Method to differentiate Flexoelectricity from Piezoelectricity

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Flexoelectricity emerges as an effective technique for actuation and sensing at the nanoscale[1], offering significant advantages over traditional piezoelectric methods. Particularly, in the context of nanoelectromechanical systems (NEMS), flexoelectricity excels in areas where piezoelectricity falls short. For instance, flexoelectric actuators eliminate the requirement for a passive layer to produce bending moments, thus outperforming their piezoelectric counterparts at comparable nanoscale thicknesses. Moreover, the flexoelectric effect is universal across all material types[2], suppressing the necessity for non-centrosymmetric materials that is crucial for piezoelectricity. As a result, flexoelectricity remains effective even under extreme temperature conditions.

Despite these advantages, the path to industrial scalability of flexoelectricity is delayed by significant obstacles: First, there is a crucial need for a reliable method to differentiate flexoelectric effects from other phenomena across various materials. Second, the creation of a comprehensive catalog of flexoelectric coefficients is necessary.

Our research addresses these significant challenges. We have developed a methodology to differentiate the flexoelectric effect from piezoelectricity, electrostriction, and electrostatic effects. This technique enables the accurate quantification of flexoelectric coefficients at the nanoscale, effectively isolating them from competing phenomena. Our method has been validated with amorphous HfO2, marking the first measurements of flexoelectricity in an amorphous material and pioneering its quantification in hafnia.

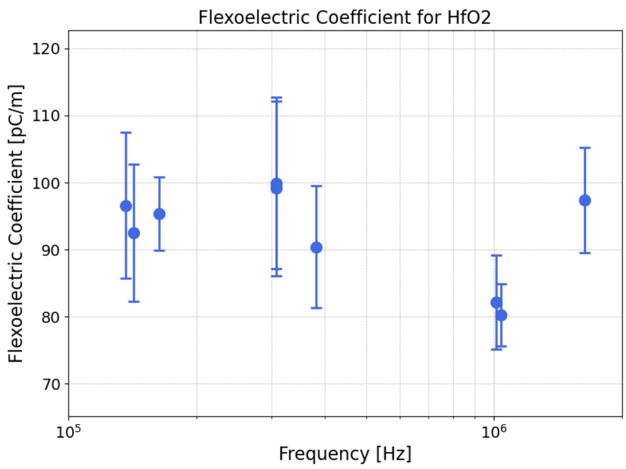

Fig. 1: Measurement of the flexoelectric coefficient in amorphous HfO2 for different frequencies. This figure illustrates the isolation of the flexoelectric effect from competing influences such as piezoelectricity, electrostatics, and electrostriction. These results represent the first quantification of the flexoelectric coefficient in hafnia, as well as the first measurement of this kind in an amorphous material.

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