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Exploring the Nanoscale Electromechanical Properties of Lead-free Thin Films and Nanostructures for Energy Harvesting Applications

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The energy crisis presents one of the most significant challenges of our century, necessitating the urgent exploration of new methods for electricity generation. A promising approach involves the development of systems made of materials with piezoelectric properties for energy harvesting devices. While certain materials like PZT exhibit excellent piezoelectric properties, the presence of toxic lead hinders their applicability. Consequently, alternative materials such as metallic (doped) oxides (i.e. ZnO) which demonstrate remarkable piezoelectric behavior, need to be explored. Furthermore, organic materials like PVDF-TrFE possess inherent piezoelectric properties, albeit with weaker coefficients than their inorganic counterparts. However, the addition of multiferroic nanoparticles (such as $BiFeO_3$) to PVDF-TrFE can enhance their piezoelectric response.

Piezoelectric and ferroelectric properties at the nanoscale of these samples were investigated using Piezoresponse Force Microscopy (PFM)-based modes. Most importantly, we tried to carefully eliminate (or at least attenuate) the artifacts (mainly coming from undesired electrostatic contributions) perturbating the measurements of the electromechanical properties.

In fine, the modelling using Finite Elements simulations (COMSOL Multiphysics) will enable us to provide some promising information about the performance of the piezoelectrical nanogenerators (PENGs).