Marie Skłodowska-Curie Actions Postdoctoral Fellowships 2022
Supervisor Profile

1. Details of the IMDEA Supervisor

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<tr>
<th>Name of Supervisor</th>
<th>Paolo Perna</th>
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<td>Website</td>
<td><a href="http://nanoscience.imdea.org/research/research-programs/nanomagnetism/spinorbitronics">http://nanoscience.imdea.org/research/research-programs/nanomagnetism/spinorbitronics</a></td>
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2. Research themes proposed

The enormous increase of the data generated and the need for fast data processing make that around the 15% of global emissions by 2040 will be caused by computer operations on pc, smartphones, tablets and “internet of things” devices. Moreover, thousands or millions of items, daily, could be transmitting and leaking sensitive information without the user’s knowledge. In this context, nanoscience research is called to provide technological solutions to face the societal challenges for information and communication technologies (ICT) in energy, artificial intelligence and data security, i.e. in finding novel architectures functioning at reduced electrical power, performing cognitive tasks, and providing a high level of data encryption.

Our research focuses to the fabrication, characterization and test of novel magnetic systems/devices with strong and tunable interfacial Spin-Orbit Interactions (SOI) that allow to manipulate efficiently and rapidly the magnetization state and to host stable chiral spin textures (as magnetic domains and skyrmions), while operating at room temperature.

We will exploit the advantages of combining ferromagnetic (FM), ferrimagnetic (FiM), non-magnetic (NM), heavy metals (HM), ferroelectric (FE) compounds and 2D related materials (2DMs), including graphene, in form of multilayers to control the interfacial magnetic properties by means of external perturbation.

We propose here two topics that the candidate may choose.

1. Build and test voltage-controlled resistive and magnetic switching devices exhibiting low power, high velocity and large density, as well as efficient spin injection/detection. Such devices will be fabricated in Ultra-High-Vacuum (UHM) condition and exploit the Graphene/FM unique properties, as tunable interfacial strong perpendicular magnetic anisotropy (PMA) and sizeable Dzyaloshinskii-Moriya interaction (DMI), to manipulate the magnetic spin configuration by acting with electric current and field.

This research will be performed in the framework of the EU FLAGERA JTC2019 SographMEM project (https://nanosciencia.imdea.org/sographmem/, https://www.flagera.eu/wp-content/uploads/2020/06/FLAG-ERA_JTC2019_GRA-BR_SographMEM.pdf) coordinated by Prof. P. Perna at IMDEA and that involve 7 European partners from 4 different countries. CNRS-Thales (Dr. V. Cros),
2. Fabricate magnetic systems and 2D materials (2DMs) to realize next generation electronic devices for neuromorphic applications. We will fabricate and test systems with ferromagnetic (FM) and antiferromagnetic (AFM) character. While FMs are non-volatile and intrinsically implement memory in artificial synapsis (memristors), materials with AFM coupling can be adopted for both artificial synaptic and neuron devices. In addition, we will resort to the volatile and non-volatile resistive switching (VRS and NVRS) properties of 2DMs. By combining nanopatterning and local material modifications in different device geometries, we will investigate the electric field manipulation of spin textures such as domain walls (DWs) and skyrmions in spintronic systems and VRS and NVRS in transition metal dichalcogenides (TMDs) layers to emulate the biological neuron and synapse functionalities, respectively. Our hybrid approach promises to give solutions for applications in which the processing speed is mandatory, as imaging and mobility applications as well as for big data processing in which low power consumption is required. This research will be performed in the framework of the EU, national and regional projects led by Prof. P. Perna and in synergy with other groups at IMDEA.

The position is open to candidates with a background Physics or Materials Science. Open minded applicants, with a passion for condensed matter physics and physical phenomena at the nanoscale, and a curiosity for advanced instrumentation are highly welcome.

The role of the post-doctoral researcher will be to design and characterize the multilayer heterostructures in different geometries by varying the material stack sequence and the device geometry by using the experimental capabilities of the group and available at the institute. These include: UHV growth by molecular beam epitaxy (MBE), chemical vapour deposition (CVD), dc and rf sputtering; nanofabrication (optical and electronic lithography); X-ray diffraction; in-situ surface characterization as X-ray and UV photoemission spectroscopy (XPS-UPS); Low energy electron diffraction (LEED); ex-situ magnetic characterization as Kerr magnetometry and microscopy, VSM, second harmonic and spin Hall magnetoresistance, ferroelectric and magnetic switching experiments. The candidate will be asked to actively participate in synchrotron campaigns, in the group meeting and in the experimental activities with collaborators, to propose new experiments, as well as to train master and PhD students in the group. The dissemination activities in terms of scientific publications and oral/poster contribution in international conferences will be demanded.

3. Brief description of the Research Group

The SpinOrbitronics Team at IMDEA Nanoscience led by Prof. P. Perna (Google scholar), specialized in the nanofabrication of hybrid spintronics systems and their surface/interface and magneto-transport properties, actively works on the search of novel systems and architectures in which the magnetic interactions can be manipulated by acting with electric fields, enabling the realization of fast and low consumptive programmable devices. Such architectures require the combination of materials that can provide suitable spin transport channels with long spin lifetime and spin propagation, as well as topologically stable spin textures that can act as fast information carriers. In addition, the ability to manipulate the magnetic state of a material by acting through an electric gate voltage or current would permit to additionally reduce the power consumption and improve the speed processing.

The research activities of the group are actually focused within the following topics:
Spin-Orbitronics: investigating the growth and the structural, surface and magneto-transport properties of heterostructures in which spin-orbit coupling plays an important role. These include thin films and multilayer stacks, combining ferromagnetic (FM), antiferromagnetic (AFM), perpendicular magnetic anisotropy (PMA) systems, 3d metals, 4f lanthanides as well as molecules and graphene.

Oxide-Spintronics: engineering artificially the surface/interface of nanostructures based on perovskite oxides (which show a wide variety of properties as half-metallicity, dielectricity, ferroelectricity, multiferroicity), with the aim to tailor their spin-dependent transport characteristics and merge in a single device the functionalities of their individual constituents.

4. MSCA Research Area Panels

☐ Chemistry (CHE)
☐ Social Sciences and Humanities (SOC)
☐ Economic Sciences (ECO)
☒ Information Science and Engineering (ENG)
☐ Environmental Sciences and Geology (ENV)
☐ Life Sciences (LIF)
☐ Mathematics (MAT)
☒ Physics (PHY)