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Polarization switching in ferroelectric nanodots subjected to a curled electric field

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Summary

Ferroelectric nanostructures exhibit vortex structures with the shrinking of the relevant lengths to the nanometer scale because of the strong depolarization field. The vortex structure in the nanoscale ferroelectrics, similar to the vortex structure in magnetic nanostructure, is regarded as a toroidal order which is different from the common homogeneous polarization order. The finding of the vortex in ferroelectric nanostructures opens exciting opportunities for designing nanomemory devices, which holds a promise to increase the density of ferroelectric nonvolatile random access memories by several orders of magnitude. The switching behavior of polarization vortex under a curled field is different from the traditional planar capacitor cases. A full understanding of the switching behavior is essential for the application of polarization vortex in further nonvolatile random access memories.

In the present study, the polarization switching in a single-crystal ferroelectric tetragonal nanodot subjected to curled electric fields is investigated by a phase field model. The simulation results show that the switching of polarization vortex in the tetragonal nanodot does not begin from the location with the highest energy density, which is different from those of ferroelectric nanotubes and ferroelectric cylindrical nanodots. It is found that the vortex switching begins from the dot corners with the lowest elastic energy density, which implies the elastic constraint as well as the geometry plays an important role on the switching of polarization vortex in ferroelectric nanostructures.