Twisted WS_2 bilayers with large suspended area for in-plane Raman thermometry

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Since the discovery of the magic angle in twisted bilayer graphene, twisted bilayers have attracted substantial research interest due to their potential for next-generation electronic devices. These structures exhibit a wide range of emergent phenomena, including significant modifications of electronic and phononic band structures, with properties that can be efficiently tuned via the relative twist angle [1,2]. Among the most studied materials are transition metal dichalcogenides, a class of van der Waals materials whose physical properties depend not only on the number of layers but also on their relative angle [3].

With respect to thermal transport, simulations performed at the Catalan Institute of Nanoscience and Nanotechnology predict a pronounced anisotropy between in-plane and cross-plane thermal conductivities in twisted TMD bilayers, strongly dependent on the twist angle. Experimental confirmation of such thermal anisotropy would support the integration of twisted TMD bilayers into nanoscale electronic devices, where efficient thermal management remains a key challenge. For WS_2 bilayers, our group has already observed twist-angle-dependent variations in cross-plane thermal conductivity using frequency-domain thermoreflectance (FDTR). However, in-plane thermal conductivity measurements are still lacking, preventing a complete characterization of the thermal anisotropy.

To experimentally address this gap, the present work focuses on the fabrication of twisted bilayer WS_2 samples featuring suspended regions of approximately 78.5 μm^2, suitable for in-plane thermal conductivity measurements via two-laser Raman thermometry. High-quality WS_2 monolayers with lateral dimensions up to 200 µm are grown by chemical vapor deposition and subsequently transferred with controlled rotational alignment to form twisted bilayers. These bilayers are then precisely transferred onto perforated substrates using a clean and alignment-controlled process to create large suspended areas. The resulting samples are characterized by photoluminescence spectroscopy, Raman spectroscopy, atomic force microscopy (AFM), and transmission electron microscopy (TEM) to assess structural quality and accurately determine the twist angle prior to in-plane thermal conductivity measurements.

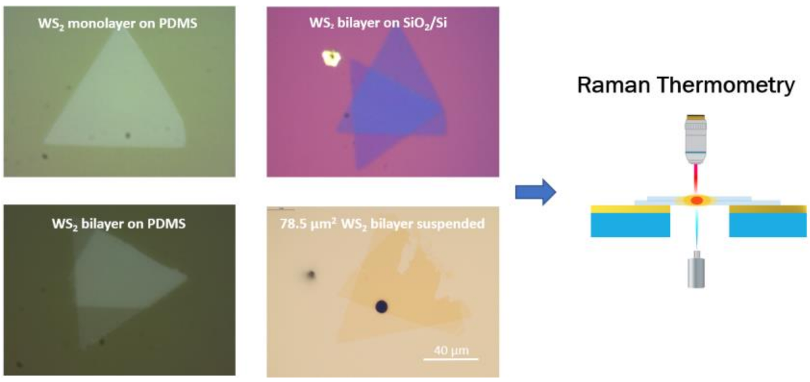

Figure 1: Big area twisted WS_2 bilayer suspension for in-plane thermal characterization.

[1] Cao, Y et. al. Nature 2018, 556 (7699), 43-50.
[2] Tang, B et. al. Small Structures, 2(5).
[3] Xiong, H et. al. ACS Applied Nano Materials 2023, 6 (17), 15685-15696.