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Terahertz Generation by Optical Rectification in GaAs and Related Materials

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Abstract: Ultrashort near-infrared laser pulses may generate terahertz radiation by transient current effects, including surface field and photo-Dember effects, and optical rectification. Distinguishing these effects in GaAs and related materials will be discussed.

Keywords: Terahertz, THz, T-ray, optical rectification, GaAs

1. Introduction

Terahertz (THz, 10^{12} Hz) frequency electromagnetic radiation may be generated through the nonlinear effect of optical rectification. Optical rectification typically takes place when high-intensity excitation radiation strikes an electro-optic material; GaAs is one such. If the excitation radiation includes components of several frequencies difference-frequency mixing (DFM), as well as second-harmonic generation (SHG), not relevant here, may occur. The DFM signal will typically lie in the THz range. Both bulk second-order and surface third-order nonlinear effects may occur. Optical rectification has been known for some time, but the experimental results reported and the theory developed has tended to concentrate on a few simple configurations of materials and geometry. For example, only the (100), (110), (111), and, recently (112) faces [1] have been investigated. Also, the relationship between the p and s polarised components of the radiation with respect to each other has tended to be neglected. This work is extended in this paper by considering the THz emission from crystals of higher-index faces, such as (311). By varying the angle of incidence, in particular between transmission geometry and reflection geometry, and by rotating the sample about its surface normal (in other words, varying the azimuthal angle), additional information may be obtained [2].

2. Experimental Methods

A mode locked Ti:Sapphire laser with a 12 fs pulse width and a central wavelength of 790 nm is used. The laser radiation is divided into a pump beam and a probe beam by a beam splitter. The pump beam illuminates the THz emitter crystal. In transmission geometry the beam is at normal incidence on the emitter crystal and the THz radiation produced is measured in the forward direction. In reflection geometry the angle of incidence is 45° and the THz radiation is detected in the specular reflection direction. The probe beam travels collinearly with THz beam inside a 1-mm thick (110) oriented ZnTe detector crystal. The probe beam polarization is modulated by the electric field of THz radiation via the electro-optic effect. The probe beam then passes through a quarter wave plate and Wollaston prism before reaching a pair of photodetectors. A lock-in amplifier is used to collect the signal in order to increase the sensitivity of detection at the μW power level.

3. Results and Discussion

The radiation from samples of index (11N) is broadly similar to that of the (111), but the modulation of intensity decreases as N increases. This may be physically related to the index approaching (001) as N increases, for which there is no THz generation by bulk optical rectification for the transmission geometry. The THz emitted from A- and B-faces of the same sample can be quite different, for example exhibiting three maxima on one side and only one maximum on the other. This can be accounted for by including both surface and bulk terms in the calculation of optical rectification.

4. Conclusion

Both bulk and surface-field induced optical rectification effects are needed to fully account for the THz radiation emitted from GaAs and related compounds.

Acknowledgments

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References

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