Microwave Microscopy on Twisted Bilayer Graphene Systems

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Twisted bilayer Graphene (TBG) systems represent a class of intriguing geometries that enables the creation of van der Walls solids. The possibility of spatial modulation of the potential by means of adjust the twist angle permits the observation of exciting phenomena, such as superconductivity at the magical angle of 1.1o [1,2], paving the way for further advances in creating solids with unique properties. Tools that can help in engineering these structures include Transmission Electron Microscopy (TEM) [3], Tip Enhanced Raman Spectroscopy (TERS) [4], Scanning Tunneling Microscopy (STM) [2], and scanning Microwave Impedance Microscopy (sMIM) [5], to name a few. Here we investigate a series of sMIM experiments on TBG with several twist angles, tip-surface interactions and hBN encapsulation at selected insulator thickness, all performed at room temperature and ambient conditions. We also utilized conductive AFM, independently and concurrently taken with sMIM data. By employing a vector-based technique such as sMIM, we can assess the local impedance, or complex dielectric function. Despite the many challenges that include, but are not limited to, sample preparation, tip and surface conditions, Electromagnetic (EM) Field modelling, phase calibration, we found that invaluable electronic information can be extracted. In particular we found the loss of spatial resolution due to the extinction of EM fields for hBN thickness beyond 2nm, and were demonstrate correlations between cAFM and sMIM, for bare and hBN encapsulated TBGs, thus allowing for assessment of real and imaginary components of the complex dielectric function.

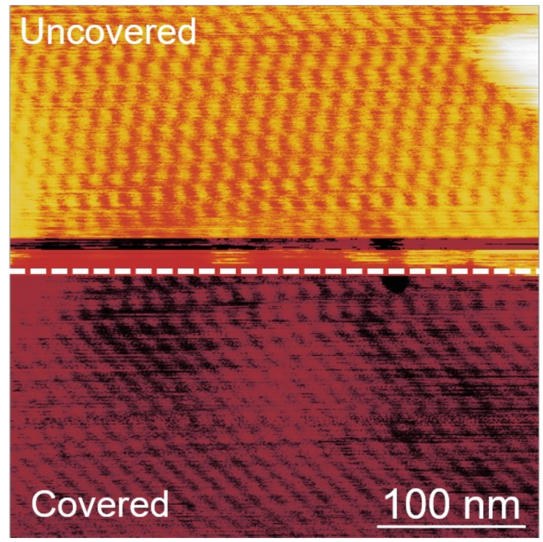

Fig.1. sMIM image of a partially covered TBG layer (top: uncovered; bottom: covered) by a 0.8nm layer of hBN. The Moiré periodicity is 16nm, for a twist angle of 0.88º.

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