IR Magneto-Spectroscopy of InAsSb

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Introduction

Metamorphic InAsSb alloys are a promising narrow gap semiconductor for use in long wavelength IR optoelectronics. Bandgaps as low as 0.12 eV, corresponding to 10µm, can be achieved in unrelaxed bulk-like InAsSb alloys by incorporating a graded buffer layer. The bandgap of metamorphic InAsSb alloys is much smaller than both InAs and InSb and is lower than the band gap reported for any bulk III-V material [1-4]. According to Veggard's law, the material parameters of a ternary allow should be the linear combination proportional to the concentration of its binary counterparts. The reduced band gap in metamorphic InAsSb alloys is the result of bowing, parameter C in Eq. 1. The effect of bowing is not completely understood, though compositional ordering [5], volume deformation, charge exchange and structural relaxation are believed to contribute [6].

$$E_g^{InAsSb} = E_g^{InAs} + E_g^{InSb}(1-x) - Cx(1-x) \quad [1]$$

Experimental

We performed detailed Low-temperature cyclotron resonance (CR) studies on a series of $InAs_{x-1}Sb_x$ quantum wells with varying Sb concentration from 9 -60%. The samples were grown on graded GaAlInSb buffers in order to accommodate the lattice mismatch to the GaSb substrate. The samples were measured in a 17.5T superconducting magnet coupled to a Bruker 70 vertex Fourier-transform IR spectrometer. The transmission through the samples was measured by a composite Si bolometer mounted directly below the sample. All measurements were performed at the NHMFL facility in Tallahassee.

Results and Discussion

We observe strong intra- and inter-band CR transitions from all samples. At low fields one very broad transition in the far-IR (FIR) region. Fig1(a) shows a characteristic set of spectra taken from a sample with 22% Sb. The shape and location is similar in all samples but with varying slopes. The CR line is linear with field, allowing us to extract an effective mass of 0.047 - 0.016m_0 as Sb varies from 9 - 60%. The FIR CR line moves into the substrate reststrahlen band above ~3T in all samples. Interestingly, along with a strong CR in the FIR, we also observe a very strong increase in transmission with increasing field likely due to plasmon resonance.

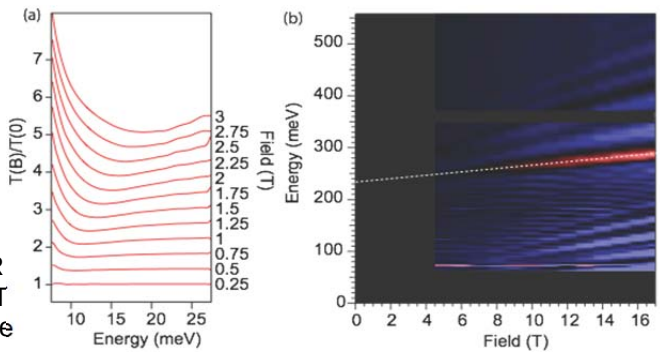

Fig.1 Normalized transmission spectra form the sample with 22% Sb (a) for select fields up to 3T and (b) shown as a false color map as a function of energy and magnetic field. Dashed line added to show intercept with the energy axis.

At higher fields, we observe another strong CR line in the mid-IR (MIR) originating from a different series than the one seen in the FIR, Fig1(b). The slope of this line is always less than the slope of the FIR CR of the same sample and is also linear in field. Along with the MIR CR line, we also observe a several interband transitions that appear to be converging at the same energy, allowing us to extract the zero field bandgap of 235-140meV for Sb concentration 22-60%.

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