# Huge in-plane piezoelectric voltage response from oriented $MoS_2$ domains in an amorphous carbon matrix

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Abstract
The piezoelectric effect of large area monolayer TMD films can decrease with size due to disorder in the form of polycrystalline domain orientation and an increasing number of grain boundaries. Here, we introduce a novel ultrathin carbon-$MoS_2$ composite lateral heterostructure consisting of an amorphous carbon membrane matrix with embedded $MoS_2$ domains of a few tens of nanometers in size. The $MoS_2$ domains display a strong mutual crystal orientation alignment thanks to the epitaxial growth process on an Au(111) surface. The piezoelectric charge generated at the periphery of these $MoS_2$ domains under strain influence the Schottky barrier at the domain contact with the amorphous carbon matrix, as well as driving a current in the composite material. A piezoelectric open circuit voltage of 616mV under 0.45% strain is measured, which is stable over hours of measurement and thousands of mechanical cycles. Our work marks the first exploration of the piezoelectric effect in conducting 2D heterostructure composite membranes, and suggests viable routes for the preservation of piezoelectricity in 2D materials at a large scale.

Figures

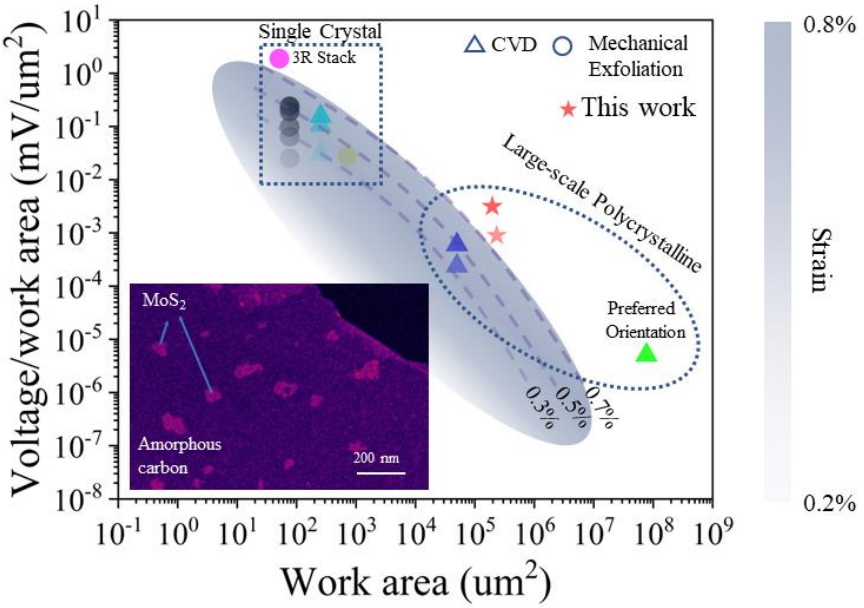


**Figure 1:** Comparison of this work with references with piezoelectric performance. Inset, scanning transmission electron microscopy image of the amorphous carbon matrix with oriented $MoS_2$ domains