Multidimensional Infrared-to-THz Photodetection in $PtTe_2$ Dirac Semimetal Schottky Junctions

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Abstract

Two-dimensional topological semimetals offer a compelling platform for compact terahertz (THz) and infrared photonic and electronic devices, thanks to their broadband optical transitions and geometry-tunable plasmonic response. [1] Here, we present $PtTe_2$-based topological Schottky junctions that enable multidimensional photodetection from 1 to 25 μm at room temperature. [2] Large-area polycrystalline $PtTe_2$ films [3] were grown by a scalable tellurization process and integrated on n-type silicon, forming a rectifying junction with a Schottky barrier of approximately 0.34 eV. Microscale devices ($40 \times 40\ \mu m^2$) exhibit responsivity of the order of 10^{-4} A W^{-1} and detectivity around 10^4 Jones under 9 μm illumination, consistent with hot-carrier-assisted internal photoemission and thermionic-field emission.

Patterning $PtTe_2$ into micro-ribbon arrays introduces geometry-controlled surface plasmon polaritons, [4] yielding polarization-sensitive photodetection with a polarization ratio close to 3 under resonant conditions, while non-resonant geometries show an almost isotropic response. Under broadband blackbody illumination, bias-dependent switching between positive and negative photoconductivity is observed, together with paired-pulse facilitation (facilitation index ≈ 140%) and synaptic-weight modulation under sequential optical pulses. These results demonstrate simultaneous control over intensity, polarization, and temporal response in a single silicon-compatible device.

The combination of scalable growth, CMOS-compatible integration, plasmonic engineering, and bias-tunable carrier dynamics positions $PtTe_2$ Schottky junctions as a versatile nanomaterial platform for multidimensional THz–infrared photonics and electronics, with potential applications in compact detectors, focal-plane arrays, and neuromorphic sensing architectures.[5]

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[2] Zeng, L. et al.,"Van Der Waals Epitaxial Growth of Mosaic-Like 2D Platinum Ditelluride Layers for Room-Temperature Mid-Infrared Photodetection up to 10.6 micron". Advanced Materials 2020, 32 (52), 2004412

[3] M. Gardella et al. "Substrate-Versatile and Stress-Free Tellurization of PtTe2 Films" Phys. Status Solidi RRL. 2025; 000, e202500305

[4] S. Macis, et al. “Terahertz and Infrared Plasmon Polaritons in PtTe2 Type-II Dirac Topological Semimetal”, Adv. Mater. 2024, 36, 2400554.

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