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# Terahertz emission from Bi/GaAs heterostructures

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Two-dimensional (2D) materials exhibit unique properties due to quantum confinement and high surface-to-volume ratios. Thin bismuth (Bi) layers are promising for topological insulators, sensors, thermoelectric devices, and ultrafast optoelectronics. Although bulk Bi is a semimetal, films thinner than ~30 nm become semiconducting, with bandgaps tunable up to 0.8 eV [1]. Bi thin films have mainly been grown on InAs, InP, and Si (111), with promising monolayer structures also shown on GaAs (111) [2–4]. Here, Bi layers were grown by molecular beam epitaxy on GaAs (100), a previously unreported substrate orientation, and their terahertz (THz) emission was investigated using THz excitation spectroscopy (TES).

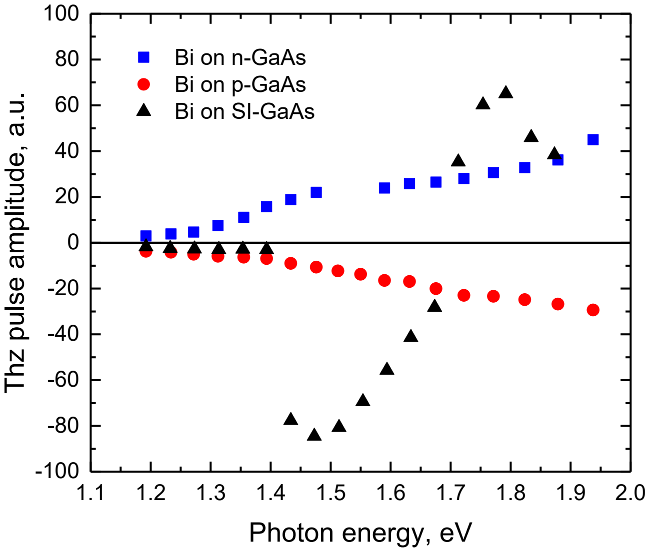


Fig. 1 THz excitation spectra of the heterostructures containing 9 nm thick Bi layers deposited on SI-GaAs, p-GaAs, and n-GaAs substrates..

Heterostructures with 9 nm Bi layers on semi-insulating (SI), n-type, and p-type GaAs (100) substrates were studied in reflection geometry. Excitation photon energy was varied while keeping the average laser power at 20 mW. Strong THz emission appeared only above the GaAs bandgap (1.42 eV), indicating that emission mainly originates from substrate-related processes. Below this threshold, measurable emission was observed only for Bi/n-GaAs. Opposite THz pulse polarities from n- and p-type samples were attributed to reversed internal electric fields at the Bi/GaAs interface. Comparison with bare substrates gave a Bi absorption coefficient of (3–4)×$10^5$ $cm^{-1}$ in the 1.5–1.7 eV range, over an order of magnitude higher than GaAs [5].

Bi/SI-GaAs showed reduced THz amplitude and polarity reversal near 1.7 eV, suggesting an additional interface-related emission mechanism. Bi/p-GaAs exhibited enhanced THz emission, attributed to hole drift velocity overshoot in strong internal fields. These results highlight Bi/p-GaAs heterostructures as promising efficient surface THz emitters.

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