Publishable executive summary

We summarise in the following the main project issues updated to the third and last year. The NUOTO goal has been to demonstrate *multifunctional properties of new dielectric ceramics*, mainly the calcium copper titanate, $CaCu_3Ti_4O_{12}$ (CCTO), develop the related *thin films* technology and propose electronic devices for novel industrial applications. The project mainly considers the giant dielectric properties, particularly crucial in high density capacitors and focuses on capacitors for Rf and hybrid circuits applications and integrated antenna used in wireless electronics. Also during the third year o*ther properties than permittivity have been investigated* (multifunctional) particularly considering magnetic, relaxor ferroelectric and optical.

The *knowledge based* activity, previously indicated in the yearly reports and promised in the DoW, has been afforded also in the third year producing a further extraordinary improvement on the basic knowledge both in single crystal, ceramics and thin films. Theoretical efforts involve ab initio calculations of the pure material, the doped material, and the role of defects and impurities in the structures. Diagram phases have been obtained by calculations, too and compared with experimental data. Doped CCTO has been sintered and characterized. CCTO sintered in powder bulk polycrystals and single crystal, demonstrated to possess an impressive dielectric constant (k), values up to 10^6 were measured within this project at 1 MHz and at room temperature also in thin films. This property has been demonstrated to be an extrinsic property. It was exhaustively described by the IBLC model (ceramics) and by the SBLC model (thin films).

About the *development of process fabrication modules for deposition of thin films* quite significant improvements has been achieved. Thin film deposition obtained by physical methods like laser ablation and sputtering demonstrated the possibility to obtain extrinsic properties for dielectric behaviour with a permittivity up to 10^4 at 1 MHz and up to 600 at 1GHz on several electrodes of industrial interest.

Deposition processes for CCTO by metal organic chemical vapour deposition (MOCVD) have been improved, too. The new equipment that has been developed (by ABCD) within the project for laser assisted Chemical Beam Epitaxy (CBE) has proved the possibility of combinatorial deposition, while the processing window for CCTO deposition has been demonstrated very narrow showing the limits of the methods for complex oxide deposition.

The developed methods to characterise the materials permittivity properties at nanoscale have been extensively used to characterise the single crystal, the ceramics and the deposited thin films within the project. In all cases significant results have been carried out allowing to achieve a nanoscale comprehension of the involved phenomena.

Capacitors were fabricated considering films deposited by the different methods at different partner sites and of different material quality. Specific metal electrodes have been developed and tested. Further electrodes with improved temperature stability have been demonstrated to improve the temperature range of the deposition process. Etching and processing of deposited CCTO thin films have been engineered. A final fabrication process for CCTO capacitors compatible with Si industrial technology has been demonstrated.

Te project coordinated by the Institute for Microelectronics and Microsystems (IMM) of the Italian National Council for Research (CNR) involves as partners the Centre for Electronic Correlations and Magnetism (ECM) of the University of Augsburg, Germany, the Laboratoire d'électrodynamique des Matériaux Avancés (LEMA) of the CNRS at the University of Tours, France, the Department of Engineering Materials - Ceramics and Composites Laboratory of the University of Sheffield, Great Britain, the Unità di Ricerca di Catania of the Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali at the University of

Catania, Italy, the Swiss Federal Institute of Technology, Switzerland and industries such as ABCD technology and ST Microelectronics.
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