Broadband Deep UV to NIR Photodetection with High Stability and Large Dichroic Ratio Enabled by Type-I Band Engineering

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Abstract
Van der Waals (vdWs) heterostructures formed from two-dimensional (2D) layered materials have opened promising avenues in broadband photodetection, particularly in polarization-sensitive applications. Previous research indicates that type-I heterostructures hold considerable potential for broadband polarization photodetector development; however, achieving high polarization sensitivity in these vdWs heterostructures remains insufficiently explored. In this work, we systematically present combined theoretical and experimental studies on designing and fabricating a high-performance photodetector based on the InSe/TiS_3 vdWs heterostructure exhibiting type-I band alignment. Theoretical studies supported by experimental verifications confirmed the presence of type-I band alignment between InSe and TiS_3. Leveraging this favourable band alignment, the fabricated device demonstrated broadband photodetection spanning the deep ultraviolet to near-infrared spectral range along with pronounced polarization sensitivity. The photodetector exhibited superior performance metrics, including a high responsivity of 55 A/W^{-1}, detectivity of 1.80×10^{13} Jones, an external quantum efficiency reaching 15633%, and a rapid response time of approximately 23.6 µs. Additionally, significant polarization sensitivity was observed, characterized by a notable dichroic ratio of approximately 5, emphasizing the device's potential for advanced optoelectronic applications. This study provides valuable insights and a practical reference for the development of high-performance polarized photodetectors across a broad spectral range.

Keywords: Two-dimensional (2D) materials; van der Waals (vdWs) heterostructures; type-I band alignment; broadband photodetection; polarization sensitivity

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Figures

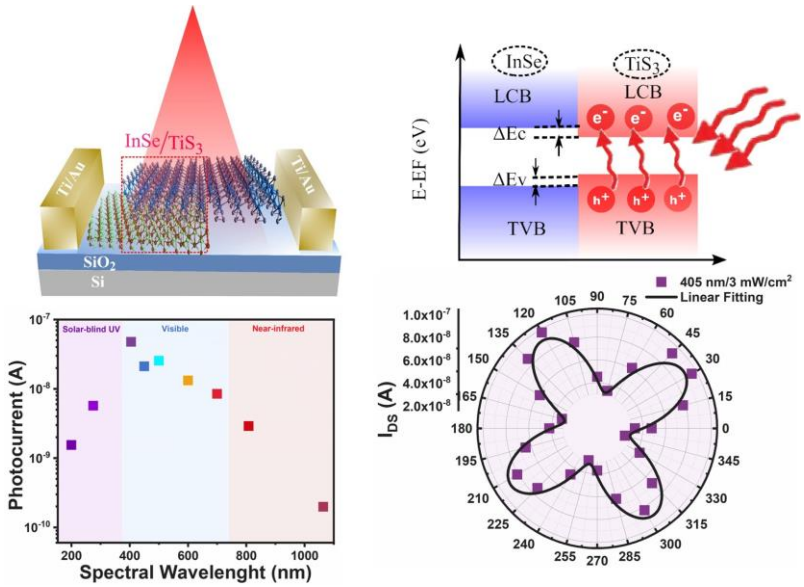

Figure 1: Table of contents figure for vdWs heterostructure for type-I band alignment based on InSe/TiS_3 showing broadband spectrum response spanning from deep UV to NIR detection and competitive polarization detection.