Exploring Piezoelectric Properties of Atomically Thin WSe2 for 2-Dimensional Nanoelectromechanical Systems

Li, Terrance

Two-dimensional (2D) graphene with exotic properties was discovered in 2004 by Andre Geim and Konstantin Novoselov, which earned them a Nobel Prize in Physics in 2010. However, it is point symmetrical and has no band gap, thus limiting its applications in nanoelectromechanical systems (NEMS) that require semiconductivity and electromechanical coupling. 2D tungsten diselenide (WSe2) monolayer can overcome these limitations, and was predicted to be piezoelectric by quantum mechanics calculations. In this study, the piezoelectricity of atomically thin WSe2 is experimentally confirmed for the first time. In my research, atomically thin WSe2 was exfoliated from bulk crystals onto silicon substrate and its layer count was measured via atomic force microscopy (AFM) topography. To make a device for testing, gold electrodes were patterned using electron beam lithography (EBL) and deposited via metal evaporation. An AC voltage was applied through the external electrodes to excite the WSe2, and the resulting piezoelectric displacement was measured at picometer resolution using an AFM probe. A computational model was developed to predict the piezoresponse of the 2D WSe2 device based on the symmetry, validating the experimental data. Through this study, I discovered that monolayer WSe2 has a strong piezoelectric response while bilayer has negligible response, consistent with quantum mechanics predictions. The response was found to be proportional to drive voltage, and the piezoelectric coefficient was quantitatively determined accordingly. This study thus confirms the piezoelectric effect in atomically thin WSe2 for the first time, enabling potential applications in sensors and actuators, NEMS, and nanogenerators.

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