Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Vendredi 06 juillet 2018
14 h 00

Salle Visio. Du C2N site Orsay

Thi Ngoc NGUYEN

« Characterization and Modeling of Magnetoelectric Micro Sensors »

Composition du jury proposé

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Abstract

Magneto-electric (ME) sensors have been demonstrated as a promising alternative for the detection of weak magnetic signals with high sensitivity. To date, most applications focused on the use of bulk piezoelectric materials on which magnetostrictive thin films are deposited leading to millimeter-sized devices. The integration of such devices into micro-electro-mechanical systems (MEMS), bringing smaller size and lower power consumption, involves addressing several scientific issues ranging from the integration of active materials on silicon to the strong reduction in amplitude of generated signals related to the size reduction of the sensor.

In this context, the first goal of this thesis work was to integrate high crystalline quality piezoelectric thin films on silicon. Pb(ZrxTi1-x)O3 (PZT) with a morphotropic composition (x=0.52) having high electromechanical coupling factor was chosen. Silicon is a necessary template as it allows for the use of conventional clean room processes for the realization of the microsystem. The crystalline quality of the active films is directly linked to the buffer layers that promote the crystalline growth on silicon. For this purpose, Yttria-stabilized Zirconia (YSZ) was used in combination with CeO2 and SrTiO3 to allow further growth of epitaxial perovskites. The choice of the bottom electrode material (SrRuO3 or La0.66Sr0.33MnO3 in this work) further tunes the crystalline orientation of the PZT layer.

To probe the potential of such PZT thin films for ME devices, the first step was to characterize the electromechanical properties of this material in a free standing cantilever structure. Under an applied electric field, the measured displacement of the epitaxial PZT-based cantilevers is characterized by a coefficient d_31=-53pmV^(-1) , a reduced value with respect to the bulk material but that can be enhanced by further optimizing the film growth. The second step consists in ascertaining the ability of the cantilever to be used as resonator. For that purpose, first characterizations of oscillators have been performed to extract the resonant frequencies and the associated quality factors. Then, the resonant frequency shift with DC bias-induced stress was measured. Finally, a magnetostrictive layer of TbFeCo was added on the PZT cantilevers to sense magnetic field based on the ME effect. The resulting resonant frequency shift with external applied magnetic field was characterized with a typical sensitivity of 10’s of µT.

Keywords: Magneto-electric effect, piezoelectric, magnetostrictive materials, magnetic sensors, ME sensors.

Mots clés en anglais : Magnetic,Sensors,Piezoelectric,magnetostriction