RCDAMP Seminar Series

Korean Dielectrics Society

Negative capacitance from the inhomogeneous stray field in a ferroelectric-dielectric structure

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Place **Bldd308 #211** (물리학과 211 호 강의실)

ZOOM Webinar https://pusan.zoom.us/j/97323601338?pwd=bS9KbnFxL1QzTzBEN05mdGcxRm1DQT09

Abstract

The phenomenological Landau-Ginzburg-Devonshire model provided a fundamental background for an understanding of the peculiar charge-voltage behavior of ferroelectric (FE) materials. However, the model cannot explain the polarization behavior of multidomain FE materials. The experimentally observed negative capacitance (NC) effect, which has been interpreted as an emergence of the Landau barrier effect, involved particular conceptual difficulty. This work provides a new conceptual framework to explain the quasi-static NC effect based on the energy formula for a stacked dielectric/ferroelectric (DE/FE) layer structure with the multidomain configuration with an arbitrary shape (See Fig. 1). The presence of such domain configuration causes the energy-displacement curve of the inhomogeneous Helmholtz energy term to have negative curvature. This is caused by the stray field between the neighboring domains. The model can be further extended to the DE/FE system with polycrystalline FE grains using the advanced phase-field analysis. It is qualified that the NC effect from the stray field is a universal phenomenon. These models provide quantitative explanations for the previously reported short-pulse measurement results for various DE/FE material systems, which have lacked accurate interpretations.

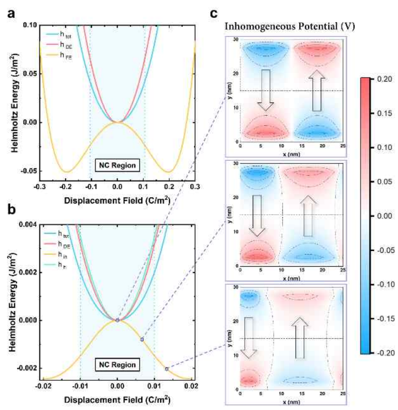

Figure 1 | Free energy density versus displacement field diagrams for the two models. a, Helmholtz energy density versus displacement field diagram that describes stabilization of the NC in the 1D LGD model. **b,** Helmholtz energy density versus displacement field diagram in the ISE model. The green curve represents the homogeneous electrostatic energy density of the DE/FE stacked device. The red curve represents the electrostatic energy density of the DE layer. The yellow curve represents the inhomogeneous electrostatic energy of the DE/FE stacked device. The blue curve represents the total electrostatic energy of the DE/FE stacked device. **c,** Distributions of the inhomogeneous potential (except for the mean potential) inside the DE/FE stacked structure. Each figure corresponds to the distribution with the relative ratio of domain width δ denoted by the corresponding purple dot in **b**. The arrows in these figures represent the polarization directions in each domain. See the Methods section for detailed derivations.

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