Visualization of grain boundaries in 2D Transition Metal Telluride

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Abstract

2D transition-metal dichalcogenides and their van der Waals heterostructures recently have drawn increasing attention owing to their promising properties. Particularly, tellurium-based compounds such as $MoTe_2$ and WTe_2 exhibit semiconducting and semi-metallic characteristics, which are associated with their distinct polymorphic crystal structures [1]. These various lattice phases make $MoTe_2$ a favourable candidate for both fundamental studies and device applications. However, the energy difference between the 2H and 1T' phases of $MoTe_2$ is small, as well as 1T'-$MoTe_2$ is thermodynamically stable [2] make it challenging for phase-selective synthesis. In addition, the location of grain boundary and lattice orientation is required when dealing with non-exfoliated samples, as the mechanical and electrical properties governed by lattice orientation and strongly influenced by presence of grain boundary.
Herein, we report a controlled synthesis of highly crystalline 1T'- and 2H-$MoTe_2$ crystals by APCVD technique. Furthermore, we investigated the existence of grain boundaries using a simple tool called 'polarized optical microscopy', which then further supported by angle resolved Raman scattering and SHG [3]. Polycrystalline 1T'-$MoTe_2$ are normally Mo-terminated and shows anisotropic optical absorption leading to the clear visualization of lattice domains. On the other hand, 2H-$MoTe_2$ lattice grains does not exhibits any difference under polarized light. Grain boundary visualization in 2D tellurides using this simple tool paves the way for the realization of grain boundary free real devices with desired lattice orientation.

References

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[2] Lin Zhou et al.,, J. Am. Chem. Soc., 137 (37), (2015) 11892-11895
[3] A. T. Hoang et al., Nanoscale, 10, (2018) 21978-21984

Figures

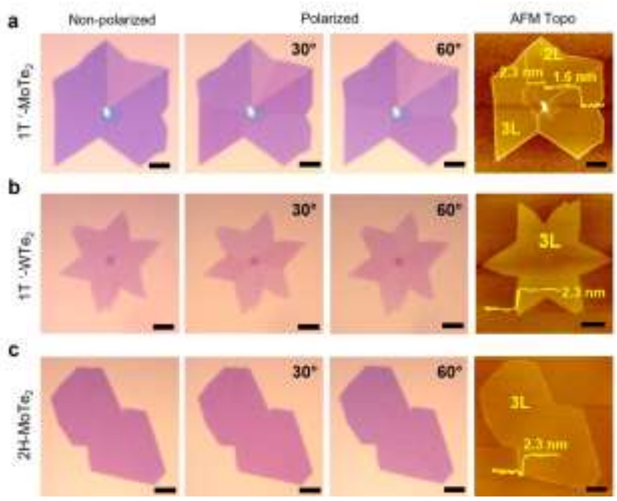

Figure 1: Non- polarized, polarized optical images with different rotational angles and AFM topography of (a) 1T'-$MoTe_2$, (b) 1T'-WTe_2 and (c) 2H-$MoTe_2$ respectively. Scale bar, 10 μm.