Charge Carrier Dynamics in Semiconducting Metal Organic Frameworks

IMDEA - Nanociencia Institute
www.nanociencia.imdea.org

CENTRE DESCRIPTION

IMDEA Nanociencia is a young interdisciplinary research centre dedicated to the exploration of basic nanoscience and the development of applications of nanotechnology in connection with innovative industries.

Our purpose-built building was inaugurated in 2014 and features state-of-the-art facilities for 21st century science, where the frontiers between fields disappear and Physics, Chemistry, Biology, Engineering, and Medicine merge. It features more than 30 operative laboratories with over € 16 M worth of equipment -including the Centre for Micro and Nanofabrication. We are located at the UAM Campus, with access to all the facilities of one of Spain's largest and most prestigious Universities. The UAM Campus is just a few minutes away from Madrid's lively city centre, connected by "cercanías" trains and several bus lines.

We are over 150 scientists, with different professional and personal backgrounds. Approximately 40% of our PhD and postdocs come from outside Spain, representing every corner of the world, from Germany to China, from the USA to Singapore –a true international environment in which to develop your scientific career. Women make up 36% of our scientific and 62% of our management staff. No matter who you are or where you come from, you will feel welcome from the very first minute.

We take science seriously and value quality over quantity. Our scientists enjoy tackling complex multidisciplinary problems, often within in-house collaborations, so all of our students receive truly interdisciplinary training. We also enjoy publishing in the very best journals, with >200 publications a year, and an institutional h index of 79. Check out our webpage http://nanociencia.imdea.org/, facebook @IMDEANanociencia or twitter @IMDEA_Nano for more information.

So if you are a talented, hard-working individual with a real interest in Science, IMDEA Nanociencia is the right place for you! Come work with us!

ADDRESS

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AREA OF KNOWLEDGE

Physical Sciences, Mathematics and Engineering

GROUP OF DISCIPLINES

Physics

GROUP LEADER

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Research Group website: https://ecanovas6.wixsite.com/nanopv

Research project/ Research Group description

Metal-Organic Frameworks (MOFs) are hybrid materials consisting of metal ions connected by organic ligands. The large degree of structural and chemical tunability and long-range crystalline order have made MOFs promising materials for a large variety of applications (prominently gas storage and separation and catalysis); however, the insulating character of most MOFs developed to date has prevented these materials to be considered for applications requiring long-range charge transport. The recent discovery of electrically conductive MOFs has hence opened yet other broad areas of potential applications of MOFs in opto-electronics and chemiresistive sensing.

Electrical conductivities reported in MOFs have been routinely measured using two-probe, four-probe, and van der Pauw methods. Unfortunately, these conventional methods measure only the sample conductivity, so they are unable to disentangle the distinct components defining it: they cannot distinguish sample doping from charge mobility. As such the true nature of charge transport in MOFs has remained unsolved till recently, when we overcame this problem by using time-resolved Terahertz spectroscopy (TRTS). TRTS is an all-optical, contact-free method which is capable of addressing the nature of charge transport via modeling the high-frequency complex conductivity, which directly reflects the mechanism of charge transport, and from which, doping and mobility components contributing to the conductivity can be disentangled.

In our recent paper in Nature Materials (https://rdcu.be/9i7p), we demonstrated that a free-standing, porous thin film of a two dimensional MOF supports band-like charge carrier transport (rather than hopping), directly demonstrated from TRTS analysis. A room temperature mobility of ~220 cm^2/Vs was estimated from TRTS, which represents a world record mobility within the MOF family. These results opens up a plethora of applications for MOF based novel optoelectronic devices.

Job position description

The main goal of this project is to gain a fundamental understanding of charge motion in MOFs by establishing neat structure-composition-conductivity-function relationships. The main tool that will be employed will be time-resolved Terahertz spectroscopy, a tool that allows the determination of a sample's conductivity in a contactless fashion and on ultrafast timescales. State-of-the-art samples will be provided via external collaborations (e.g. Prof. Xinliang Feng at TU Dresden). Furthermore, in parallel, we will attempt developing novel functional MOF-based devices.

The ideal candidate will have a BSc and MSc in Physics or equivalent with proven excellent grades. She/He should have a strong commitment towards critical and independent thinking and be driven towards achieving specific goals. Experience in optics and ultrafast spectroscopy will be evaluated positively. Prior knowledge on device engineering will be a plus.

The project will be conducted at IMDEA Nanoscience (Madrid, Spain), a Severo Ochoa center of excellence that has a research line exclusively devoted to transport in 2D systems (with 6 sub-groups and more than 20 PIs involved). Furthermore, during the PhD, the selected candidate is expected to do a

minimum of 3 month placement at Max Planck Institute for Polymer Research (Mainz, Germany), where Dr. Cánovas (PI for this project) was group leader over the last 7 years (Dept. of Molecular Spectroscopy – Prof. Mischa Bonn). All advanced laboratory services at IMDEA Nanoscience and Max Planck Institute for Polymer Research will be available to the student working within this project. Within this scheme, the selected candidate will benefit from an exciting line of research within a high profile international collaboration; and being exposed to different scientific environments and world-class facilities.

OTHER RELEVANT WEBSITES

Group Homepage

https://ecanovas6.wixsite.com/nanopv

Department of Molecular Spectroscopy at Max Planck Institute for Polymer Research

http://www.mpip-mainz.mpg.de/molecular_spectroscopy

Center for Advancing Electronics at TU Dresden

https://cfaed.tu-dresden.de/cmfm-about