A singular paramagnetic susceptibility peak in a WSe2/MoSe2 chemical bonding structure

Shiu-Ming Huang [1,2,*] Pin-Cing Wang [1] and Fu-En Cheng[1]
1. Department of Physics, National Sun Yat-sen University, Kaohsiung 80424, Taiwan
2 Center of Crystal Research, National Sun Yat-sen University, Kaohsiung 80424, Taiwan

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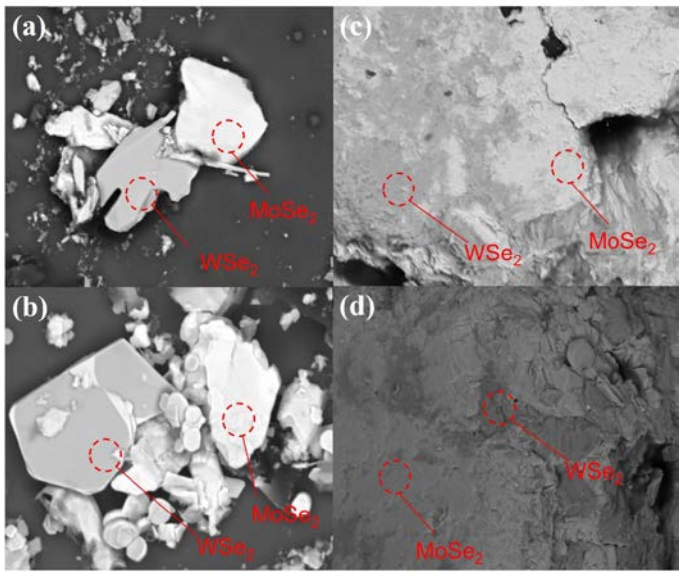
Abstract

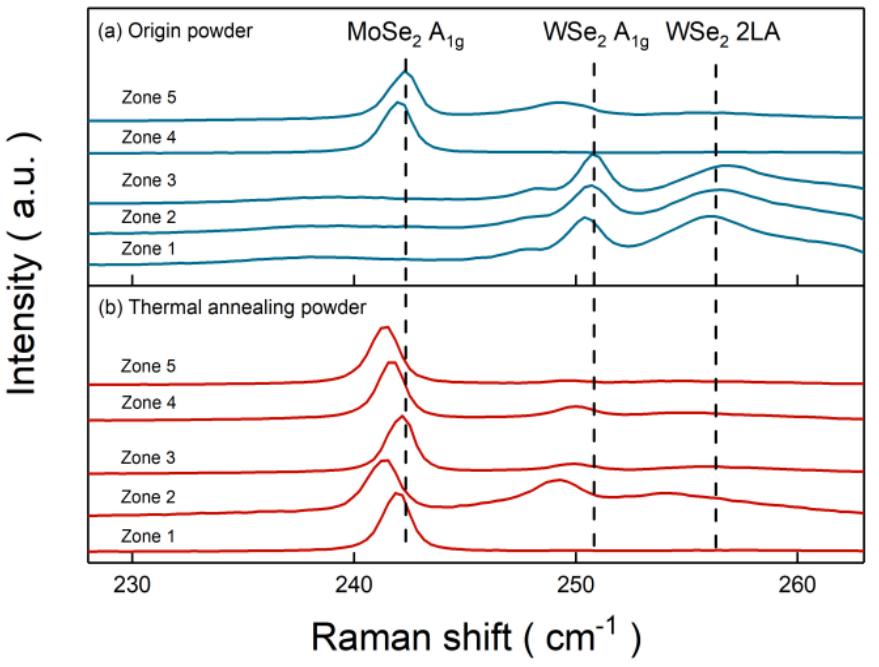
- Singular paramagnetic susceptibility peaks at zero magnetic field are reported in various kinds of topological materials. It is speculated to originate from the spin texture at the Dirac point of the topological surface state.
- Our previous experimental work reveals that the paramagnetic susceptibility peak at zero magnetic fields is also observed in a Bi0.3Sb1.7Te3 topological insulator in which Fermi level is 80 meV below the Dirac point at liquid nitrogen temperature.
- In addition to the spin texture model, theoretical and experimental work support that the paramagnetic susceptibility might originate from the lattice mismatch induced ferromagnetism.
- We perform the experiments on WSe2 and MoSe2 1:1 mixed powder with and without thermal annealing process. The paramagnetic susceptibility peak only observed at thermally annealed powder is also weakly temperature dependent. Our experiment provided one possible mechanism to demonstrate paramagnetic susceptibility peak.

Experiment method

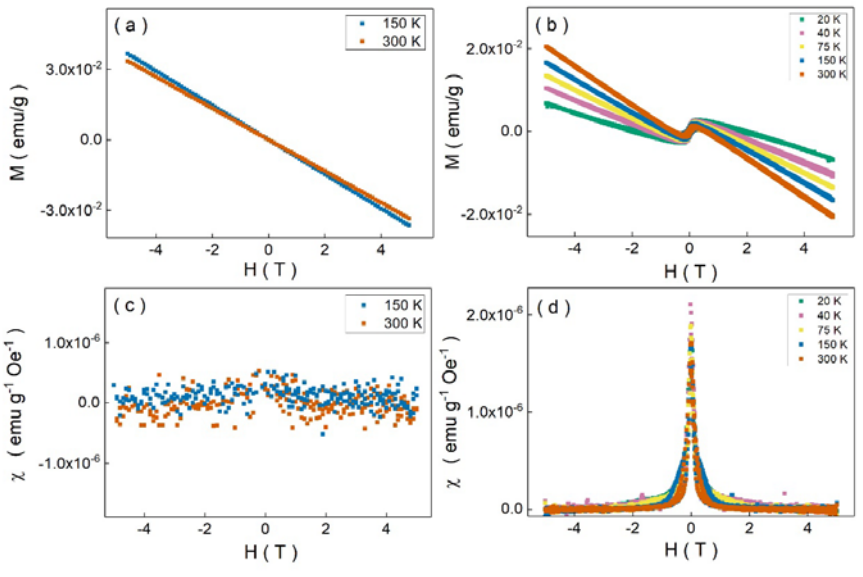
The mixed $WSe_2/MoSe_2$ powder is a commercial product and was purchased from SixCarbon Technology. Co. (ShenZhen, China) The purchased $WSe_2/MoSe_2$ powder was vacuum-sealed in a glass tube with a pressure of 10^{-3} torr, and then further thermally annealed. The $WSe_2/MoSe_2$ powder was heated up to 1000°C by a rate of 2.7°C/min and maintained at 1000°C for 1 hour. After thermal annealing, it was naturally cooled down to room temperature.



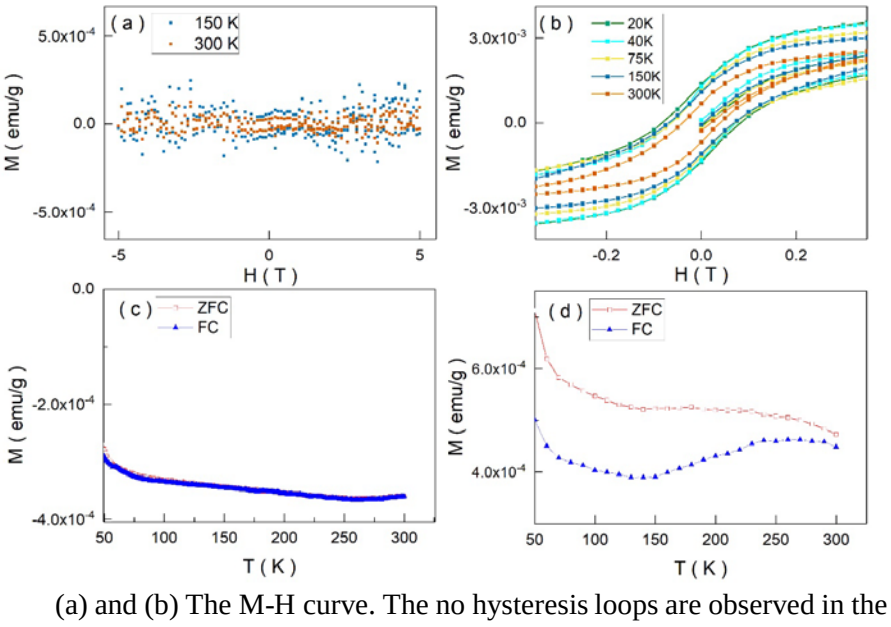
The BEI mode of SEM image of WSe2 and MoSe2. The lighter zone is the MoSe2 and the darker zone is the WSe2 crystal. (a) and (b) The SEM image of WSe2 and MoSe2 without thermal treatment. The WSe2 and MoSe2 exhibit only in physical contact. (c) and (d) The SEM image of WSe2 and MoSe2 with thermal treatment. WSe2 and MoSe2 are chemically bound at the boundary of the WSe2 and MoSe2 crystals.



(a) The Raman spectra of WSe2 and MoSe2 without thermal treatment at different zones. The peak positions are consistent with the database of WSe2 and MoSe2. (b) The Raman spectra of WSe2 and MoSe2 with thermal treatment at different zones. The Raman peak redshift was observed.



(a) The M-H curve of WSe2 and MoSe2 without thermal treatment at different temperatures. The magnetic moment is negative linear to magnetic fields. (b) The M-H curve of WSe2 and MoSe2 with thermal treatment. It shows paramagnetic momentum near zero magnetic fields. (c) The magnetic susceptibility of WSe2 and MoSe2 without thermal treatment after subtracting the diamagnetic background signal. No paramagnetic susceptibility peaks were observed. (d) The magnetic susceptibility of WSe2 and MoSe2 with thermal treatment after subtracting the diamagnetic background signal. The paramagnetic susceptibility peaks were observed which was weak temperature dependent.



(a) and (b) The M-H curve. The no hysteresis loops are observed in the WSe2 and MoSe2 without thermal treatment, and hysteresis loops are observed in the WSe2 and MoSe2 with thermal treatment. The coercivity field is around 500 Oe and it is weak temperature dependent. (c) and (d) The FC and ZFC curves of WSe2 and MoSe2 without and with thermal treatment. The magnetic momentum splitting is only observed in the system with thermal treatment.

Conclusions:

- The SEM images and Raman spectra peaks shift support that the WSe2 and MoSe2 were chemically bound after the thermal annealing process.
- The temperature independent singular paramagnetic peaks are observed only in the system with chemical bonding at the boundary of WSe2 and MoSe2. Furthermore, it exhibits the hysteresis loops, and magnetization moment splitting between zero field cooling and field cooling precesses in the WSe2 and MoSe2 chemical bonding system.
- On the contrary, temperature independent singularity paramagnetic peaks, Raman peak shift, hysteresis loops, and magnetization moment splitting between zero field cool and field cool precesses are all not detected in the individual WSe2 and MoSe2 crystals.
- These results support that the temperature independent singular paramagnetic peaks should originate from the intrinsic lattice induced ferromagnetism.