Energy Spectrum of $InAs_{1-x}Sb_x/InAs_{1-y}Sb_y$ Metamorphic Superlattices with Ultra-Thin Layers

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Introduction

Quasiparticles with Dirac type dispersion can be observed in nearly gapless bulk semiconductor alloys where the bandgap is controlled through the material composition. We demonstrate that the Dirac dispersion can be realized in short period $InAs_{1-x}Sb_x/InAs_{1-y}Sb_y$ metamorphic superlattices with the bandgap tuned to zero by adjusting the superlattice period and layer strain. Extreme design flexibility makes the short-period metamorphic InAs1-xSbx/InAs1-ySby superlattice a new prospective platform for studying the effects of charge carrier chirality and topologically nontrivial states in structures with the inverted bandgaps.

Experimental

To obtain information on the material bandgap and carrier dispersion in the growth and in-plane direction we performed magneto-absorption and magneto-transport measurements. Both types of measurements were done at the NHMFL. Optical absorption as a function of magnetic field and energy was measured in SCM3, magneto-transport measurements were done in SCM6.

Results and Discussion

It was demonstrated experimentally that the in-plane dispersion in ultra low bandgap metamorphic $InAs_{1-x}Sb_x/InAs_{1-y}Sb_y$ superlattices is Dirac type with the Fermi velocity _$v_F=6.7\cdot10^5$ m/s. Remarkably, the Fermi velocity in this system can be controlled by varying the overlap between electron and hole states in the superlattice. It was found that the electron dispersion in the growth direction is parabolic at low energies and can be characterized by an effective mass of $0.034m_0$ in the SL with a period of 6 nm and $0.065m_0$ in the SL with a period of 7.5 nm.

Metamorphic strain compensated $InSb/InAsSb_{0.52}$ SLs with ultrathin layers and different periods grown on GaSb substrate were designed, fabricated and characterized. It was shown that a period increase from 3 to 6.2 nm reduced the band gap energy from 70 to 0 meV. Further increase in the period leads to inversion of the valence and conduction bands. Magneto-optical experiments demonstrated that almost gapless $InSb/InAsSb_{0.52}$ SLs are characterized by Dirac-like carrier dispersion which leads to square root dependence of the Landau level energies on the magnetic field (**Fig. 1**). Evidence for the hole transport enhancement compared to $InAsSb_{0.3}/InAsSb_{0.75}$ structures were presented.

Conclusions

Extreme design flexibility makes the short-period metamorphic InAs1-xSbx/InAs1-ySby superlattice a new prospective platform for studying the effects of charge carrier chirality and topologically nontrivial states in structures with the inverted bandgaps.

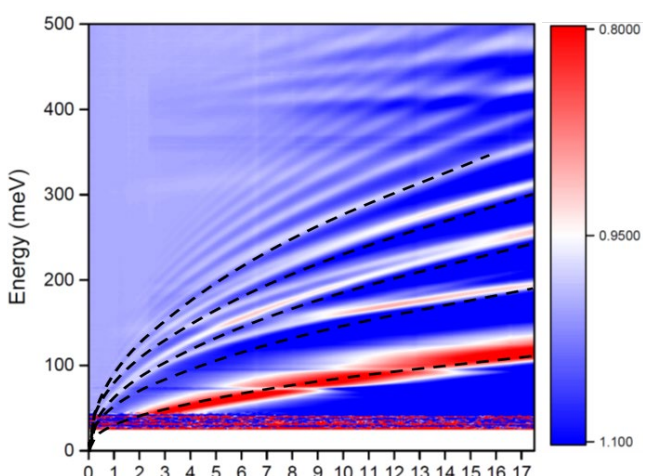

Figure 1. Color plot of the relative transmission as a function of energy and the magnetic field B for $InSb/InAsSb_{0.52}$SL with a 6 nm period. Black dashed lines are calculated transition energies.

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References

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