MBE growth of 2D topological quantum materials

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Abstract

In this tutorial, first a general review of molecular beam epitaxy (MBE) basics with a particular focus on 2D materials and van der Waals heterostructures will be presented. Emphasis will be given on the merits of MBE compared to other thin film deposition techniques. Subsequently, the focus will be on the influence of the substrate and in-situ surface preparation techniques on the structural quality and physical properties of the 2D materials. In-situ surface analytical techniques will be discussed such as STM and RHEED for the imaging of surfaces with atomic resolution and ARPES for the imaging of the electronic band structure. Particular attention will be given to 2D materials with non-trivial topology in reciprocal space such as topological insulators [1], T_d-$MoTe_2$ Weyl semimetals [2] and $HfTe_2$, $ZrTe_2$ Dirac semimetals [3]. Similarly, ferromagnetic 2D metals (e.g $Cr_{1+\delta}Te_2$, Fe_xGeTe_2) [4, 5] with skyrmion topological structures in real space will be discussed

Figures

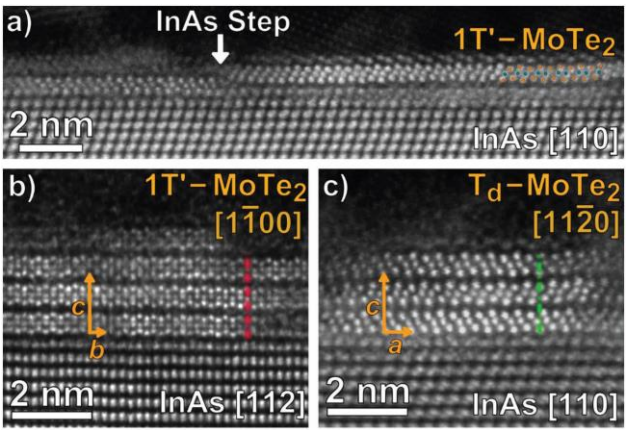

Figure 1: After Ref [2] MBE growth of Weyl semimetal orthorhombic non-centrosymmetric phase T_d-$MoTe_2$.

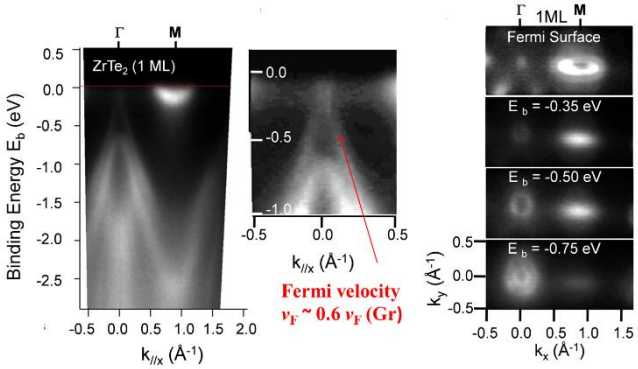

Figure 2: After Ref [3] In-situ ARPES of MBE grown 1T-$ZrTe_2$ showing massless Dirac fermions at the zone center

References

[1] S. Fragkos et al., *Phys. Rev. Mater.* (2021) **5**, 014203
[2] P. Tsipas et al., *Adv. Funct. Mater. (*2018), 1802084.
[3] P. Tsipas et al., *ACS Nano* **12** (2018) 1696
[4] N. Figueiredo-Prestes et al., Physical Review Applied (2023) 19, 014012
[5] E. Georgopoulou-Kotsaki et al., *Nanoscale* (2023) **15**, 2223