Study of the correlation between microstructure-physical properties- application in materials for microelectronics

HABILITATION THESIS

Dr. Lavinia-Petronela Curecheriu

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Summary

The present habilitation thesis includes some of the most important scientific results published by the author since obtaining the doctor in science title. The common ground that defines these results is the study of correlation between microstructural features and physical properties, mainly focused on high field properties, of multifunctional materials for their proposal in applications for microelectronics. While the main part of this work is constructed around high field properties of oxide materials (single phase and composites), there is also a section devoted to translating knowledge from high field properties of oxide materials to polymer based composites and also a chapter where the functional properties of materials with core-shell structure are describing.

The thesis is divided in three sections, from which the first one is presenting, in three chapters, scientific results of the author.

After an introduction that outlines some of the main concepts used in the text, the first chapter consists of contributions to understanding the correlation between microstructure and nonlinear properties of polar dielectric (single phase and composites). After a short overview of the general requirements for tunable materials we present how these requirements can be satisfied by different types of polar dielectrics. If in case of single phase materials an essential role is playing by composition, in composite materials the geometry and phase interconnectivity are more important. As single phase materials we investigated $BaTiO_3$ solid solutions (with homo and heterovalent substitution) and some single phase multiferroics. For the study of composite materials with nonlinear properties we proposed the concept of *local field engineering*, in which macroscopic permittivity and tunability can be controlled *via* microstructural features through local field inhomogeneity. The method was exemplified in two cases: nanostructurate ceramics and porous ceramics.

In the second chapter we used the same approach of controlling the functional properties by microstructure features, this time in composite materials with core-shell structure. This method has the advantage of producing 0-3 composites even for high filler content and a large contact surface between the constituent phases. Thus, the reaction at interfaces can be controlled by synthesis parameters (temperature, time, pressure, sintering procedure) and consequently the functional properties. In the present work we used this method for magnetoelectric composites, in which new magnetic properties were induced by the formation of new magnetic phases and for the dielectric-dielectric composites (dielectric-ferroelectric and

antiferroelectric-ferroelectric), where dielectric permittivity and nonlinearity are controlled by formation of secondary phases.

The last chapter is dedicated to the study of polymer-based materials with applications in flexible electronics. In the last years, a special attention was dedicated to development of low-cost materials and environmentally friendly for use them in flexible electronics devices. On this topic, we investigated polymers obtained using plasma at atmospheric pressure in order to use as biosensors and polymer-based composites. These composites were formed from chitosan as polymeric matrix and gold nanoparticles and $BaTiO_3$ particles as filler. As it was shown in first chapter, these inclusions determined a strong local field inhomogeneity and consequently an increase of permittivity and tunability. The dielectric and nonlinear properties were investigated in detail and the experimental data was in good agreement with that predicted by theoretical calculations.

The second section discusses contributions related to the teaching activity and research with emphasis on the potential contribution to the development of some new classes of materials with applications in microelectronics. The author is also responsible for disciplines related to Physics of nanocomposite materials for the students in the last year of faculty. Then, the author is involved as supervisor of bachelor's thesis and as member of PhD thesis guiding committees, where she is using her ability to manage interdisciplinary research relating Physics, Chemistry and Materials Science. The last part of habilitation thesis presents some perspectives regarding the research activities of the author. New research directions are identified, in the frame of current achievements in the fields of materials with applications in microelectronics.

The last section includes the references cited throughout this work.