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High Responsivity Short-Wavelength Infrared Phototransistor Based on Black Phosphorus

Abstract:

Short-wavelength infrared (SWIR) phototransistors are vital components in a variety of advanced technologies, including optical telecommunications, and thermal imaging for night vision. Conventional SWIR photodetectors, such as those based on In GaAs, often suffer from lattice mismatch issues that limit their integration with silicon-based integrated circuits and flexible substrates. Black phosphorus (BP), a two-dimensional (2D) material with a layered lattice structure, effectively addresses this limitation, offering excellent compatibility with both silicon and flexible substrates. BP nanosheets, typically 10–20 nm thick, possess a direct bandgap of approximately 0.3 eV and demonstrate significantly stronger infrared absorption than other monolayer 2D materials. These characteristics make BP a highly promising candidate for high-performance infrared photodetectors. In this work, we report a high-sensitivity SWIR phototransistor based on a 26 nm-thick BP flake, operating at a wavelength of 2.2 µm. The flake was mechanically exfoliated onto a silicon substrate, and source-drain electrodes were patterned using electron beam lithography (EBL). The device achieved a high responsivity of 85 A/W and a detectivity of 108 Jones under a low illumination power of 2 nW and a small source-drain bias voltage of -0.6 V. Additionally, a temperature-dependent study of the photo response was conducted across a temperature range of 300 K to 50 K. These results underscore the strong potential of BP-based phototransistors for SWIR detection applications, particularly in weak-light-level scenarios such as biomolecular sensing and thermal imaging.

Biography

Rajdeep Banerjee is a Ph.D. alumnus of the Indian Institute of Technology (IIT) Kharagpur, where his research focused on the first-principles design of nanomaterials, particularly tuning their electronic, magnetic, chemical, and topological properties. Currently based in Kolkata, India, he works as a Lead Data Scientist at IHX, applying his deep scientific knowledge to real-world data analytics and modeling. His academic background bridges advanced computational materials science with practical, data-driven applications. Rajdeep's work continues to contribute to the evolving intersection of nanotechnology and artificial intelligence.