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Title

Role of vanguard counter-potential in terahertz emission due to surface currents explicated by three-dimensional ensemble Monte Carlo simulation

Source

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Abstract

The discovery that short pulses of near-infrared radiation striking a semiconductor may lead to emission of radiation at terahertz frequencies paved the way for terahertz time-domain spectroscopy. Previous modeling has allowed the physical mechanisms to be understood in general terms but it has not fully explored the role of key physical parameters of the emitter material nor has it fully revealed the competing nature of the surface-field and photo-Dember effects. In this context, our purpose has been to more fully explicate the mechanisms of terahertz emission from transient currents at semiconductor surfaces and to determine the criteria for efficient emission. To achieve this purpose we employ an ensemble Monte Carlo simulation in three dimensions. To ground the calculations, we focus on a specific emitter, InAs. We separately vary distinct physical parameters to determine their specific contribution. We find that scattering as a whole has relatively little impact on the terahertz emission. The emission is found to be remarkably resistant to alterations of the dark surface potential. Decreasing the band gap leads to a strong increase in terahertz emission, as does decreasing the electron mass. Increasing the absorption dramatically influences the peak-peak intensity and peak shape. We conclude that increasing absorption is the most direct path to improve surface-current semiconductor terahertz emitters. We find for longer pump pulses that the emission is limited by a newly identified vanguard counter-potential mechanism: Electrons at the leading edge of longer laser pulses repel subsequent electrons. This discovery is the main result of our work.