Imaging Hexagonal Boron Nitride Monolayers with Sum-Frequency Spectro-Microscopy

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Nonlinear optical spectroscopy and microscopy are powerful tools to characterize interfaces and lower-dimensional materials [1,2]. Here we introduce infrared + visible sum-frequency generation (SFG) imaging of hexagonal boron nitride (hBN) monolayers within a wide-field optical microscope. The technique enables us to image the topography and crystal orientation of chemical vapor deposition (CVD) grown hBN islands, which are usually optically invisible. A mid-infrared laser is used to resonantly excite the transverse optical phonon of hBN and a second visible laser then upconverts this excitation to generate a sum-frequency signal in the visible spectral range. This allows us to image the topography of hBN with a sub-diffractional spatial resolution that is set by the visible SFG wavelength. Heterodyning the generated SFG signals further enables us to obtain phase information [2,3] which, when combined with azimuthal scanning of the sample and subsequent Fourier decomposition [4], allows us to isolate the 3-fold symmetry of the hBN islands and determine their precise local crystal orientation.

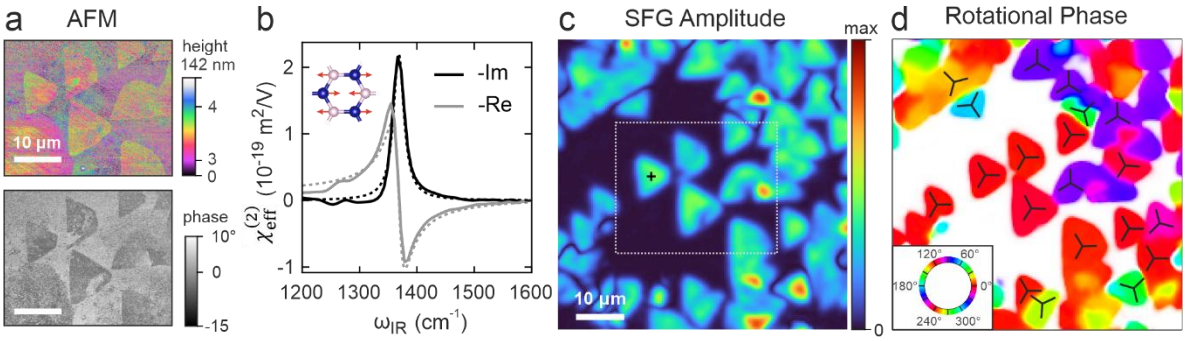

Figure 1. (a) AFM image of hBN monolayer islands grown with CVD on an Fe catalyst and transferred onto fused silica. (b) SFG spectrum showing the resonance of the hBN phonon. (c) SFG magnitude and (d) phase images of hBN monolayer islands showing the topography (c) and crystal orientation (d).

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