Institute of Microelectronics of Barcelona IMB-CNM CSIC

The **IMB-CNM** is the largest institute in Spain dedicated to the research and development of Micro and Nano Technologies and Microsystems and with unique capabilities in silicon technology. It belongs to CSIC since its foundation in 1985 and is distinguished as a María de Maeztu Unit of Excellence.

IMB-CNM aims to contribute to the advancement of knowledge and to the economic and social development of society, as well as to the training of researchers and engineers and to the advice to public and private entities.

The research activities of IMB-CNM are dedicated to Micro/Nano Integrated Systems: miniaturized electronic systems which include sensing and/or actuating capabilities in addition to electronic information processing, power management and external interfaces.

The IMB-CNM is located on the Autonomous University of Barcelona (UAB) Campus and contains the largest clean room facilities in Spain with full capability to process its own CMOS technologies and laboratories.

Project Type: TFG/TFM

Project Title: Design, Simulation and Performance Benchmarking of Novel Neuro-Synaptic CMOS Cells for Extreme-Edge AI

Research Group: Integrated Circuits and Systems (ICAS)

Project Description:

❖ This project explores the circuit-level potential of neuro-synaptic (NS) behaviours in standard CMOS transistors.
❖ The goal is to design, simulate and benchmark 2/3T NS cells in TSMC 65nm technology.
❖ The focus is on creating a robust behavioural model that captures hysteretic neuron and synaptic plasticity behaviours to deliver efficient extreme-edge AI capabilities in advanced in-house electrooptical/chemical/mechanical sensory microchips. The deliverables include a fully characterized and benchmarked cell design, with analysis of energy efficiency, speed, and variability compared to existing implementations of neuromorphic CMOS neurons.

Work Plan:

Methodology:

1. Literature Review & Theory:
   • Study physics of punch-through and impact ionization in MOSFETs.
   • Understand operation of few-transistor NS cells (neuron and synapse modes).
2. Electrical Model Development:
   • Develop a compact functional and electrical model for a chosen NS cell.
   • Calibrate the model using characteristic I-V and transient responses.
3. Circuit Design & Simulation:
   • Design the NS cell in a commercial IC design suite (Cadence Virtuoso).
   • Simulate neuron and synapse modes:
     – Hysteretic I-V curves (neuron operation)
     – Synaptic weight updates via pulsed operation (LTP/LTD)

  - Short-term plasticity dynamics (facilitation, depression)
4. Performance Benchmarking:
   - Define metrics: energy per spike, area, switching speed, dynamic range.
   - Compare the NS cell against other neuromorphic implementations.
5. Analysis and Reporting:
   - Document methodology, simulations, and results, highlighting performance and limitations.

Work Plan:

Month 1 - Literature review, study NS concepts, set up simulation environment

Month 2 - Develop and calibrate models for sa few-transistor NS-RAM cell

Month 3 - Simulate NS cell in neuron and synapse modes, preliminary data analysis

Month 4 - Perform performance benchmarking (energy, speed, area, dynamic range)

Month 5 - Refine simulations, collect final data, and start thesis writing

Month 6 - Complete analysis, finalize thesis, and submission

Candidate desired studies:

- ✓ MSc in Semiconductor Engineering and Microelectronic Design
- ✓ MSc in Nanoscience and Nanotechnology
- ✓ MSc in Physics of Complex Systems and Biophysics
- ✓ Double Bachelor's Degree in Physics and Chemistry
- ✓ BSc in Nanoscience and Nanotechnology
- ✓ BSc in Telecommunications Electronic Engineering
- ✓ BSc in Industrial Electronics and Automation Engineering
- ✓ MSc in Modelling for Science and Engineering

Application Process:

Before applying, please **check with your TFG/TFM program supervisor,** as he/she may already be coordinating with us to assign the project.

If there is no such coordination**, complete this [form](#) and send your CV and a motivation letter** to **Talent@imb-cnm.csic.es**, with the **subject: "TFG/TFM at IMB-CNM"**

Your CV will be forwarded to the Researcher leading the project who will contact you directly if interested.

Check our website for more information about the IMB-CNM and our research activities

https://www.imb-cnm.csic.es/en

Take the next step in your research career with us!

*By applying, you accept our [data protection policy.](#)

**IMB-CNM (CSIC) adheres to the [European Charter and Code of Conduct for Researchers](#), ensuring full alignment with their principles and requirements, including equal opportunity, transparency, merit and ability, caring for an open, fair, and excellence-based hiring processes.

IMB-CNM holds the [HR Excellence in Research award](#), which acknowledges CSIC's commitment to continuous improvement in HR strategies for researchers.