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Fabry–Pérot Enhanced THz Sensitivity of Antenna-Coupled HgCdTe Detectors

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The efficient detection of terahertz (THz) waves remains a critical challenge, despite the vast potential of the THz spectrum. We present a method to significantly enhance the sensitivity of THz detectors featuring a metallic antenna on a conducting film with a dielectric substrate. The study utilizes mercury-cadmium-telluride (HgCdTe), a proven semiconductor for infrared detection, extending its capabilities into the THz range.

Our approach proposes leveraging the Fabry–Pérot (FP) interference effect to maximize the electromagnetic (EM) energy absorbed within the conducting film by precisely adjusting the substrate thickness. We modeled and fabricated THz detectors consisting of a bow-tie antenna on a p-type HgCdTe film with a CdZnTe substrate. Electrodynamic modeling and simulations, focusing on the 140 GHz frequency, revealed that the EM energy oscillates dramatically as a function of substrate thickness. Simulations predicted that average field intensity in the film could be enlarged by using the optimal substrate's thickness.

Experimental results comparing samples with near-optimal and non-optimal CdZnTe substrate thicknesses confirmed the theoretical predictions. The optimization strategy yielded more than a threefold increase in sensitivity (an enhancement factor of approximately 3.2 in photoresponse: 3.63 nA vs 1.14 nA). This technique provides a practical and effective way to significantly improve the sensitivity of single-frequency or narrow-band THz detectors without requiring complex fabrication changes or cryogenic cooling systems. Furthermore, this substrate optimization method is compatible with established semiconductor manufacturing processes, suggesting potential for integrated dual-band IR-THz systems based on the HgCdTe platform.

Type of presence

Author: Prof. TSYBRII, Zinoviia (V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine)

Co-authors: KUKHTARUK, S.; KUKHTARUK, N.; ZABUDSKY, V.; LYSIUK, I.; VUICHYK, M.; KORCHOVYI, A.; BOLTOVETS, M.; SVEZHENTSOVA, K.; DZHAGAN, Volodymyr (Lashkaryov Institute of Semiconductor Physics (ISP), NAS of Ukraine)

Presenter: Prof. TSYBRII, Zinoviia (V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine)

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