Direct Mechanical Evaluation of Flexoelectric Response of Free-standing Cantilever Beams by Nanoindentation Instrumentation

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Flexoelectricity and flexoelectric effects have been gathering and increasing attention in the past few years. This new enthusiasm has been boosted, at least in a big part, due to the potential exploitation of this effect in micro/nanoelectromechanical actuators and sensors without inherent piezoresponse [1]. Currently, there are a few limiting aspects to their testing. i) the dimensions and geometry required (relatively large samples, typically millimetric in size); ii), the maximum oscillation frequency of the instrument because the relationship $I=Q*f$ (between electric current (I), charge (Q) and frequency (f)) implies that higher frequencies are desirable to improve signal detection; and iii), the mechanical resilience of the nanocrystals studied. The last aspect is particularly important since single crystalline samples will normally break with amplitudes over a few microns and relatively low strain fields (>0.3 m^{-1}); as a consequence, large samples are required, limiting the strain gradients accessible in experiments. Previosuly, a method for measuring flexoelectric response on free-standing cantilever beams using nanoindentation instrumentation was developed. The general advantages of the method are the use of controlled sub micrometric oscillations, small strain field and the possibility of exploiting the micro and nano capabilities of modern indenters to probe small devices in-operando conditions. Moreover, several instrumentation and error sources are discussed and considered prior measurements. Finally, the efficiency of the methodology is confirmed by testing Strontium Titanate (STO) and Hydroxyapatite (HAp) beams, with an established flexoelectric response. Further tests have allowed the evaluation of the photo flexoelectric coefficient of STO. The results confirm the applicability and accuracy of the method [2].

References:

[1] J. Narvaez, F. Vasquez-Sancho, and G. Catalan, Nature 538, 219 (2016).
[2] E. Coy, Measurement 163, 107986 (2020).

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