The temperature independent paramagnetism susceptibility peaks at zero magnetic fields in the non-topological WSe_2 single crystal

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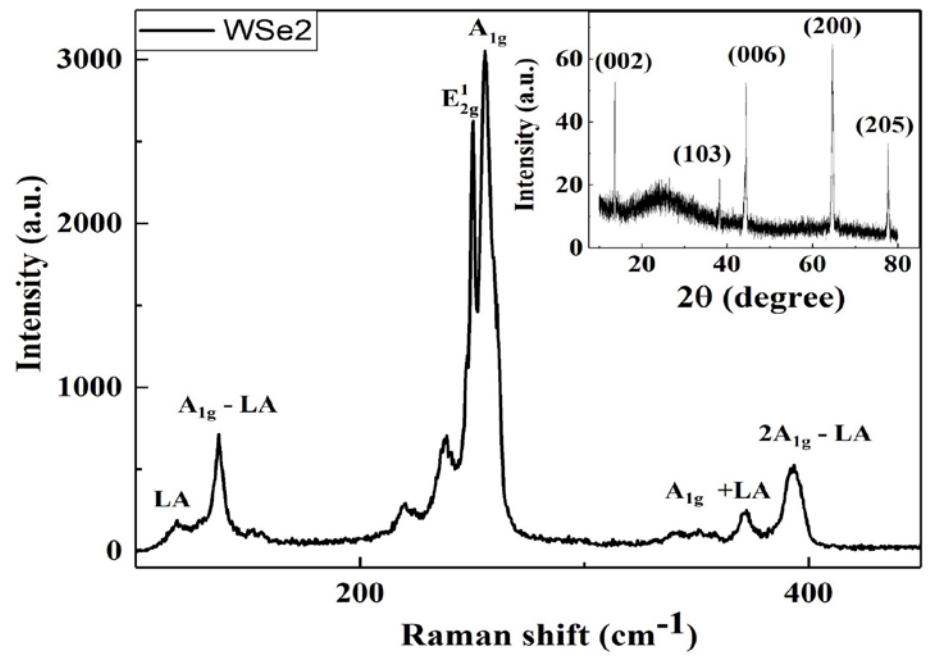
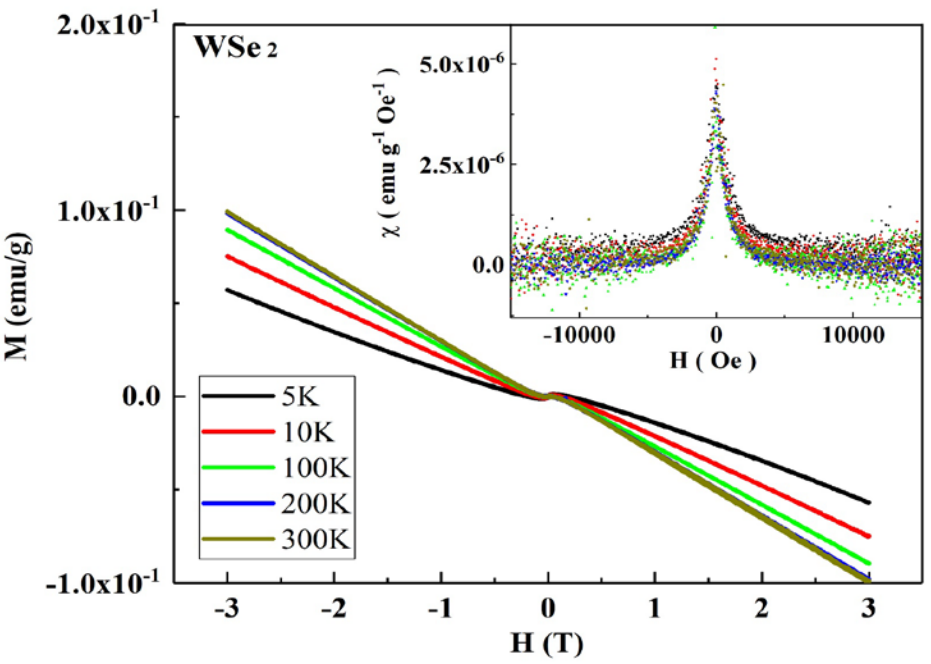
Motivation

- The temperature independent paramagnetic peaks at zero magnetic fields have been observed in various kinds of topological materials.
- All experimental and theoretical works speculate this behavior originates from the singularity spin texture at Dirac point topological surface state.
- Our previous experimental work in topological insulators without Dirac point support this behavior should not originate from the Dirac point of surface state and subvert all previous experimental and theoretical conclusions.
- To further exam and clarity this behavior, the magnetic characteristics of the non-topological WSe_2 single crystal were performed.
- The experimental results support that singularity paramagnetic peaks might originate from the intrinsic magnetic moment induced by the lattice dislocation, not from spin orientation Dirac point of the topological surface state.

Results and Discussions

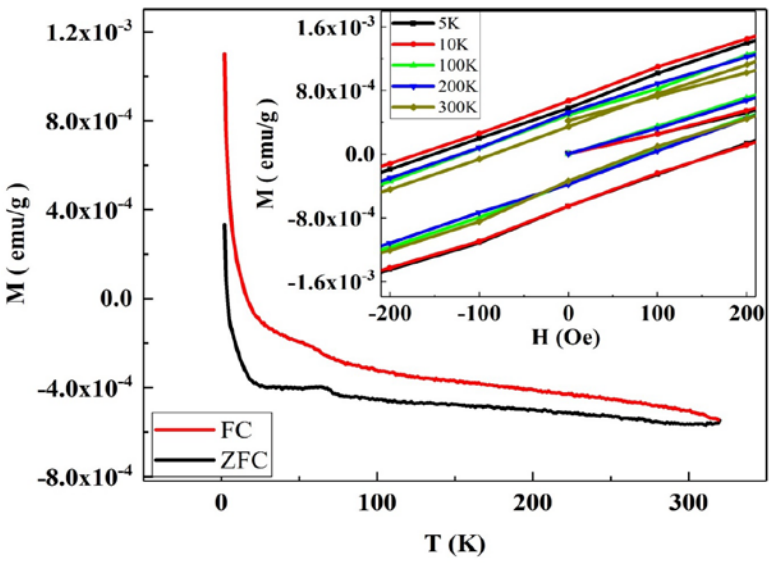


- The Raman spectra is sensitive the lattice vibration, and the Raman peaks are consistent with the database of the WSe_2 single crystal
- The XRD spectrum reveals sharp peaks and that supports the WSe_2 crystal is highly single crystallized.

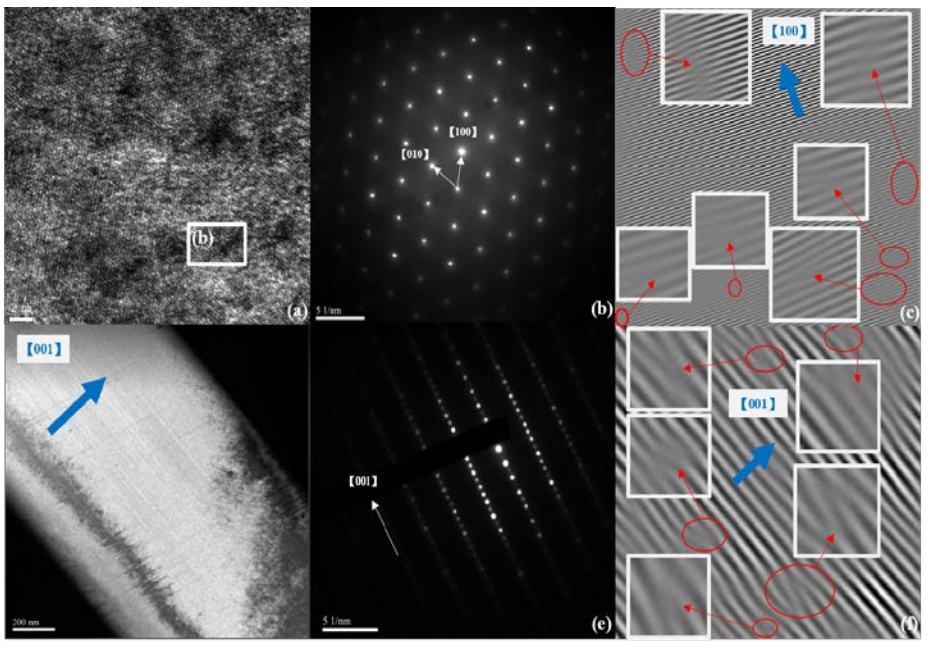


- The M-H curves of WSe_2 bulk single crystal, and the magnetization shows a weak magnetization upturn near zero magnetic fields. It behaviors paramagnetism at low magnetic fields and diamagnetism at high magnetic fields. The diamagnetism is negatively proportional to magnetic fields at high magnetic fields, and a larger diamagnetism at lower temperatures.
- The inset shows the susceptibility as a function of magnetic fields and it reveals paramagnetic susceptibility peaks at B = 0. These peak values are weak temperature dependence.

- Only a single layer WSe_2 exhibits topological characters, and our WSe_2 is bulk system.
- These support the temperature independent paramagnetic peaks at zero magnetic fields should not originate from the topological surface state.



- The magnetization of field cool and zero field cool processes splits and that supports the ferromagnetism feature in the WSe_2 single crystals. Inset shows the hysteresis loop.
- These results support the ferromagnetism feature.
- XPS, EMPA and ICPMS support no ferromagnetism elements in our WSe_2 single crystal.
- These results imply that in contrast to the proposed spin-texture model, the paramagnetic peak might be a ferromagnetism feature.



- a)-(f) The high resolution TEM images in different crystal planes.
- Figure (b) reveals the WSe2 single crystal is hexagonal structure. Figure (e) supports it is a layer structure.
- Figure (c) and (f) show that some crystal dislocation at different layer plane and axis, and that would induce intrinsic ferromagnetic

Conclusions

The temperature independent paramagnetic peaks are observed in the non-topological WSe2 single crystal. That subverts the widely reported concept that the temperature independent paramagnetic peaks in topological materials originate from the spin texture of topological surface state. In addition to the susceptibility characteristic, it reveals weak ferromagnetic characteristic while no detectable ferromagnetic element in the WSe2 single crystal. The HRTEM supports that the ferromagnetism originates from lattice dislocation at different layer plane and axis. The temperature independent paramagnetism susceptibility peak might originate from the ferromagnetism induced by the lattice dislocation.