Quasi-2D freestanding oxide membranes

Master internship

Context:

The shift from bulk ceramics and single crystals to thin films has been a game changer for ferroelectrics, both for fundamental studies and for industrialization [1]. Recent studies on 2-dimensional (2D) materials and free-standing ferroelectric membranes hold similar promises. By controlling the stacking angle between the 2D material layers in heterostructures, the appearance of new correlated phenomena such as superconductivity, ferroelectricity and magnetism have been demonstrated in graphene, hexagonal boron nitride and transition metal dichalcogenides [2]. Inspired by these works on 2D materials, twisted ferroelectric freestanding layers have already revealed moiré features and ferroelectric vortex patterns [3].

Project description:

The objective of this internship is the characterisation of thin perovskite oxides, such as $PbZrO_3$ and $BaTiO_3$ (BTO) either as an individual freestanding layer or two layers twisted with respect to each other. In freestanding membranes there are no constrictions from the growth substrate, and thus we expect a change in their properties. We expect that reducing the oxides' thickness and modifying mechanical and electrical boundary conditions and thus potential interfacial phenomena, will have a marked effect on the ferroelectric domain structure, the symmetry of the material, and lead to new properties.

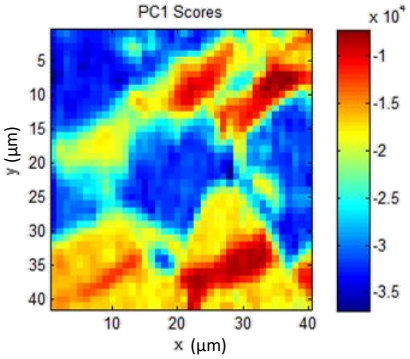

Figure 1: Raman map on BTO layers obtained from principal component analysis.

In this project the student will learn how to characterise perovskite oxide membranes using Raman spectroscopy (fig.1), scattering scanning near field optical microscopy and piezoresponse force microscopy to characterise the membranes' ferroelectric properties. The student will acquire knowledge of optical as well as surface probe characterisation techniques, and statistical data analysis.

Location, salary, dates

The proposed internship will take place at two sites of the GREMAN laboratory: Faculty of Science and Technology of the University (Parc Grandmont, 37200 Tours) and at the IUT (rue de la Chocolaterie 41029 Blois). It can start in February-March 2025, for a period up to 6 months. The salary will be a "gratification" of 4.35€/hour (around 600€ per month).

Candidate profile:

- currently in a Master 2 (or equivalent)
- preferably background in physics, materials science, engineering
- ability to work in a group, curiosity and motivation to learn
- willingness to work in interdisciplinary and international teams
- knowledge of written and spoken English

How to apply:

Prospective candidates should send their CV and a cover letter by email **before 1st of December** to:

Anna Ott: anna.ott@univ-tours.fr
Guillaume Nataf: guillaume.nataf@univ-tours.fr
Vinh Ta-Phuoc: vinh.ta-phuoc@univ-tours.fr

References:

[1] M. Dawber, et al. Physics of Thin-Film Ferroelectric Oxides, Rev. Mod. Phys. 77, 1083 (2005).
[2] D. Pesquera, A. Fernández, E. Khestanova and L. W. Martin. Freestanding complex-oxides membranes. J. Phys.: Condens. Matter 34, 383001 (2022).
[3] G. Sánchez-Santolino et al. A 2D Ferroelectric Vortex Pattern in Twisted $BaTiO_3$ Freestanding Layers, Nature 626, 529 (2024).