Structure–property relations for manganite memristive devices

Doctoral school / Starting date

IMEP2 / Starting date: 01/09/2018 or 01/10/2018

Subject

CONTEXT

Among the various emerging devices expected to replace conventional Flash memories, **Resistive Random Access Memories (ReRAM)** are currently attracting a strong scientific and industrial interest. Their operations are based on the switching between a low resistive and a high resistive state, which represents the two binary states. ReRAM devices have already demonstrated significant advantages over other technological options, such as high scalability, fast switching speed combined with low switching energy, low power consumption, strong endurance and data retention larger than ten years. Different types of ReRAM have been demonstrated so far: some of them exploit the breakdown properties of metal-oxides, while others use the formation of a conductive bridge (CBRAM). In the case of **valence change memories (VCM)** it is believed that the change in resistance is induced by the application of a voltage (or current), which results in a local valence change in the oxide material. This valence change is presently thought to be controlled by the migration of oxygen vacancies either in the form of filaments or on the contrary, homogeneously distributed near the entire electrode area (homogeneous interface-type switching).

Manganite heterostructures show very promising resistive switching characteristics and multilevel resistance states. This makes them ideal candidates for alternative non-volatile memories, but also as building blocks for neuromorphic computation. In contrast to the more common filamentary switching, manganite devices have been shown to switch homogeneously over the whole device area and might therefore be superior with respect to their cell-to-cell and cycle-to-cycle variation. Moreover, electronic and ionic transport in these materials can be tuned by varying the composition and microstructure, which could directly affect the switching performance. Although it is clear that ion transport plays a key role in the switching mechanism, many open questions are still to be understood. In particular, grain boundaries (GBs), present in CMOS-compatible polycrystalline manganite devices, significantly influence ionic transport in these materials, but their impact on resistive switching has not been directly studied yet.

THESIS PROJECT

This PhD research project will be devoted to the study of **resistive switching (RS) in Sr-doped lanthanum manganites** with the aim of presenting a comprehensive and consistent picture of the transport properties of dislocations (GBs) in manganites. This will be carried out by combining various experimental techniques to probe the oxygen and charge transport along and across the dislocations.

Epitaxial thin film model systems with different chemical compositions and well-defined grain boundaries will be fabricated by Metal Organic Chemical Vapour Deposition (MOCVD) through the use of bicrystal substrates. The impact of the grain boundaries on the ion transport and the switching properties of the films will be comprehensively studied. The chemical composition and the structure of films and devices will be investigated by the large variety of techniques surface analysis and bulk sensitive techniques available in the LMGP laboratory or at different European synchrotron facilities (e.g. SOLEIL and BESSY). Performing *operando* spectroscopy of switching devices will enable us to gain insights into the chemical and structural changes taking place during device operation. Oxygen diffusion and surface exchange in different thin-film configurations will be investigated by ^{18}O tracer diffusion experiments in combination with Raman spectroscopy. This will enable us to uncover the complex interplay between microstructure, chemical composition, ionic and electronic transport and the switching performance of manganite memristive devices. Based on this, we will develop new routes for the fabrication of CMOS-compatible manganite micro-devices with high reliability and improved switching kinetics.

Scientific Environment

The candidate will work within the **LMGP, Materials and Physical Engineering Laboratory**, in the NanoMat team. Located in the heart of an exceptional scientific environment, the LMGP offers the applicant a rewarding place to work.

LMGP Web Site: http://www.lmgp.grenoble-inp.fr/

The PhD thesis work will be carried out in the framework of on the "*Mangaswitch*" ANR research project, and will involve collaboration and interaction with 2 partners in Germany: Prof. Dr. Roger A. De Souza's group at **RWTH Aachen** and Prof. Regina Dittmann's group at **FZ-Jülich**. During the PhD the student will spend 3 months at the German collaborators' laboratories.

Profile & requested skills

The candidate must be graduated from an engineering school and/or with a Master 2R degree whose training focuses primarily on materials science, physics, chemistry or related field.

We are looking for a highly-motivated student with a strong interest in experimental physics and materials science. Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates should be fluent in English and/or in French. In addition, well-written English will be highly appreciated.

Salary

According to French regulations for a PhD

Supervisors

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Application

Please send by email **by the 23rd May 2018** your:

- Detailed Curriculum Vitae
- Cover letter explaining the motivation for the PhD work
- Transcript of marks obtained in Masters