Epitaxial 2D ferromagnet Cr_xTe_y/Bi_2Te_3 topological insulator heterostructures

Akylas Lintzeris[1, 2]
Elli Georgopoulou-Kotsaki[1, 3], Panagiotis Pappas[1], Polychronis Tsipas[1], Athanasios Dimoulas[1]
Nicholas Figeuiredo - Prestes[4], J.-M. George[4]
[1]*NCSR "Demokritos", Patr. Gregoriou E & 27 Neapoleos STR, 15341 Agia Paraskevi, GREECE*
[2]*Department of Physics, National Technical University of Athens, 15780, Athens, Greece*
[3]*Department of Physics, National and Kapodistrian University of Athens, 15784, Zografou, Athens*
[4] Unité Mixte de Physique, CNRS, Thales, Université Paris-Saclay, 91767, Palaiseau, France
a.lintzeris@inn.demokritos.gr

The discovery of two-dimensional (2D), van der Waals (vdW), ferromagnetic materials (among them Cr_xTe_y) has opened new routes in low-dimensional magnetism and new opportunities for spintronics. Depending on the stoichiometry Cr_xTe_y [1] compounds show different behaviors such as high T_c up to room temperature and perpendicular magnetic anisotropy (PMA) [2], [3]. Combined with Topological Insulators (T.I.) or heavy-metals like Pt, Cr_xTe_y compounds form heterostructures that host skyrmions [4] and can be used to achieve all-electrical switching of the magnetization [5]. In the present work, we study the influence of the growth temperature T_g on the composition and the magnetic properties of Cr_xTe_y thin films grown by MBE. We show that at low T_g ~ 220°C, a pure phase $Cr_{1+\delta}Te_2$ and $Cr_{1+\delta}Te_2/Bi_2Te_3$ is obtained with PMA and a T_c ~ 150°C-170°C. This phase yields indirect evidence of skyrmions via the topological Hall Effect, large fieldlike torque indicative of topological surface states dominated charge to spin conversion and (partial) current induced magnetization reversal [5]. At higher T_g~ 400-490°C, more than one phases coexist which have higher T_c near or above 300K (fig.1a), one of them with lower coercivity and predominately in-plane magnetization. The high T_c phases are attributed to Cr-rich phases due to Cr self-intercalation and the influence from the substrate. We will focus on a detailed investigation of the growth and the control of the composition of Cr_xTe_y phases by various techniques including in-situ RHEED, STM and ARPES and ex-situ XRD. The magnetic properties were studied using Magneto-optical Kerr (MOKE) magnetometry/microscopy, SQUID and Hall-effect measurements. Cr_xTe_y grown at high T_g, show MOKE magnetic hysteresis at T>300K with in-plane anisotropy (Fig. 1b) Anomalous Hall Effect (AHE) is observed in low T_g samples with the magnetization easy axes out of the plane of the films.

We acknowledge EU funding from project H2020 FET PROAC SKYTOP-824123.

References

[1] Lasek K, ACS Nano, 8473-8484, 14(7) (2020)
[2] Zhang X. et al., Nat Commun, 12, 2429 (2021)
[3] Li H. et al., ACS Appl. Nano Mater., 2, 11, 6809–6817 (2019)
[4] Saha R. et al., Nat Commun, 13, 3965 (2022)
[5] Figueiredo-Prestes N. et al., Physical Review Applied, Vol. 19, Iss. 1(2023)

Figures

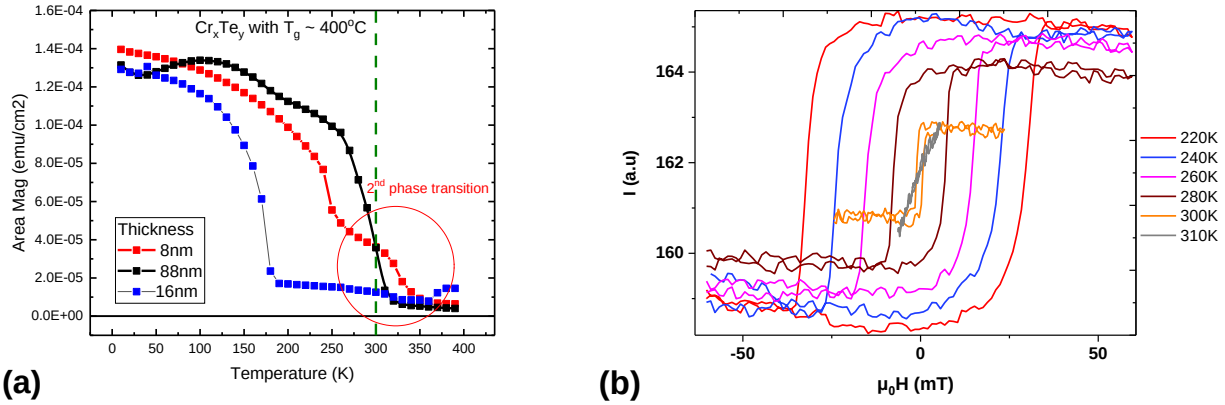

Figure 1: (a) SQUID magnetometry for 3 Cr_xTe_y samples with thickness from ~8nm – 88nm. The thinner sample presents a second magnetic phase with T_c above RT. (b) MOKE of Cr_xTe_y showing in-plane ferromagnetism above 300K.