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Terahertz Emission from Giant Optical Rectification in a van der Waals Material

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Exfoliation and stacking of two-dimensional (2D) van der Waals (vdW) crystals have created unprecedented opportunities in the discovery of quantum phases. A major obstacle to the advancement of this field is the limited spectroscopic access due to a mismatch in sample sizes (10^{-6} – 10^{-5} m) and wavelengths (10^{-4} – 10^{-3} m) of electromagnetic radiation relevant to their low-energy excitations. Here, we introduce ferroelectric semiconductor $NbOI_2$ as a 2D vdW material capable of operating as a vdW terahertz (THz) emitter. We demonstrate intense and broadband THz generation from $NbOI_2$ with optical rectification efficiency over one-order-of-magnitude higher than that of ZnTe, the current standard THz emitter. Moreover, this $NbOI_2$ THz emitter can be integrated into vdW heterostructures to enable on-chip near-field THz spectroscopy of a target vdW material and device. Our approach provides a general spectroscopic tool for 2D vdW materials and quantum matter.

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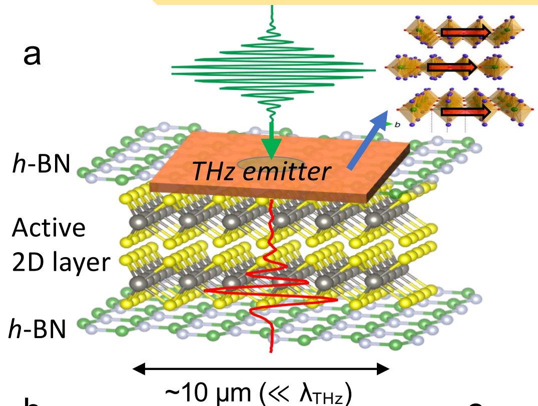

Fig. 1. Near-field THz spectroscopy exploiting efficient THz emission of 2D vdW ferroelectric $NbOI_2$. **a**, Schematic illustration of sub-diffraction limit THz spectroscopy. The inset shows the structure of the vdW layered $NbOI_2$. **b**, Time-domain waveform of THz emission from 2.5-μm $NbOI_2$ (red) and 0.2-mm ZnTe (blue, multiplied by 0.5). **c**, Frequency-domain spectra for $NbOI_2$ (red) and ZnTe (blue). **d**, Pump fluence dependences of the emitted field amplitudes, normalized by the thickness. The dotted lines show a linear dependence. The thickness normalized THz emission efficiency from $NbOI_2$ is 20x to 100x higher than that from ZnTe, the standard THz emitter used today.