Thickness dependence of ferromagnetism in Cr_3Te_4 epitaxial thin films grown by molecular beam epitaxy

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The discoveries of intrinsic ferromagnetism in atomically-thin van der Waals crystals have opened up a new research field enabling fundamental studies on magnetism at two dimensional (2D) limit as well as development of magnetic van der Waals heterostructures. To date, a variety of 2D ferromagnetism has been explored with different electronic properties, such as insulating ferromagnets $Cr_2Ge_2Te_6$ [1] and CrI_3 [2], and metallic ferromagnet Fe_3GeTe_2 [3] and V_5Se_8 [4]. However, 2D ferromagnets with high Curie temperature (T_C) was still missing, until recent discovery of room temperature ferromagnetism in monolayer VSe_2 [5], although there have been many discussions and enigma on the origin of its ferromagnetism. One promising candidate is chromium telluride, which has been known to possess T_C ranging from 220 K to 340 K depending on the chromium intercalation level. Recently we have succeeded in growing atomically-thin chromium telluride epitaxial thin films on insulating sapphire substrates by molecular beam epitaxy (MBE), and identified its phase as Cr_3Te_4 based on the detailed analysis on the structural and magnetic properties (Fig. 1). We found that T_C of the as-grown samples were about 160 K, but it increased up to 310 K by post-growth annealing (Fig. 2). Moreover, very interestingly, we found that those with- and without-annealing samples show different thickness dependence of T_C. In this presentation, we will discuss those results in detail.

[1] C. Gong *et al., Nature* **546**, 265 (2017); [2] B. Huang *et al., Nature* **546**, 270 (2017); [3] Z. Fei *et al., Nat. Mat.* **17**, 778 (2018) [4] M. Nakano *et al., Nano Letters,* **19**, 8806 (2019). [5] M. Bonilla *et al., Nat. Nanotechnol.* **13**, 289 (2018)

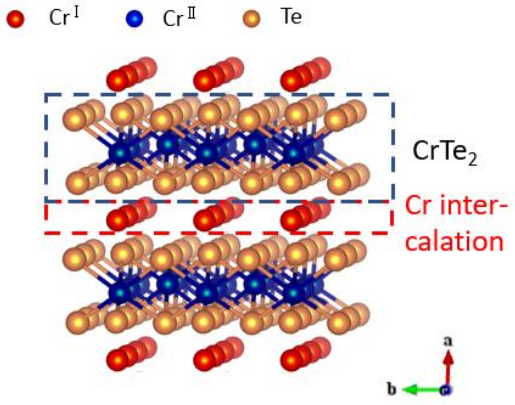

Fig. 1. Crystal structure of Cr_3Te_4.

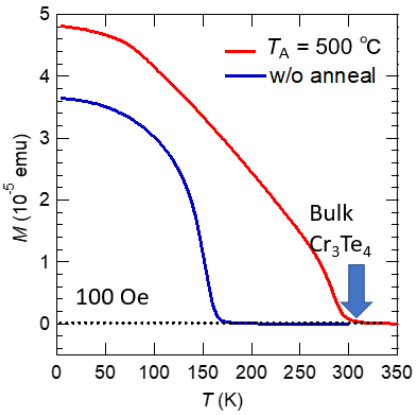

Fig. 2. Increase of T_C by post-growth annealing in Cr_3Te_4.