IMM Institute for Microelectronics and Microsystems
Consiglio Nazionale delle Ricerche

The Institute for Microelectronics and Microsystems of the National Research Council (CNR)

finances 3 scholarships for the 34th cycle (November 2018 - October 2021) of the

Phd Program in Materials Science and Nanotechnology

of the University of Milano-Bicocca

The 3 research projects are:

1) Advanced dielectric stacks for smart power devices: synthesis, characterization and modelling

2) Memristive devices for brain inspired computing

3) Synthesis and isolation of epitaxial Xenes based on group IV-VI elements

The call will open on May 8th 2018 and it will close on June 7th.

The call will be available at the websites

https://www.unimib.it/didattica/dottorato-ricerca/accedere-al-dottorato

https://www.unimib.it/unimib-international/phd/how-apply

A description of the three IMM-CNR Phd projects is reported in the following pages.

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Advanced dielectric stacks for smart power devices: synthesis, characterization and modelling

Supervisor: Dr. Sabina Spiga – CNR-IMM, Unit of Agrate Brianza (sabina.spiga@mdm.imm.cnr.it)

The PhD fellowship is focused on the development of advanced dielectric stacks, based on high-dielectric constant materials, for metal-insulator-metal capacitors suitable for the integration in smart power devices. The activity has a strong industrial interest and is developed in the framework of an EU project under the Horizon 2020 program.

The development of advanced materials, such as high-dielectric constant materials (h*igh-k*), has been one of the boosting factors driving the evolution of nanoelectronics in the last 2 decades. *High-k* dielectrics such as binary and ternary metal oxides (HfO_2, ZrO_2 and many others) has been used as gate insulator in transistors, as well as functional layers in non-volatile memories, and are today available in commercial products. The atomic layer deposition (ALD) of very thin, conformal and of controlled stoichiometric oxides has definitely been one of the key enablers for this revolution. Today ALD deposited metal oxides are of increasing interest for a variety of new applications, such as Smart Power ICs, MEMS sensors and actuators. This interest calls for further materials research and understanding of the properties of high-k dielectric materials.

The main goal of the PhD program is the development of binary or ternary oxide compounds deposited by ALD having ultra-low leakage current and dielectric constant values in the range 20-40. One of strategies to be explored is the doping of ZrO_2 and HfO_2 dielectric films to stabilize crystallographic phases exhibiting high-k values. Facilities for the growth of these materials as well as for the fabrication of devices are available in the clean room of the Unit of Agrate Brianza of CNR-IMM; the laboratory is also equipped with advanced characterization techniques for the analysis of the physical, chemical and electrical properties of materials and devices. Further, within the international partnership of the EU project, other materials such as perovskites may be available for extending the study to alternative routes.

The proposed approach include the synthesis of materials, device/material characterization (electrical and physical), as well as the modelling of charge transport properties and defect distribution within the oxides; a commercial specialized software will be made available for the latter purpose.

The student will join a team with an extensive experience in the field and highly committed to expanding knowledge in application-oriented material and device science; she/he will have the chance to develop broad skills ranging from material science to electrical testing and modelling, as well as to enhance her/his expertise in an international framework. Exchange visits with foreign partners will be organized; part of the activity will be carried out in strict collaboration with one of the leading semiconductor industries in Italy and worldwide, with a direct interaction of the student with the company R&D team.

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Memristive devices for brain inspired computing

Supervisor: Dr. Sabina Spiga – CNR-IMM, Unit of Agrate Brianza (sabina.spiga@mdm.imm.cnr.it)

The PhD fellowship is focused on the development of memristive devices as new building blocks for advanced brain inspired computing technologies. The activity has a strong interdisciplinary character at the cross-road between materials science, device technology, computer science and neuroscience, and will be carried out in the framework of European Projects and existing international collaborations.

Memristive systems represent a large class of emerging nanoscaled devices that exploits various physical mechanisms to achieve a controlled and persistent conductance variation upon electrical stimuli. Most of the devices have a simple structure where an active organic or inorganic thin layer (e.g. an oxide) is sandwiched between two metal films and can be scaled down to few nanometers. Memristive devices are today of large interest since they can be used to reproduce bio-inspired systems: for example, they can act as dispersed memory elements mimicking the role of synapses in the nervous systems, or as stochastic and non-linear elements of neuronal units. With the further advantage of being compatible with integrated processes of electronic industry, these devices can be used as new building blocks for brain-inspired computing technologies. Thanks to event-driven computation, highly-parallelized non-von Neumann architecture, and spatio-temporal coding, the brain-inspired spiking neural network (SNN) is one of the most promising approach to artificial intelligence. Among the various available memristive technologies, resistance switching memories (RRAM) based on redox reactions and electrochemical phenomena in oxides are very promising because of low power consumption, fast switching times, scalability down to nm scale and CMOS compatibility. For these reasons, RRAM are today investigated as synaptic elements for spiking neural networks.

The main goal of the proposed PhD activity will be the development of RRAM-based nanoscale synapses for spiking neural network. Materials (oxides, nitrides and metals) will be deposited by atomic layer deposition, sputtering and electron beam evaporation; devices will be patterned via optical or electron beam lithography. The electrical testing will be performed both in DC and pulsed regimes to study the switching properties and the evolution of conductance dynamics under various stimuli. Further, modelling of SNN including the developed devices will be performed. Facilities for the growth of materials as well as for the fabrication of devices are available in the clean room of the Unit of Agrate Brianza of CNR-IMM; the laboratory is also equipped with advanced characterization techniques for the analysis of the physical, chemical and electrical properties of materials and devices.

The student will join a team with an extensive experience in the field and internationally positioned in the area of neuromorphic computing; she/he will have the chance to develop broad skills ranging from material science to electrical testing and modelling in an emerging area of research, as well as to enhance her/his expertise in an international framework through the existing collaborations of the hosting group. Exchange visits with international partners (both academic and industrial) will be organized.

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Synthesis and isolation of epitaxial Xenes based on group IV-VI elements

Supervisor: Dr. Alessandro Molle – CNR-IMM, Unit of Agrate Brianza
(alessandro.molle@mdm.imm.cnr.it)

Project(s): XFab (ERC-CoG 2017)

The topic of the PhD thesis will be focused on the development of standardized procedures for the synthesis and processing of new epitaxial Xenes, that is two-dimensional atomically thin crystals made of non-carbon atoms supported by substrates. Xenes have recently come to the research forefront as complementary materials to graphene with X spanning from alternative group IV elements (like silicene, germanene, stanene), to pnictogens (like phosphorene, antimonene, and bismuthene), and chalcogens (like selenene and tellurene). Basic motivation for the Xenes is to outstandingly expand graphene functionalities in nanotechnology.

The research activity will be carried out in the framework of the ERC CoG 2017 grant "XFab" ("Xene fabrication for a new two-dimensional nanotechnology platform", grant no. 772261) recently assigned to Dr. Alessandro Molle. The project objective is to produce Xene that can be readily integrated into functional devices for applications in nanotechnology. On this background, the identification and isolation of a selected number of Xenes in device-friendly configurations will be a key goal of the PhD activity.

In detail, a specific task will be devoted to the installation of new growth equipment increasing the production capabilities with respect to the current state. A second task will be concerned with the advanced characterization of the grown materials with light- or electron-based spectroscopy enabling the selection of a portfolio of Xenes that will be readily transferred to the device processing step. Overseas exchanges (stages, internships, and access to large-scale facilities) will be scheduled for these purposes.

The overall activity will be pro-actively conducted according to the project roadmap and within a strongly motivated research team (including Researchers, Post-Doc fellows, PhD students). As such, being respectful of project timing and milestones, and working in a team under the coordination of the supervisor will be considered as pre-requisites for the PhD activity.