Techniques of
Informatics and
Microelectronics for Integrated Systems
Architecture

CNRS - Grenoble INP - UGA

LMGP

Laboratoire des
Matériaux et du
Génie
Physique

Study and development of La2NiO4 memristive devices for bio-inspired computing

Context of the PhD

The computing performance needed by emerging electronic applications (such as Internet-of-Things) is posing a serious challenge to current computer architectures and technologies, required to provide increasing computing power while withstanding severe constraints on size, energy consumption and reliability. Conventional Von-Neumann architectures and memories are not likely to fulfill all the needs of modern applications, due to inherent technological and conceptual limitations. Hence, in order to be at the forefront of the electronic industry in terms of design and manufacturing capabilities, it is essential to focus research and innovation efforts on the development of novel non-Von Neumann architectures enabled by emerging technology devices. In this context, the **neuromorphic computing paradigm** has a huge potential when it makes use of **emerging technologies such as memristors**.

The SynConnect project focuses on the use of La2NiO4 devices as artificial synapses for bio-inspired computing architectures, i.e., Spiking Neural Networks (SNNs) with a bio-inspired learning rule. The learning is applied on each synapse independently of the global state of the network; therefore, the synapse must be doted of computation capabilities. The goal of the project is to demonstrate, at small scale, the feasibility of a La2NiO4-based SNN and understand the main advantages and shortcomings (from technology and application) such that concomitant optimization of device and algorithm can be performed to guarantee the achievement of a truly efficient bio-inspired electronic system.

The SynConnect has three **main objectives**:

- To develop the microfabrication technology to build a synaptic array formed by 4x4 L2NO4 memristive devices,
- To test a small-scale spiking neural network with L2NO4 synaptic connection,
- To optimize the memristive device and the neural algorithm for high accuracy training.

Summary of the PhD thesis project

During the course of the PhD project, the PhD candidate will be strongly involved in the SynConnect project, working on all its aspects, from the microfabrication of the synaptic array, to its integration in a spiking neural network and the co-optimization device-algorithm for an efficient network model. This PhD project is puri-disciplinary, it brings together: microtechnology, microelectronics and neuromorphic engineering. The **main actions** of this thesis are:

- Neuromorphic Engineering
  - to develop and evaluate a Spiking Neural Network (SNN) with bio-plausible learning algorithm;
  - to identify the critical parameters affecting the learning efficiency and their interconnections. The PhD candidate will study, for instance, the learning rate, neuron functionality, synaptic plasticity;
- Microtechnology
  - to contribute to the development of the microfabrication technology to build L2NO4 memristive devices suitable for neuromorphic applications and the development of a small-scale synaptic array;
  - to perform electrical characterization of the memristive devices and extract relevant data for memristor control optimization on the one hand, and memristor compact modelling improvement on the other hand;

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- Microelectronics
  - to design a small scale hardware-based SNN (using the memrsitor models) and simulate it at Spice level to extract the activity of a spiking neuron.

This research plan will enable the PhD candidate to become a well-trained, versatile and mature scientist with the capability of solving scientific problems with an original perspective, thanks to the large degree of interdisciplinarity acquired in this project combining the materials science, microtechnology, microelectronics and neuromorphic engineering.

Work environment

This PhD is funded by the CNRS via the SynConnect project (80Prime MITI), a pluri-disciplinary project and it will be hosted by 2 laboratories: **TIMA & LMGP**, **Grenoble, FR.**

The candidate will have access to all the facilities present in the LMGP, the TIMA lab, the university and all the necessary platforms and resources, including with direct access to the Consortium des Moyens Technologiques Communs (CMTC), the Upstream Technology Platform (PTA) - MINATEC and the Centre Interuniversitaire de MicroElectronique et Nanotechnologies (CIME) technological platforms.

Salary: 2 135,00 € monthly income (before tax)

Profile of the PhD Candidate:

We are looking for a highly-motivated candidate with a master degree or equivalent in a related field of microelectronics technologies, semiconductor physics and modelling and/or new advances in Artificial Intelligence. Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates should be fluent in English and have good English writing skills.

Application instructions:

If you are interested in the topic, please use the following link to apply:
https://emploi.cnrs.fr/Offres/Doctorant/UMR5159-ANNFOU-006/Default.aspx
A complete application consists of:

- **Cover page:** short motivation of the applicant and connection with the position, including how this position serves future career goals. Include name and contact information of applicant (1 page max)
- **CV:** Academic and professional background, detailing relevant experience, particularly research.
- **Relevance for Application:** The applicant should include a clear description of how his or her scholarly background and expertise is applicable, and might add value, to the project set out above.

Our team welcomes applicants with diverse backgrounds and experiences. We regard gender equality and diversity as strength and an asset.

Advisors:

Elena Ioana Vatajelu, CNRS Researcher – TIMA Laboratory
Monica Burriel, CNRS Researcher – LMGP Laboratory
Celine Ternon, MCF INPG – LMGP Laboratory

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