EFFECTS OF BAND STRUCTURE AND TRANSPORT PROPERTIES ON TERAHERTZ EMISSION FROM III-V SEMICONDUCTORS

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ABSTRACT

This research explores the effects of III-V ternary semiconductor energy band structure and transport properties on THz emission. In particular, the ternary InAsP system has been studied for Hall effect transport properties, below bandgap transmittance spectra, and THz emission magnitude as a function of As composition for the first time. Strong attention has also been paid to developing a framework for broad spectrum excitation analysis of InAsP, GaInSb, GaInAs, InAsSb, and their constituent binaries as a means for band structure determination and possible material characterization for use in future study.

The dominant THz emission mechanism from InAsP at approximately 637 $\frac{nJ}{cm^2}$ excitation fluence has been found to be the photo-Dember effect for As compositions of 78% or greater while the surface field effect is the dominant emission mechanism for As compositions of 50% or lower for the measured transport properties. The magnitude the emitted THz radiation due to the photo-Dember effect increased with increasing As composition. The THz emission contribution due to the surface field effect in this study was found to be more heavily influenced by high-field mobility effects than by As composition, although samples with higher As compositions retained higher mobility values under larger surface field magnitudes as expected.

Preliminary studies on broad spectrum excitation THz emission analysis of band structure transitions in InSb reveal that nonlinear deviations from conventional THz emission models occur near the transition wavelengths coinciding with interband transitions into the L valley and X valley and intraband transitions from the Γ valley to the L and X valleys. The nature of these deviations from conventional theory hint at possible asymptotic or plateau behavior near the transition wavelengths; however, such results need to be investigated further in future studies for more accurate behavioral determination.

Our studies on alloy semiconductors has provided a comprehensive basis for developing future high efficiency THz emitters.