Pressure-Tuned Interlayer Magnetism in Two-Dimensional Chromium Trihalides

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Introduction

The recent discoveries of 2D magnets have opened the door to van der Waals spintronics [1,2]. In few-layer CrI_3 samples, the interlayer spin interaction has been observed to be antiferromagnetic (AFM) [3], while bulk crystals are understood to be ferromagnetic [4]. Additionally, the electrostatic doping [5] and electrical field [6] both are proved to be able to effectively control the interlayer magnetism in CrI_3. All these facts reflect a weak exchange interaction between layers in CrI_3. We expect that narrowing the interlayer spacing of the 2D magnets, CrX_3 (X =I, Br, Cl), would modulate the interlayer spin coupling as well and provide another approach for achieving active control of 2D magnets.

Experimental

In this work, we study CrX_3 in the atomically thin limit by incorporating them in vertical tunnel junctions with graphene electrodes. Upon application of a high hydrostatic pressure up to 1.01 GPa at SCM-2, the tunneling current is measured as a function of magnetic field and temperature, which allows us to directly detect the possible changes in their magnetic ground phases due to pressure effect.

Results and Discussion

All CrI_3 tunnel junctions were not working under high pressure, possibly due to the material's fragility. **Fig.1 (a)** and **(b)** show the I-V characteristic curve at 1.5K under different hydrostatic pressure in the absence of field for $CrBr_3$ and $CrCl_3$ respectively. In both $CrBr_3$ and $CrCl_3$ devices, we observe an obvious increase in conductance as higher pressure is applied, which is likely associated with the narrowed thickness of tunnel barriers. **Fig.2 (a)** and **(b)** shows the normalized temperature-dependent voltage biased at 1nA, under different pressure for $CrBr_3$ and $CrCl_3$ respectively. The peak from $CrBr_3$ and the kink from $CrCl_3$ in the V-T curve indicates the Curie temperature, due to spin-filter effect. No obvious changes are detected for the critical temperature, showing that the magnetic ground state remains unchanged under pressure. The pressure might not be high enough to induce any effective changes in the interlayer coupling.

Conclusions

The applied hydrostatic pressure effectively changes the spacing between layers in the few-layer $CrBr_3$ and $CrCl_3$ devices and thus their conductance. However, no pressure effect in interlayer magnetism is observed in this work.

Acknowledgements

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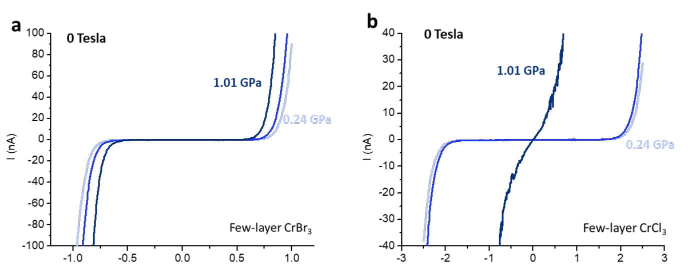

Fig.1 Current vs voltage under different hydrostatic pressure (0.24, 0.45 and 1.01 GPa) at 1.5K for few-layer (a) $CrBr_3$ and (b) $CrCl_3$.

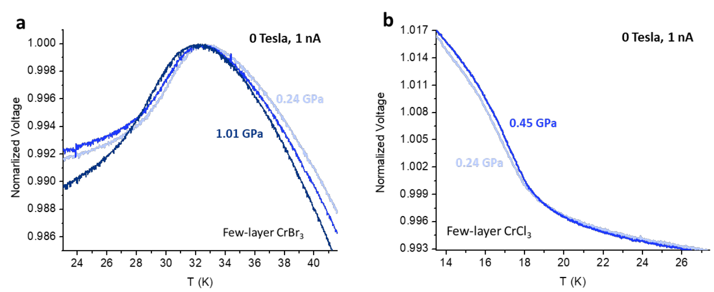

Fig.2 Temperature-dependent voltage, normalized by the voltage at Curie temperature, under different hydrostatic pressure (0.24, 0.45 and 1.01 GPa) for few-layer (a) $CrBr_3$ and (b) $CrCl_3$. $CrCl_3$ device shows open circuit under 1.01 GPa.