MARIE SKŁODOWSKA-CURIE POSTDOCTORAL FELLOWSHIPS 2021

EXPRESSION OF INTEREST FOR HOSTING MARIE CURIE FELLOWS

HOST INSTITUTION

NOVA University Lisbon | School of Science and Technology

RESEARCH GROUP AND URL

CENIMAT/I3N
www.cenimat.fct.unl.pt/

SUPERVISOR (NAME AND E-MAIL)

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SHORT CV OF THE SUPERVISOR

Asal received her PhD in Electronics and Optoelectronics at University of Algarve (2010-2013) in collaboration with Philips Research Laboratories in the Netherlands, coordinated by Prof. Dago de Leeuw. Since 2014, she is a researcher in the field of memristors at CENIMAT/i3N at NOVA University Lisbon. She is principal investigator (PI) of the project NeurOxide, currently orienting a research team consisting of 4 PhD students (under her supervision) and two post-doctoral researchers.
She coordinates a shared PhD grant with Prof. Weidong Zhang, leader of the collaboration with the IMEC Memory Device Consortium, including Intel, Micron, Samsung, Hynix, Toshiba and SanDisk and Professor of Nanoelectronics in Liverpool John Moores University (LJMU). She also supervises Master students in collaboration with Prof. Andreas Klein from Technical University of Darmstadt in Germany.
In 2015, with collaboration of Prof. Joana Vaz Pinto, she introduced the lecture entitled Electronic Information Storage to Master students of Micro and Nanotechnology which she is lecturing since then. She is regularly presenting her research at international conferences and has published more than 30 peer-reviewed papers, of which 21 of them were published during the last 5 years. She is involved in the following scientific dissemination actions: She is a member in the organization team of the Advanced Doctoral Conference on Computing, Electrical and Industrial Systems (DoCEIS), since 2016 up to present. She is Guest Editor of Micromachines (IF: 2.53) for the Special Issue: Amorphous oxide semiconductor-based memristive devices and thin film transistors. She served as a jury member in the PhD defense of Dr. Carlos Rosario, whose work was under supervision of Prof. Rainer Waser, from RWTH Aachen, who is one of the leading scientist in oxide memristor technology world-wide.

5 SELECTED PUBLICATIONS

- Noble-Metal-Free Memristive Devices Based on IGZO for Neuromorphic Applications (Advanced Electronic Materials 6, 2000242 (2020), https://doi.org/10.1002/aelm.202000242).

- 2D Resistive Switching Based on Amorphous Zinc–Tin Oxide Schottky Diodes (Advanced Electronic Materials 6, 1900958 (2020), https://doi.org/10.1002/aelm.201900958).

- Flexible and transparent ReRAM devices for system on panel (SOP) application (Advances in Non-Volatile Memory and Storage Technology, 2nd Ed. (2019), https://doi.org/10.1016/B978-0-08-102584-0.00014-0).

- Recent Progress in Solution-Based Metal Oxide Resistive Switching Devices. (Advanced Materials 33, 2004328 (2020), https://doi.org/10.1002/adma.202004328).

- Improving positive and negative bias illumination stress stability in parylene passivated IGZO transistors (Applied Physics Letters 109, 051606 (2016), https://doi.org/10.1063/1.4960200).

PROJECT TITLE AND SHORT DESCRIPTION

Photo-induced memristive devices for neuromorphic computing

It is imperative to achieve a computing power consumption several orders of magnitude below the current von Neumann architecture. This is possible with chips consisting of components such as memristive devices. The latter are known as non-linear resistors with intrinsic characteristics similar to synapses in biology. This property makes the memristive devices perfectly suited for neuromorphic computing, where the computing architecture is based on principles inherent to the brain. Memristive architectures offer a simple cross-point structure of two electrodes on either side of a resistive switching (RS) medium whose resistance is changed upon the application of an electric field. The memristive behavior is not specific to a type of material configuration, being rather a general electrical behavior. This provides flexibility in the construction of the memristive devices. The right choice of electrodes and active material layers (junction properties) can provide an additional dimension of modulating the RS characteristics by incident light. This results in a photo-induced memristive device. Compared with purely electric field-controlled memristors, photo-induced memristive devices offer a non-electric programming method, which solves the problems of excessive Joule heating and sneak paths present in the high-density crossbar architecture. Beyond that, adding light as a third terminal facilitates parallel data transmission and processing, because the learning function and signal transmission cannot be performed simultaneously on these devices with electric field alone. Hence, the application of a memristive system can be extended to all mobile computing applications: wearables, health care, visual information processing, invisible touch screens, electronic eyes, etc..

This project work is divided into two main topics:

1) Design and fabrication of novel optoelectronic memristor devices based on amorphous oxide semiconductors (AOS) such as indium-gallium-zinc oxide (IGZO) and zinc-tin oxide (ZTO). IGZO is the gold standard for AOS transistor technology. ZTO is a promising sustainable alternative, free of critical raw materials. Strategies to be capable of performing the write and erase operations by only light (targeting broad range of wavelengths) or in combination with voltage for multi-level cell (MLC) programming will be explored. For an optoelectronic artificial synapse configuration, synaptic properties of cross points will be tested, such as potentiation, depression, short-term plasticity, long-term plasticity, spike-rate-dependent plasticity (SRD), spike-time-dependent plasticity (STDP) and learning will be tested.

2) Towards a complete neuromorphic system, spiking neural networks (SNNs) will be explored because they are more biologically plausible. Here, encoding information is via the device response to the timing and frequency of the spikes needs to be explored. At first the device and circuit will be evaluated in the simulation frameworks. It follows then the design of peripheral circuits, using the same technology as employed for memristor fabrication.

In conclusion, the outcome of this project will finally allow to design sustainable, power-efficient optical neuromorphic hardware for complex image recognition. Due to the compatibility of AOS technology with flexible substrates and the excellent uniformity on large areas, this project will open new field of applications for neuromorphic hardware systems, such as wearables or biomedical devices.

SCIENTIFIC AREA WHERE THE PROJECT FITS BEST*

Information Science and Engineering (ENG)