

Master thesis proposal

Title: Piezoelectricity in epitaxial oxide thin films and devices

Keywords: Functional oxides, ferroelectrics, thin films, devices

Scientific description: **Ferroelectrics** (FE) are fascinating multifunctional materials with a spontaneous electric polarization P which can be controlled by applied electric field (Fig. 1(a)). In addition, the coupling of electric polarization to strain make FEs good piezoelectrics for the development of microelectromechanical systems (MEMS), such as actuators and sensors. For devices applications, **thin films** are preferred because they can show improved performance when they are epitaxially grown. However, most of the piezoelectric thin films integrated in MEMS are based on Pb, which is toxic. The search for alternative lead-free FE is thus crucial, and, among them, BiFeO_3 appears as a very promising candidate thanks to its lead-free composition, very large remanent polarization, and low dielectric constant.

Recently, we have reported the first investigation of the piezoelectric response in epitaxial BiFeO_3 microcantilevers (Fig.1(b)), demonstrating larger **electromechanical performance** than that of Pb-based state-of-the-art piezoelectric MEMS. A strong asymmetry in the properties was observed with the voltage polarity (Fig.1(c)), which points towards a significant contribution from the flexoelectric effect (electrical polarization induced by strain gradient).

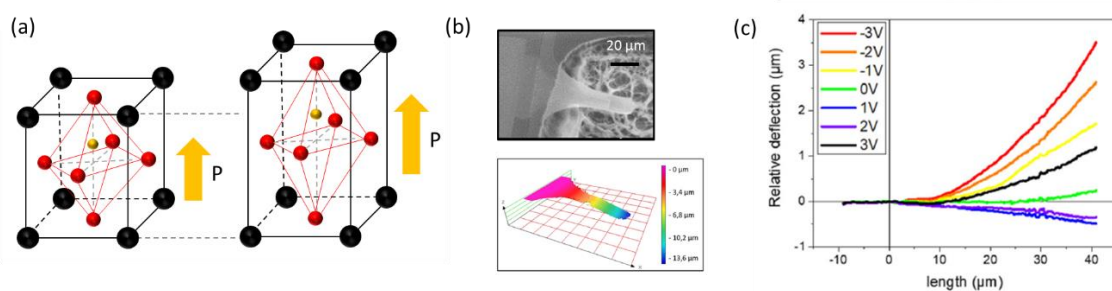


Fig: (a) sketch of the crystalline unit cell in a ferroelectric with piezoelectric effect. (b) Images of a microcantilever based on BiFeO_3 epitaxial thin films (SEM and optical profilometry pictures). (c) Electromechanical response (deflection under applied voltage).

The objective of this M2 internship is to investigate more deeply the piezoelectricity in BiFeO_3 microdevices by developing **materials engineering strategies** to further enhance the electromechanical response of the devices. The effect of materials stacks and geometrical parameters will be studied. The student will participate to the epitaxial growth of oxide thin films by pulsed laser deposition, their structuring in microdevices by clean room processes and their electro-mechanical characterizations thanks to several experimental techniques (at C2N and through collaborations).

Techniques/methods in use: epitaxial growth by pulsed laser deposition, X-ray diffraction, clean room processes (lithography, deposition, etching), electrical measurements (dielectric, ferroelectric) and deformation measurements (optical interferometry).

Applicant skills: Gifted and willing for experimental physics, with a background in materials science and/or solid state physics.

Internship supervisor(s): Sylvia Matzen (sylvia.matzen@universite-paris-saclay.fr)

Internship location: Centre for Nanoscience and Nanotechnology (C2N), Univ. Paris-Saclay, Palaiseau.

<https://www.c2n.universite-paris-saclay.fr/fr/>

Possibility for a Doctoral thesis: Y

