Energy harvesting with the effects of leakage currents for ferroelectric nanogenerators

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Due to increasing interest in efficient technologies for energy harvesting, this nanogenerator principle reveals a concept based on the transformation of mechanical into electrical energy. Ambient parasitic vibrations serve as energy source, whereas the energy conversion is performed within the ferroelectric material barium titanate and is enabled by designed polarization domain topology [1]. Vibrations deform the substrate, whereas the polarization domains reorder in the ferroelectric film and, resultantly, an electron flow is measurable in case of an existing gradient in the electric potential between surface electrodes.

Since the ferroelectric film is not a perfect insulator and leakage current is a well-known reason for energy losses, we analyse the effect of different leakage current formulations, [2]. On the one hand we investigate the effect of Ohm's law and space-charge-limited current (SCLC) as bulk formulations on the electric potential. On the other hand we investigate the effect of these formulations on the polarization domains. In addition, the Schottky emission is implemented as interface formulation between the electrodes and the barium titanate ferroelectric film.

Each of these formulations has a different dependency of the leakage current on the electric field. Ohm's law has a linear dependency, SCLC a quadratic and the Schottky emission has an exponential dependency on the electric field.

We extend the finite element phase-field model, developed by Su and Landis [3], by implementing these different leakage current formulations. The order parameter for the phase-field model is the material polarization. The prediction of expected energy losses in correlation to leakage current and polarization domains is a promising tool in terms of optimization of the generator principle.

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