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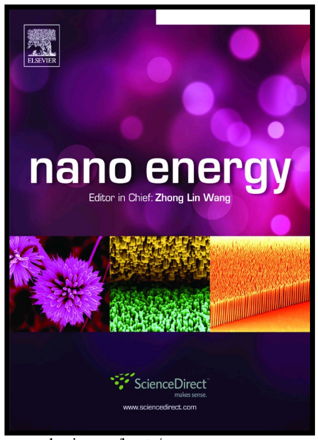

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Piezoelectricity of Atomically Thin WSe2 via Laterally Excited Scanning Probe Microscopy

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Abstract

Lattices of odd-layered two-dimensional (2D) transition metal dichalcogenides (TMDs) such as WSe_2 are non-centrosymmetric, and thus could possess linear piezoelectricity that is attractive for applications such as nanoelectromechanical systems (NEMS) and nanogenerators. Measuring the electromechanical coupling of 2D TMDs, however, is rather challenging, since its D_{3h} point group symmetry makes conventional piezoresponse force microscopy (PFM) inapplicable. Here we develop a lateral excitation scanning probe microscopy (SPM) technique that enables mapping of the piezoelectric response of atomically thin WSe_2 directly on a substrate with high spatial resolution. Planar electrodes are used to excite piezoelectric vibrations while imposing anisotropic in-plane mechanical constraint to the WSe_2, resulting in an out-of-plane deformation due to Poisson's effect that can be measured by an SPM probe. Using this technique, we show that WSe_2 monolayer and trilayers exhibit strong electromechanical response linear to the applied excitation biases that is distinct from the substrate, while WSe_2 bilayers show negligible electromechanical response as expected. The effective piezoelectric coefficient is estimated to be 5.2 pm/V from the measurement, consistent with theoretical predictions. This method can be conveniently applied to a wide range of 2D materials with similar symmetry.

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