Scientific report

Project name: *ADVANCED RESEARCH ON NBT-BT FERROELECTRIC THIN FILM SYNTHESIS USING RADIOFREQUENCY ASSISTED PULSED LASER DEPOSITION*

Stage name: Stage I/2009 (intermediate) having two objectives:

1) Adaptation of the experimental setup for RF-PLD and PLD in order to obtain NBT-BT thin films.
2) Preliminary investigations on the obtaining of NBT-BT thin films with low doping (x=0.06) using PLD.

During this stage the main goal was especially linked to the target and support preparation necessary for the experiments in the upcoming stages, adaptation of the PLD and RF-PLD deposition systems in order to obtain (1- x)$Na_{0.5}Bi_{0.5}TiO_3$-x $BaTiO_3$ (known as NBT-BT) thin films and/or heterostructures, as well as preliminary deposition experiments of NBT-BT thin films. Moreover, various actions have been undertaken to update the knowledge and know-how presented in the latest scientific literature regarding the properties of NBT-BT thin films and NBT-BT based test devices obtained by pulsed laser deposition, as well as the realization of the project's web page.

Objective 1. **Adaptation of the experimental setup fot RF-PLD and PLD in order to obtain NBT-BT thin films.**

- *Activity 1.1: Preparation of targets used for PLD experiments.*

From a structural point of view, the NBT-BT targets produced by sinterization in collaboration with the Institute for Acoustics "O. M. Corbino" Rome, Italy, were analyzed by means of X-ray diffraction to check weather parasite pyrochlore phases are present. The recordings for the X-ray diffraction analysis were obtained using a PANalytical X'Pert MRD diffractometer using a Bragg-Brentano geometry. The XRD characterization of the targets revealed that the targets are well reactioned.

- *Activity 1.2: Selection and preparation of holders for NBT-BT deposition*

The choice of supports (or substrates) used in the deposition of thin films is very important, especially due to differences at the level of crystalline lattices (mismatch) between the material to be deposited and the substrate. In the case of NBT-BT, the most adequate support is Pt/Si, not because of the mismatch between the crystalline lattices,

but because of the fact that it is relatively cheap and it is one of the most utilized in dielectric characterizations at low frequency. In order to be able to eliminate the measurement errors that appear in the electrical characterization of a thin layer, errors that are usually large, an alternative support to Pt/Si was chosen, namely 1at% niobium doped strontium titanate: Nb:STO (or STON) in the form of a monocrystal, support which has an *n*-type conductivity with a high carrier concentration.

- *Activity 1.3: Preparation of the laser ablation installation; realization of the experimental setup, verification of the system's continuity, supply of necessary prime materials.*

The ablation system is made out of a Nd-YAG (CONTINUUM, SURELITE II-10) and an excimer COMPexPro 205(ArF) pulsed laser working at 193 nm, as well as a vacuum system. The ablation system was tested in order to establish the experimental conditions necessary for the achievement of low initial pressures, below the value of 10^{-6} mbar, as well as regarding the stability of the laser parameters (energy/pulse) and of the deposition geometry.

- *Activity 1.4: Logistics: acquisition of necessary materials.*

The necessary materials for the obtaining of NBT-BT thin films were acquired, namely MgO and STON supports, dedicated especially for the characterization of NBT-BT thin layers from a structural, morphological and electrical point of view.

Objective 2. **Preliminary investigations on the obtaining of NBT-BT thin films with low doping (x=0.06) using PLD.**

- *Activity 2.1: Establishing the experimental parameters; checking of the temporal stability of the experimental parameters, setting the experimental parameters.*

The vacuum system (reaction chamber plus pumping system) was tested and improved by changing the deposition geometry and by replacing various worn-out components (Viton seals), and the working parameters of the Nd-YAG laser, such as energy density per pulse and temporal energy stability were checked for the 4th harmonic (266 nm).

- *Activity 2.2: Realization of 0,94 NBT-0,06BT thin films on Si(100) and MgO(002) supports.*

During this activity the first NBT-BT thin film depositions were made by pulsed laser deposition (PLD), using the NBT-BT target with a 0.06 at% $BaTiO_3$ doping. Several sets of experiments were made using the 3rd (355 nm) and 4th (266 nm) harmonics of the Nd-YAG laser. Two types of substrates were used Si(100) and MgO(100) in order to be able to perform a structural, as well as a morphological characterization of the obtained NBT-BT thin films.

- *Activity 2.3: Realization of 0,94 NBT-0,06BT thin films on Pt/Ti/Si metallic support and Nb:SrTiO3.*

This activity was dedicated to the obtaining of NBT-BT(0.06) thin films on metallic support to able to perform an electric characterization of the obtained structures. Morphological investigations were conducted with the aid of an atomic force microscope. Moreover, plane capacitor types of structures were realized by the deposition of gold metal electrodes (by thermal evaporation) on the surface of NBT-BT/PtSi and NBT-BT/STON films in order to conduct electrical measurements.

In conclusion, the results presented in this report prove that the objectives of the first stage of the project were achieved. Moreover, activities pertaining to the final stage of 2009 are being undertaken, respectively:

- morphological and structural characterization of the obtained thin films by X-ray diffraction and scanning electron microscopy.
- dielectric and ferroelectric characterization of the obtained thin films.