Technical University of Denmark

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Baekke, B.S. ; Beleggia, Marco

Published in:
Book of Abstracts. DTU's Sustain Conference 2015

Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

Polarization enhancement of ferroelectric nanoparticles

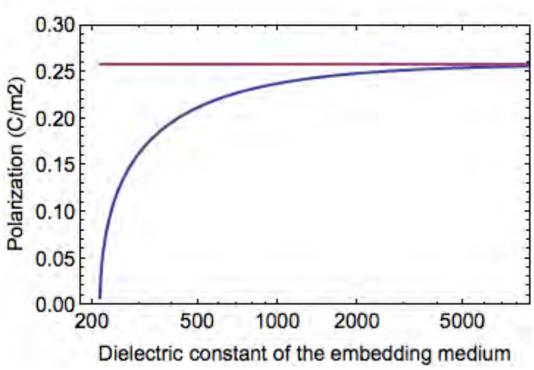
B.S. Baekke[1], M. Beleggia*[1]

1: DTU Danchip/Cen

*mailto:marco.beleggia@cen.dtu.dk

Ferroelectric (fe-) nanostructures are the core elements of several modern technologies, from fe-capacitors, to random access memories (fe-RAM, a viable alternative to the popular flash memory). They bring the promise of *lower power consumption*, *increased durability and speed* over existing technologies for information storage and manipulation. A physical limitation is, however, preventing their large-scale implementation: *the polarization is suppressed at small sizes* [1]. We demonstrate here why this is the case, and illustrate a possible avenue for *enhancing the polarization of ferroelectric nanoparticles* with suitable energy-relief mechanisms to *create the smallest ferroelectric capacitor yet*. Our strategy is to embed the structures in a matrix to screen the depolarizing field while preventing the formation of domains, and to exploit elongation and shape effects by controlled lithographic patterning. Aiming at achieving spatially-resolved measurements of the polarization with electron holography, we estimate the signal to be expected in the electron microscope and support the feasibility of such experiments. Electron holography, a specialty of DTU Cen, is a phase-sensitive technique in transmission electron microscopy capable of detecting the fields generated by elementary charges [2] and spins inside materials while maintaining near-atomic spatial resolution. Combining theoretical and experimental analysis will provide us with the opportunity to *develop functional ferroelectric nanodevices with a degree of miniaturization, performance and sustainability far greater than what currently possible.*

[1] Phatak C et al., Phys Rev B 89 (2014) 214112
[2] Beleggia M et al., Appl Phys Lett 98 (2011) 243101



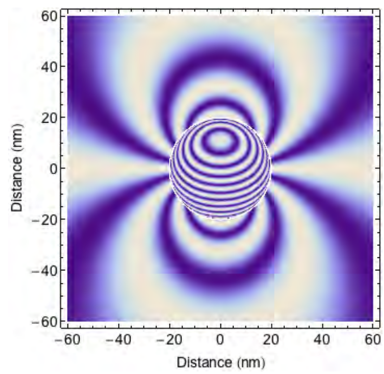


Figure 1. Left: polarization of a hypothetical single-domain BaTiO nanoparticle as a function of the dielectric constant of the embedding medium; the polarization vanishes below a critical value of e_r=214. Right: cosine-map (256x amplified) representation of the electron-holographic phase shift for a BaTiO nanoparticle when e_r=300 with the effect of the mean-inner-potential (MIP) added to that of the polarization; the particle radius is 20 nm, the accelerating voltage 300 kV, and the MIP 1 V.