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Room-temperature ferromagnetism in monolayer WSe_2 semiconductor via vanadium dopant

Diluted magnetic semiconductors including Mn-doped GaAs are attractive for gate-controlled spintronics but Curie transition at room-temperature with long-range ferromagnetic order is still debatable to date[1–7]. Here, we report the room-temperature ferromagnetism with long-range order in semiconducting V-doped WSe_2 monolayer synthesized by chemical vapor deposition. Ferromagnetic hysteresis curves are clearly manifested with exclusive Al_2O_3 passivation via vibrating-sample-magnetometer, exhibiting coercivity remanent to 360K, while retaining high on/off current ratio of 10^5 at 0.1% V-doping. This is also confirmed by the presence of magnetic domains from magnetic force microscopy. V-substituted W atoms keep a V-V separation distance of 5 nm without V-V aggregation, scrutinized by high-resolution transmission-electron-microscopy. We further demonstrate that the magnetic order and Curie temperature can be modulated by applying the back gate, implying the validation of the Zener model in establishing the long-range ferromagnetic order in V-doped WSe_2 monolayer, which is consistently supported by our density functional theory calculations. Interestingly, the competition between ferromagnetic and antiferromagnetic states is theoretically predicted. Our findings open new opportunities for using two-dimensional transition metal dichalcogenides for future spintronics.

Figures

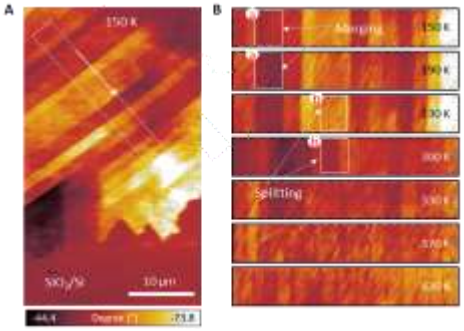

Figure 1: Temperature dependent magnetic domains in V-doped WSe_2

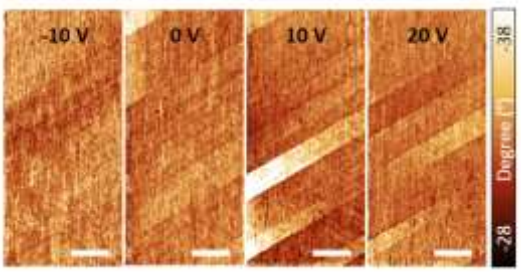

Figure 2: Gate bias dependent magnetic domains in V-doped WSe_2