Probing Giant Zeeman Shift in Vanadium-Doped WSe_2 via Resonant Magnetotunneling Transport

Lan-Anh T. Nguyen,[1,2,*] Jinbao Jiang,[1,2,*] Tuan Dung Nguyen,[1,2] Dinh Hoa Luong,[1,2] Duk Young Kim,[1] Youngjo Jin,[1,3] Philip Kim,[3] Dinh Loc Duong ,[1,2,†] and Young Hee Lee [1,2,4,‡]

[1]Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Suwon 16419, Republic of Korea

[2]Department of Energy Science, Sungkyunkwan University, Suwon 16419, Republic of Korea

[3]Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA

[4]Department of Physics, Sungkyunkwan University, Suwon 16419, Republic of Korea

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Doping van der Waals layered semiconductors with magnetic atoms is a simple and effective approach to induce magnetism. However, investigation of the electrical properties of such two-dimensional semiconductors and the modulation of their magnetic order for spintronics is still lacking. Herein, we report a giant Zeeman shift from the spin-polarized state in tungsten diselenide (WSe_2) doped with a small amount of vanadium (V) atoms (~0.1%). The Zeeman shift was measured via resonant magnetotunneling spectroscopy with a vertical graphite/V-WSe_2/graphite heterojunction. The p-type doping state near the valence band is substantially shifted under an external magnetic field by 7.8 meV/T, equivalent to a giant g factor of approximately 135, an order of magnitude higher than that of other two-dimensional magnetic semiconductors. The ferromagnetic order of the spin glass state and its long-range interaction are revealed by the remanence of magnetoresistance between the zero-field cooling and field-cooling processes as well as magnetoresistance hysteresis. The ferromagnetic glass order is fully established at 50 K, whereas the long-range interaction persists at higher temperatures of up to 300 K in V-doped WSe_2 flakes with an approximate thickness of 5 nm. Our work sheds light on the magnetic nature of V-doped WSe_2 semiconductors and paves the way for future spintronics based on two-dimensional van der Waals magnetic semiconductors.

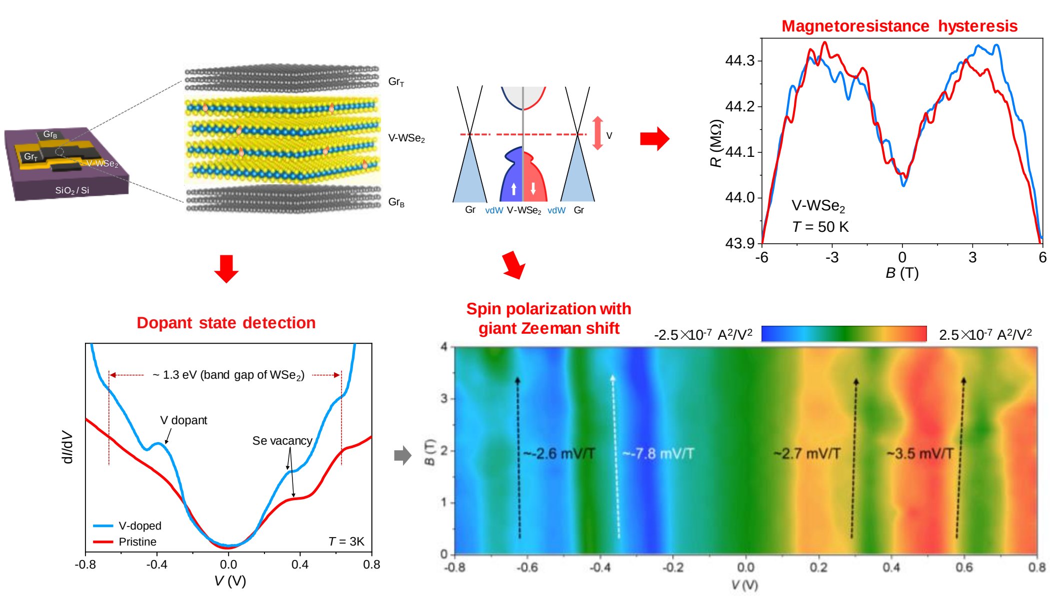

Figure | Probing the magnetism in V-WSe_2 from the spin polarization of the band structure to magneto-transport