NUS – IIT Graphene Exchange Students Award

The Centre for Advanced 2D Materials (CA2DM) and Graphene Research Centre (GRC) at the National University of Singapore – NUS (www.nus.edu.sg) and the Graphene Labs at Fondazione Istituto Italiano di Tecnologia (G@IIT) – IIT (www.iit.it) in Genoa (Italy) are jointly opening the

NUS – IIT Graphene Exchange Students Award

**to identify PhD students** who will be trained and **perform research between Singapore and Genoa (Italy)** on the application of graphene and 2D materials in the fields of energy, new materials, and imaging and diagnostics.

PhD students at NUS working in the field of graphene and 2D materials are particularly invited to apply.

To be eligible, full-time NUS PhD students **must have completed, at least, two academic years at NUS, in Singapore**, before the beginning of the exchange period. This award contemplates an **exchange period ranging from one to two consecutive years at IIT in Genoa (Italy)** to complement and further strengthen their research work.

The awarded students will focus their activities in one of the following research topics (see topic details at the end of this document):

- **Graphene for Li-based batteries**
- **Ultra-fast optics in 2d crystals**
- **Graphene for advanced imaging**

This exchange programme/award offers:

- the opportunity to enrich your PhD programme with cross-disciplinary research in an international and multidisciplinary scientific environment;
- supervision and mentorship by teams of internationally renowned experts;
- state-of-the-art research facilities;
- a scholarship in line with international standards for the duration of the exchange period;
- reimbursement of NUS tuition fees for the duration of the exchange period.

Applications must be submitted online (instructions and documents described there):


**Deadline** for applications is 28 August 2015.

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IIT was established in 2003 and successfully created a large-scale infrastructure in Genoa (Italy) and a network of 10 state-of-the-art laboratories countrywide with an international staff of about 1100 people from more than 50 countries. IIT’s research endeavour focuses on high-tech and innovation, representing the forefront of technology with possible application from medicine to industry, computer science, robotics, life sciences and nano-biotechnologies.

In 2014 IIT starts the **Graphene Labs (G@IIT)** in order to develop a new class of smart materials based on graphene and other 2D layered materials. Production methods range from wafer-scale 2D layers obtained by CVD and SIC sublimation methods, to chemically functionalized inks produced by liquid phase exfoliation. Through the development of key demonstrators G@IIT want to establish a new set of potential applications in the energy, optoelectronics and biotechnology sectors.
Details of Research Topics

Graphene for Li-based batteries

This activity will focus on the development of graphene-based lithium ion batteries. The aim is to develop a new class of lithium ion battery embedding the (electro)chemical functionalities of graphene and exfoliated layered two-dimensional (2D) materials or composites between graphene and other exfoliated crystals and nanotubes. These will be exploited as active and passive materials for printable and flexible electrodes development to be used in Li-ion batteries. We also plan to investigate graphene-supported sulfur and/or oxygen composites in order to develop new cathode morphologies for high energy Li/S or Li/O2 batteries or, eventually to combine them with lithiated graphene for an innovative, full-graphene lithium-ion battery.

Ultrafast optics in 2d crystals

Over the past 10 years, we have seen a dramatic rise of the use of graphene and other 2D (layered) crystals. Most importantly, they are organic and/or free of heavy metals and therefore offer a viable alternative to many opto-electronic materials used today, with applications in lasing, nonlinear optics, optical sensing, or quantum information technology. 2D crystals such as graphene, MoS2, WS2 or other materials are also synthesized at the IIT Graphene labs and at the Singapore Graphene research center, and in this project we will push forward the understanding of their opto-electronic properties using ultrafast time-resolved optical spectroscopy. The source material can be prepared by in-house collaborators, and the Ph.D. student will carry out the optical characterization using fs-lasers, ps-resolution detectors and a cryostat to perform investigations at room- as well as cryogenic temperatures. Successful materials may be further integrated into prototypical opto-electronic devices.

Graphene for advanced imaging

Multi scale and multimodal correlative nanoscopy is an emergent field of research. Within such a framework we focalize our attention on the development of a versatile modular optical microscope allowing different image contrast mechanisms, from fluorescence to label free signatures, and able to push resolution to the nanoscale level (1-5 nm in materials science – 20-50 nm in life sciences) on a variety of samples including 3D thick (> 50 um) biological systems. Such a bioimaging platform is conceived for in-vivo imaging and for lab-on-a-chip development of selected modules for possible integration on diagnostic devices. Super resolution modules are the core of the design that aims to be competitive with current electron microscopes both in terms of spatial resolution and costs. The new paradigm for microscopy development is shifted to new scale and portable multimodal nanoscopes having the potential of being flexible, low power, tunable versus tailored applications and low cost for high dissemination. Such a new generation microscope will integrate microscopy, spectroscopy and flow cytometry modules on demand, a sort of Iphone uploading new capabilities as they are apps. Among the (today) classical immediate applications are those related to the study and characterization of oncological and neurodegenerative diseases (nuclear pore complex and membrane channels dynamics, chromatin-DNA organization and dynamic changes as potential pre-neoplastic indicators, cellular molecular trafficking, protein accumulation pathways, cell aggregation and growth), tissue engineering processes (artificial retina, bone substitutes) and smart materials developments (nanoparticle packing and functioning in nanocomposite materials). This means that further and original developments of techniques have to be integrated with the absolute need of new materials for still inconceivable solutions and applications. Since the direction is towards lab-on-a chip devices, we cannot escape at this stage the effects of the Graphene revolution and of the general perspective of developing plastic, portable and flexible devices. So far we plan utilizing graphene layers for new smart supports towards nanobiomaging: refractive index gradient layers; 2D illumination sources with integrated optics; SNR improved photon counting; self-powering modules; 2D electronics; fluorescence enhancers/bleaching towards single molecule detection/plasmonics applications. The activity will be related to the understanding of 2D light confinement by graphene and to its implementation to realize an illumination source for super resolution methods. Due to the 2D geometry of such an illumination waveguide, we also plan to monitor effects on the confined field due to deposition of biological samples from single proteins to biological cells under super resolution imaging regime.