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Polaronic model of the Giant Dielectric and Pyroelectric Responses of Ferroelectric Fine-Grained Ceramics

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We described the anomalous temperature behavior of the giant dielectric response and losses using the core-shell model for ceramic grains and modified Maxwell-Wagner approach. We assume that core shells and grain boundaries, which contain high concentration of space charge carriers due to the presence of graphite inclusions in the inter-grain space, can effectively screen weakly conductive ferroelectric grain cores.

We considered several possible mechanisms, which can lead to the giant values of the relative dielectric permittivity accompanied by the very high values of dielectric losses in the strongly inhomogeneous ferroelectric-semiconducting ceramics.

The first mechanism is the effect of "geometric" capacitance, which could appear in the highly porous mixtures of the insulating and conducting inclusions. In this case the effective surface area of the capacitor could be much larger than the electrodes area, and the effective area could accumulate the space charge. Note that the geometric capacitance effect contribution could be verified by measuring the capacitance of the ceramic samples of different cutting angles, thickness, electrode area, frequency, and temperature.

The second mechanism is the Maxwell-Wagner effect [1], which could lead to the apparent enhancement of the dielectric response in the dielectric-semiconducting mixture in the presence of insulating polar grains, screening shells and conducive graphite inclusions. In principle all conductivity effects in the inhomogeneous media are strongly inter-wined and closely related with possible electric percolation effects. The possible roles and relative contributions of the different conductivity effects were considered with the help of the different theoretical models.

According to the effective media model proposed by Liu et al. [2], the one can consider two (or more) layers representing all grain cores, their screening shells and grain boundaries, graphite inclusions and inter-grain space in the Maxwell-Wagner approach. One of the "effective" layers corresponds to weakly-conductive grain cores, and the other corresponds to all stronger conductive regions (such as screening shells, grain boundaries and/or inter-grain space). The layers are characterized by the effective dielectric permittivity and conductivity for grain cores, grain boundaries and/or inter-grains. These effective parameters are temperature and/or frequency dependent.

The superparaelectric-like state with a giant dielectric response can appear in the paraelectric shells and inter-grain space due to the step-like thermal activation of localized polarons in the spatial regions, being in agreement with experimentally observed frequency-dependent transition of the electro-transport mechanism [3]. Obtained results can be the key for the description of complex electrophysical properties inherent to the strongly inhomogeneous media with electrically coupled insulating ferroelectric nanoregions and semiconducting superparaelectric-like regions.

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[1] K.W. Wagner, Arch Elektrotech 2, 371 (1914); https://doi.org/10.1007/BF01657322

[2] L. Liu, S. Ren, J. Liu, F. Han, J. Zhang, B. Peng, D. Wang, A. A. Bokov, and Z.-G. Ye, Phys. Rev. B 99, 094110 (2019), https://doi.org/10.1103/PhysRevB.99.094110

[3]. O. S. Pylypchuk, S.E. Ivanchenko, M.Y. Yelisieiev, A. S. Nikolenko, V.I. Styopkin, B. Pokhylko, V. Kushnir, D.O. Stetsenko, O. Bereznykov, O.V. Leschenko, E.A. Eliseev, V.N. Poroshin, N.V. Morozovsky, V.V. Vainberg, and A.N. Morozovska. https://doi.org/10.48550/arXiv.2407.01108 (http://arxiv.org/abs/2407.01108)

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