STRUCTURAL, MAGNETIC AND TRANSPORT PROPERTIES OF VAN DER WAALS CR_2TE_3 BASED HETEROSTRUCTURES

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Achieving the large-scale growth of 2D ferromagnetic materials with high Curie temperature and perpendicular magnetic anisotropy is highly desirable for the development of future ultra compact magnetic sensors or magnetic memories based on van der Waals (vdW) heterostructures. In this context, vdW materials in the class of $Cr_{1+x}Te_2$ compounds, which are stable in the range of $0 \leq x \leq 1$, appear as promising candidates [1]. Among them, Cr_2Te_3 exhibit strong perpendicular magnetic anisotropy and a Curie temperature in bulk of 180 K. With increasing chromium content, Curie temperature is augmented and magnetic anisotropy changes to an in-plane easy axis [2].

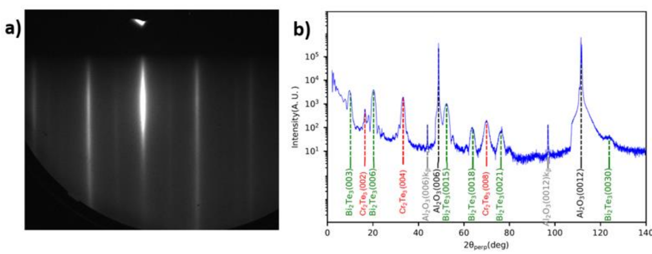

Figure 1: Structural properties of epitaxial Cr_2Te_3. a) RHEED image of Cr_2Te_3 grown on graphene/SiC. b) Specular x-ray diffraction of a vdW heterostructure of Cr_2Te_3 on Bi_2Te_3 on a sapphire (0001) surface.

Successful growth of vdW Cr_2Te_3 layers was achieved at the SPINTEC laboratory of CEA-Grenoble by molecular beam epitaxy (MBE). The growth was realized on various substrates such as epitaxial graphene on SiC(001), GaAs(111), WSe_2/GaAs(111) and Bi_2Te_3/Al_2O_3(0001). Systematic structural and magnetic analysis have been performed for each heterostructure. We obtained single crystalline growth on a centimeter scale surface, as can be seen by in situ reflection high-energy electron diffraction (RHEED) and ex situ x-ray diffraction (Figure 1), and well-defined magnetic properties (Figure 2). The surface morphology was studied by atomic force microscopy (AFM) and the stoichiometry of the layers was probed by Rutherford back scattering.

We observed - by SQUID magnetometry – perpendicular magnetic anisotropy and long range ferromagnetic order on vdW subtrates. We also found a decrease of the coercivity and an increase of the Curie temperature by post-growth annealing of the layers (Figure 2), that we attribute to a change of the stoichiometry (a raise of the chromium content symbolized by a positive ε in $Cr_{2+\varepsilon}Te_3$) as reported in thick films [2]. Following this method, we can expect to push the Curie temperature up to room temperature.

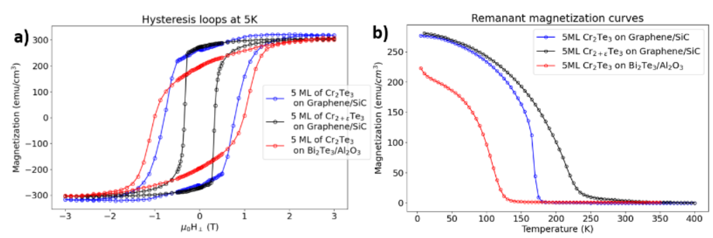

Figure 2: Magnetic properties of Cr_2Te_3 measured by SQUID magnetometry. a) Hysteresis loops at 5K with perpendicular applied magnetic field. b) Remanent magnetization obtained by heating the samples without any applied magnetic field starting from a saturated state.

Finally, magnetotransport measurements performed on Cr_2Te_3 epitaxially grown on graphene/SiC and on Bi_2Te_3/Al_2O_3 will be discussed with the purpose to study proximity effects and the topological Hall effect in these vdW heterostructures [3]. Despite the presence of out of plane chemical bonds in the Cr2Te3 crystal structure, we observe sharp interfaces with vdW materials and the Shubnikov de Haas oscillations in the graphene layer.
This study confirms Cr_2Te_3 and the class of $Cr_{1+x}Te_2$ materials as very promising candidates for future spintronic applications thanks to large scale single-crystalline growth, vdW interfaces with 2D materials and tunable Curie temperature possibly up to room temperature.
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References

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