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Characterization of Liquid-Phase Epitaxy Grown Thick GaInAs(Sb)N Layers

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Abstract. The addition of nitrogen in small concentrations is known to shift the absorption edge of III-V materials to longer wavelengths, which makes dilute III-V nitrides promising materials for third-generation multi-junction solar cells. We present an experimental and theoretical study of GaInAs(Sb)N layers with thickness around 2 μm, grown by liquid phase epitaxy (LPE) on n-type GaAs substrates. The samples were studied by surface photovoltage (SPV) spectroscopy in the metal-insulator-semiconductor geometry mode and by photoluminescence spectroscopy. Theoretical calculations were carried out using a full-band tight-binding approach in the $sp^3d^5s^*s_N$ parameterisation.

The SPV spectra measured at room temperature are sensitive to the optical absorption spectrum of the structures and clearly show a red shift of the absorption edge with respect to the absorption of the GaAs substrate. The shift is of the order of 50-70 meV for the samples without Sb and around 100-110 meV for the samples containing Sb. The analysis of the SPV amplitude and phase spectra provides information about the alignment of the energy bands across the structures. Photoluminescence measurements performed at room temperature and at 2K also show a red shift of the emission energy with respect to GaAs, but this shift is 30-40 meV smaller than that obtained by SPV. These differences are explained by the existence of a tail of slow defect states below the conduction band edge, which are probed by SPV, but are less active in the PL experiment.

Theoretical calculations of the electronic structure and optical transition energies were carried out for different Sb and N concentrations and show a good agreement with the experimental data. The obtained results contribute to better understanding of the physical properties of dilute nitride materials grown by LPE and their potential for optoelectronic applications.