provides a means for THz carrier energy loss through emission. Short pulse excitation above the InN bandgap introduces electron hole pairs which give off THz emission in the surface electric field[9]. The magnitude of THz emission from InN is comparable to emission from InAs, where a similar band bending exists.



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