Ferroelectric–metallic $BaTiO_3$ thin films grown by hybrid MBE for non-volatile field-effect devices

laboratoire Albert Fert

Centre de Nanosciences et de Nanotechnologies C2N

Scientific Context

Ferroelectrics are polar materials whose switchable polarization can be used to store non-volatile information. Among them, **$BaTiO_3$ (BTO)** stands out for its **low-voltage switching** and **high endurance** in thin-film form. Remarkably, BTO can also become **conducting when doped with electrons**, leading to a rare coexistence of ferroelectricity and metallicity. This unconventional combination raises key questions: how do structural distortions, carrier density, and electrostatic screening interact at the nanoscale? How does this balance evolve with film thickness, doping level, or epitaxial strain? Beyond fundamental interest, creating a 2D conducting channel – either a two-dimensional electron gas (**2DEG**) or a **lightly doped polar metal** – within the same ferroelectric matrix offers a new route to mitigate interface defects that limit the performance of **ferroelectric field-effect transistors (FeFETs)**.

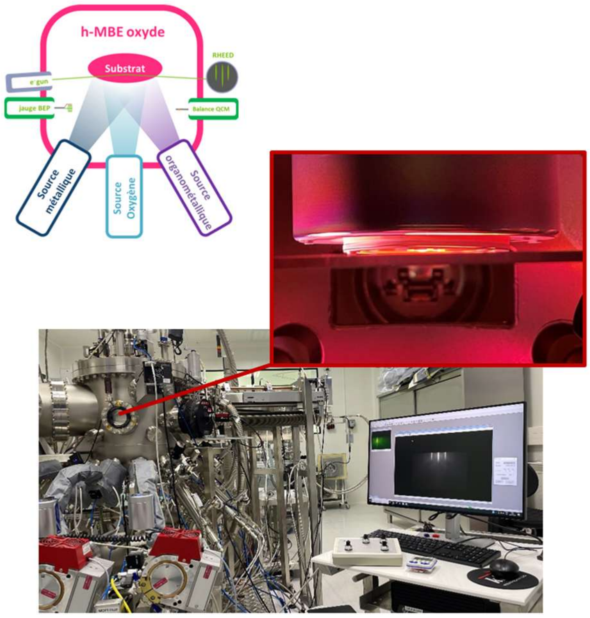

Fig.1. Hybrid MBE setup at C2N.

Work program & skills acquired during internship

The goal of the internship is to **grow epitaxial $BaTiO_3$ films by hybrid molecular beam epitaxy (MBE)**, a technique enabling atomic-scale control and the highest material quality. The intern will:

- Learn and assist in the operation of the hybrid-MBE system to deposit BTO and $SrRuO_3$ bottom electrodes;
- Characterize films using X-ray diffraction, atomic-force microscopy, pizeoresponse-force microscopy and electrical measurements;
- Generate and study ultrathin conducting layers in BTO, either by controlled La doping or by inducing a 2DEG at the surface;
- Fabricate SRO/BTO/SRO capacitors and measure ferroelectric properties (switching voltage, endurance, retention);
- Use conducting BTO layers as channels for FeFETs, and analyze their transport characteristics.

This internship will provide strong hands-on experience in thin-film growth, advanced characterization, and device physics. Depending on progress, it can be extended into a PhD thesis focusing on the physics and applications of ferroelectric-metallic oxides.

Work environment

You will work at **C2N** with **Thomas Maroutian** for film growth, and at the **Laboratoire Albert Fert** with **Manuel Bibes** for ferroelectric characterization and device studies.

https://laboratoire-albert-fert.cnrs-thales.fr/
Laboratoire Albert Fert
Located in: Thales Research and Technology
1 avenue Augustin-Fresnel
91767 Palaiseau, France

Requested background : **Master 2**
Duration : **4-6 months**
Start period : **Feb 2025**
Possibility of the PhD thesis: **YES**
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