Université catholique de Louvain UCL SECTEUR DES SCIENCES ET TECHNOLOGIES

INSTITUTE OF CONDENSED MATTER AND NANOSCIENCES

Invitation à la soutenance publique de thèse

Pour l'obtention du grade de Docteur en Sciences de l'ingénieur et technologie

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Master in Condensed Matter Physics

New Routes to Design Vertically Aligned Multiferroic Nanocomposites

Multiferroics have attracted great attention due to a possible magnetoelectric (ME) coupling linking ferroelectric polarization and magnetization, which allows to control the spontaneous polarization and magnetization by an applied magnetic field (direct ME effect) and electric field (converse ME effect), respectively, resulting in potential technology application in multiple-state logic device, random access memory, spintronics, sensors, and microwave devices.

We are exploring artificially designed multiferroic nanocomposites consisting of two phases, ferroelectric [PbZr0.52Ti0.48O3 (PZT), Ba0.7Sr0.3TiO3 (BSTO), BaTiO3 (BTO)] and ferrimagnetic $CoFe2O_4$ (CFO) oxides, where magnetoelectric effect can be observed at room temperature through interface and strain interaction. Although large magnetoelectric coupling was reported in multiferroic multilayers (so called 2-2 connectivity system), the key limitation in epitaxial multilayers is a substrate imposed clamping effect limiting the film's strain. Designing innovative architectures is a challenge in the field of multiferroic nanocomposites. Our work is focused on vertically aligned multiferroic nanocomposites, so called (1-3) connectivity system, where ferrimagnetic CFO nanopillars and nanowires (1) are embedded into three-dimensional PZT, BTO and BSTO layers (3), which allows to increase interfacial surface area and reduce clamping effect.

New routes were considered to design three geometries of nanocomposites: i) vertically aligned CFO nanowires surrounded by PZT nanotubes embedded into alumina membranes; ii) vertically aligned CFO nanopillar arrays embedded into thin BTO, BSTO and PZT layers on Si substrates; iii) 3-D interconnected CFO nanowire networks embedded into thick PZT matrix. The three geometries were developed by combining sol-gel deposition, RF magnetron sputtering, thermal annealing, and pulsed electrodeposition into anodized alumina nanoporous structure or commercial alumina and track-etched polymer membranes. Specific attention was focused on interfaces through structural and microstructural characterizations of nanocomposites using XRD, HRSEM, TEM and EDX characterizations. The performances of the nanocomposites were evaluated both on macro- and micro-scale using an alternating gradient magnetometer, impedance analyser, piezoresponse force microscopy, and magnetoelectric susceptometer.

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