Tunneling Effects in Crossed $Ta_2Pt_3Se_8$−$Ta_2Pd_3Se_8$ Nanowire Junctions: Implications for Anisotropic Photodetectors

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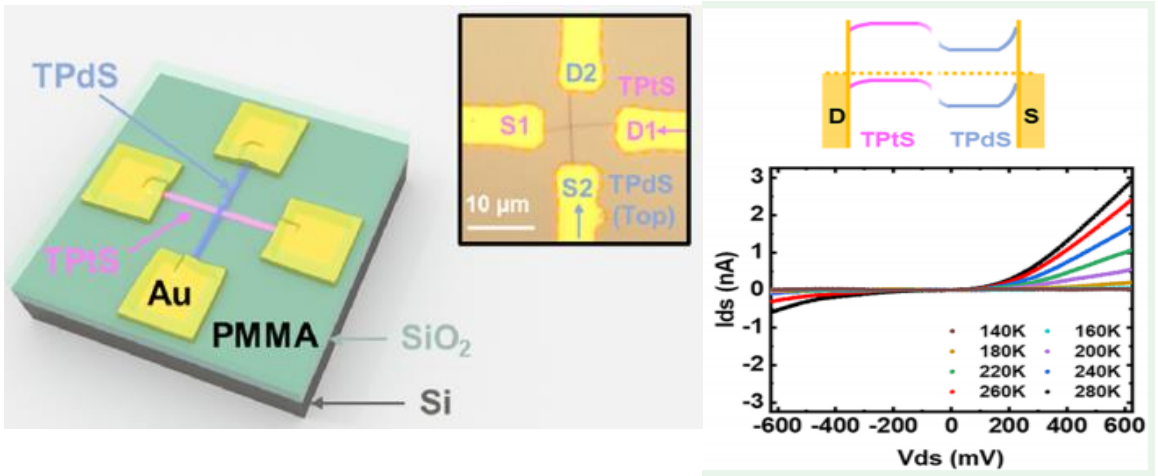
Project Summary: Transition metal dichalcogenides (TMDCs) with van der Waals gaps (vdW) have been a subject under extensive studies, since 2D thin layers of these materials exhibit a plethora of technologically useful properties, e.g. large direct band gap and high photoresponsibility. Quasi-one-dimensional (1D) transition metal vdW materials are also predicted to not only inherit some features of 2D TMDCs, such as strong light - matter coupling and thickness-dependent band gaps, but also possess unique thermal, electrical, and optical properties due to their distinctive chain structures. However, quasi-1D vdW materials are less experimentally explored. Yaqiong Xu's group at Vanderbilt University recently demonstrated nanoscale crossed p-n junctions formed by two quasi-1D vdW materials, i.e. p-type $Ta_2Pd_3Se_8$ (TPdS) and n-type $Ta_2Pt_3Se_8$ (TPtS). Such p-n junctions exhibit asymmetric nonlinear output behaviors, inelastic tunneling effects, and isotropic photocurrent signals. This study not only offers a way to build nanoscale junctions but also provides fundamental understandings of the electronic and optoelectronic properties of vdW nanowires and their heterojunctions.

2DCC Role: High quality $Ta_2Pd_3Se_8$ and $Ta_2Pt_3Se_8$ single crystals used in this project were synthesized by the 2DCC researchers using the chemical vapor transport method.



Left panel: Schematic diagram of a nanoscale crossed junction between perpendicularly stacked n-type $Ta_2Pt_3Se_8$ (TPtS) and p-type $Ta_2Pd_3Se_8$ (TPdS) nanowires. Inset: Optical micrograph of a typical device. S and D indicate the source and drain electrodes, respectively.
Right panel: Band diagrams of the TPtS−TPdS junction (top) and I_{ds}−V_{ds} characteristics of the TPtS−TPdS junction with a gate voltage of −80 V at various temperatures (bottom).

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