Flexoelectricity: a small effect with big consequences at the nanoscale

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Flexoelectricity is the ability of many materials to generate a voltage in response to bending or, conversely, to bend in response to a voltage. While this effect is virtually imperceptible at the macroscale, it is very important at the nanoscale, where large strain gradients are easier to achieve. Over the last decade, our lab has been exploring the limits of flexoelectricity, both in terms of materials and applications. The present talk will give an overview of the field, with an emphasis on important recent results.

Flexoelecticity was initially postulated as a property of insulators, and in particular oxides with high dielectric constants such as ferroelectrics (materials with a spontaneous switchable polarization). The combination of flexoelectricity and ferroelectricity at the nanoscale allows the use of strain gradients to manipulate polarization (e.g. writing[1] or reading[2] ferroelectric memory bits by local indentation), and also, conversely, manipulating mechanical reponse (fracture toughness, bending) by voltage [2,3].

More recently, however, we have discovered that flexoelectricity also exists in semiconductors [4] and even some biological materials such as bones [5]. The interplay between flexoelectricity and semiconductor physics is only beginning to be explored, but we already know that it has consequences for combined photovoltaic + electromechanical energy harvesting (flexophotovoltaics, photoflexoelectricity [6]). As for biomaterials, flexoelectricity appears to play a physiological role on bone fracture repair and bone remodeling [7].

The bottom line is that flexoelectricity can be large at the nanoscale, and has important and potentially useful consequences across the board for information technologies, energy and health.

References

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Figures

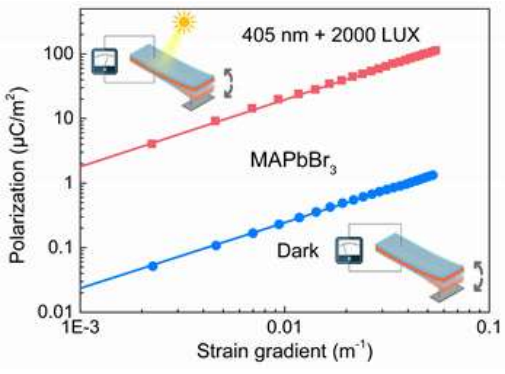

Figure 1. Photo-flexoelectricity of halide perovskites [6]

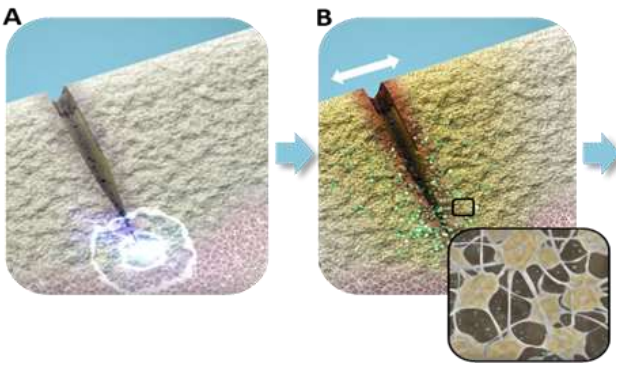

Figure 2. Flexoelectric effect in bone fractures [7]