POLITECNICO
MILANO 1863

NanoLab

NanoLab Talks

Department of Energy, Politecnico di Milano

2021

ERC-2014-CoG No. 647554
ENSURE

ERC-2016-CoG No. 724610
EspLORE

We strongly believe in the importance of spreading knowledge and sharing ideas for the advancement of science and the formation of young people. This is why we organize the NanoLab Talks as periodic seminars within the activities of the NanoLab group at the Department of Energy at Politecnico di Milano, Italy. The NanoLab talks are open to everyone and are given by experts from the academy, research centers, and private companies on Education, Science, and Technology. The topics cover different aspects of Physics, Engineering, Material Science, Nanotechnology, Chemistry, and Education to a target audience composed of master thesis students, PhDs, postdocs, technicians, researchers, and academics.

We started in 2018 and up to now, we were honored to host 67 speakers presenting their research at the Nanolab Talks. In 2021 we had 15 speakers with an average attendance of about 40 people. We adopted hybrid mode, in presence and in distance when possible due to Covid-19 restrictions trying to come back to the human contact that is fundamental for networking and sharing of ideas.

NanoLab Talk 2021 List of speakers

Speaker	Title	Affiliation
Francesco Bisio	**Plasmonics in a variable-temperature thermodynamic bath**	CNR-SPIN, Genova
Valentina Giordano	**The effect of disorder in phonon propagation: from glasses to random crystalline alloys, to nanocomposites**	ILM-CNRS, Lyon (France)
Andrei N. Khlobystov	**Chemistry in the World's Tiniest Test Tube**	University of Nottingham (UK)
Dario Polli	**Coherent Raman Microscopy: a powerful label-free imaging modality for biological applications**	POLIMI, Dept. of Physics
Matteo Ferri	**CuFeO2–Water Interface under Illumination: Structural, Electronic, and Catalytic Implications for the Hydrogen Evolution Reaction**	POLIMI, Dept. of Energy
Luca Fedeli	**Probing strong-field Quantum Electrodynamics with ultra-intense lasers**	CEA, Paris (France)
Gulia Grancini	**Hybrid Perovskite Solar Cells: a game changer for near future Photovoltaics**	University of Pavia
Caterina Vozzi	**A Novel Source for Ultrafast X-ray Spectroscopy: High-order Harmonic Generation in Glass Chip Fabricated by Femtosecond Laser Micromaching**	CNR-IFN, Milano
Guido Raos	**Polymer adhesion: fundamentals and molecular simulations**	POLIMI, Dept. of Chemistry, Materials and Chem. Eng.
Giorgio Contini	**On-surface synthesis of 2D materials with Dirac cones and semiconducting properties**	CNR-ISM, Rome
Edoardo Besozzi	**Stryker Trauma and Extremities: Company overview and Medical Device Products development process**	Stryker (Switzerland)
Subrata Ghosh	**Ti3C2Tx MXene-Epoxy composite for Joule Heating Application**	POLIMI, NanoLab
Fabrizio Preda	**A novel Fourier-Transform spectrometer and its application to Time Resolved Fluorescence and Hyperspectral Imaging**	Nireos s.r.l (Italy)
Giancarlo Soavi	**Nonlinear optics in atomically thin materials**	University of Jena
Stefano Casalini	**Organic Thin-Film Transistors: from organic semiconductors to 2D materials**	University of Padova

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NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, January 12th, 2021 at 11.00 a.m. (Central European Time)
(in teleconference at this link: Join Microsoft Teams Meeting)

Plasmonics in a variable-temperature thermodynamic bath

Francesco Bisio

CNR-SPIN, C.so Perrone 24, 16152 Genova

Nanometric metallic particles (NMP) under optical illumination may exhibit a resonant oscillation of their free-electron plasma, a phenomenon that goes under the name of localized surface plasmon resonance (LSPR). In correspondence of the LSPR, the cross section for light scattering and absorption become resonantly enhanced, with dramatic consequences for the local distribution of electromagnetic fields around the NMP. Whereas absorption was initially regarded as a spurious, unwanted effect, it was soon realized that it held the potential to realize nano-sized heaters, remotely controllable by light. The branch of physics investigating these processes goes under the name of thermoplasmonics.
Whereas it is undisputed that MNP indeed perform well as nano-heaters, the challenge remains to measure the temperature the NMPs (and their environment) achieve during thermoplasmonics irradiation. In this talk, I will outline some of the strategies that can be implemented to tackle this issue [1,2], from the characterization of NMP properties in a variable-temperature bath, to their exploitation as self-thermometers in ultrafast thermoplasmonics experiments.

References

[1] M. Ferrera et al., ACS Photonics **7**, 959-966 (2020).
[2] M. Magnozzi et al., Nanoscale **11**, 1140-1146 (2019).

About the speaker:

Francesco Bisio is a researcher at CNR-SPIN. His research interest are the optical properties of materials with low dimensionality, composite nanomaterials with complex morphology, and plasmonics.

For further information please contact: carlo.casari@polimi.it

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, January 26th, 2021 at 11.00 a.m. (CET)

(in teleconference at this link: Join Microsoft Teams Meeting)

The effect of disorder in phonon propagation: from glasses to random crystalline alloys, to nanocomposites

VALENTINA GIORDANO

Institut of Light and Matter – CNRS & University of Lyon 1

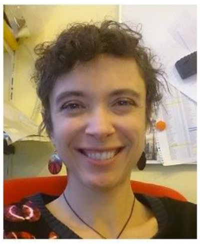
It is today largely recognized that collective vibrations such as phonons in crystals, can propagate as well in disordered materials, such as glasses or liquids at long wavelengths. Indeed, when the wavelength is very large with respect to the characteristic lengthscale of the disorder, the wave won't event notice the existence of such disorder and the phonon will propagate in an effective medium with effective elastic constants. When however the two lengthscales are similar, the wave will be scattered by the disorder, until scattering is so strong that the wave cannot propagate anymore. This is the Ioffe-Regel limit, separating the propagons (propagative phonons) from diffusons (diffusive vibrations) in glasses. Such limit is usually located at wavelengths of 1-5 nm, and energies in the THz range, which is the lengthscale of the elastic constants fluctuations in a glass, and it has been related to the appearance of the vibrational anomalies typical of glasses: a phonon attenuation growing with the fourth power of its energy (Rayleigh scattering) and an excess of states in the reduced phonon density of states, the fameous Boson Peak [1]. There are however other materials in which elastic constant fluctuations can naturally or artificially arise. One example are the random crystalline alloys, such as the High Entropy Alloys: long range perfectly ordered crystalline alloys with the maximum short range disorder possible, with an equal atomic occupation probability of 5 elements in the unit cell positions. In this case elastic constant fluctuations are at a lengthscale of few angstrom and have been predicted to play a major role in phonon attenuation [2). Another example and nanocomposites, materials made of the intertwinning at the nanoscale of different materials with different elastic constants. Here the elastic constant fluctuations are at a lengthscale of tens of nanometers and have been predicted as well to strongly scatter phonons. In this lecture I will go through all these systems, showing their similarities and differences in phonon dynamics.

References

[1] G. Monaco and V. M; Giordano, PNAS, 106, 3659 (2009)

[2] S. Mu et al., Npj Computational Materials 6, 4 (2020).

[3] A. Tlili, V. M. Giordano et al., Nanoscale, 2019, 11, 21502



About the speaker: Former beamline scientist at the inelastic x-ray scattering beamline of ESRF, Valentina Giordano is a CNRS researcher at ILM since 2011. Expert of phonon dynamics in disordered systems, she uses advanced large scale facilities techniques together with laboratory techniques to investigate the microscopic origin of thermal transport properties in materials of interest for energy harvesting and thermal management applications.

For further information please contact: carlo.casari@polimi.it

ERC-2016-CoG No. 724610

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, February 2nd, 2021 at 11.00 a.m. (CET)

(in teleconference at this link: Join Microsoft Teams Meeting)

Chemistry in the World's Tiniest Test Tube

Andrei N. Khlobystov

School of Chemistry, University of Nottingham, United Kingdom

How do we know that molecules react in one way rather than another? Conventional analytical techniques, such as spectroscopy or diffraction, can only support rather than confirm a chemical reaction mechanism. Ultimate knowledge of the reactions can be provided only by studying them at the single-molecule level. Carbon nanotubes, 80,000 times thinner than a single strand of human hair, allow us to entrap molecules and film chemical reactions triggered by heat, electric potential or electron beam with atomic resolution [1]. Reactions in nanotubes often deliver unusual products, such as graphene nanoribbons [2,3], or enable improvements of important physical and chemical processes. For example, loaded with metal nanoparticles the nanotubes exhibit remarkable catalytic properties that can be exploited in many applications, including electrocatalysis in fuel cells [4], outperforming traditional materials. All this becomes possible due to the world's tiniest test tubes.

References

[1] S. T. Skowron et al., Acc. Chem. Res., 2017, 50, 1797-1807.

[2] A. Chuvilin et al., Nature Mater., 2011, 10, 687-692.

[3] T. W. Chamberlain et al., ACS Nano, 2017, 11, 2509-2520.

[4] M. D. Gimenez-Lopez et al., Adv. Mater., 2016, 28, 9103-9105

About the speaker:

Andrei trained as a chemist (MSc Moscow State University 1997; PhD University of Nottingham 2002) and started his post-doctoral career at the Department of Materials, Oxford University (2002-2004). He applied transmission electron microscopy (TEM) for imaging structures of individual molecules and studying molecular dynamics in direct space and real time, which shed light on intermolecular interactions, and the translation and rotational motion of molecules at nanoscale. In 2004 he established the Nottingham Nanocarbon Group. His team discovered important mechanisms of interactions between carbon nanostructures and molecules or nanoparticles which enabled the design of nanoreactor systems with tuneable size and functionality. The nanoreactors have been applied for a range of reactions, including catalytic and electrochemical processes where molecular transformations are controlled at nanoscale. TEM remains key in his research, not only for the structural characterisation of individual molecules, but also as a new tool for the study and discovery of chemical reactions at nanoscale.

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ERC-2016-CoG No. 724610

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, March 2nd, 2021 at 4pm (CET)
(in teleconference at this link: Join Microsoft Teams Meeting)

Coherent Raman Microscopy: a powerful label-free imaging modality for biological applications

Prof. Dario Polli

Dipartimento di Fisica, Politecnico di Milanon (italy)
Institute for Photonics and Nanotechnologies – CNR Milano (Italy)

Fluorescence microscopy is a powerful investigation tool for life sciences. It can visualize morphological details in cells and tissues with sub-micrometer resolution and single-molecule sensitivity. However, fluorescent markers can perturb the investigated system and induce phototoxicity. This calls for intrinsic, label-free imaging methods such as Spontaneous Raman (SR) microscopy. SR measures the vibrational spectrum that characterizes every component of a biological specimen, reflecting its molecular structure and providing an endogenous and chemically specific "fingerprint". Its main drawback is the very low scattering cross section, making it difficult to probe diluted species and preventing real-time imaging of dynamical processes in living cells or tissues. These limitations can be overcome by the use of coherent Raman scattering (CRS) techniques. CRS is a nonlinear optical technique employing a sequence of ultrashort pulses to set up and detect a vibrational coherence within the molecules in the laser focus, which enhances the Raman response, thus allowing high imaging speeds with 3D sectioning capability. In this talk, I will review the state of the art and recent advances of CRS microscopy, in both coherent anti-Stokes Raman scattering (CARS) and stimulated Raman scattering (SRS) modalities.

About the speaker:

Dario Polli is Associate Professor of Physics at Politecnico di Milano (Italy). His main research focus is on coherent Raman spectroscopy and microscopy, ultrafast and non-linear optics, Fourier-transform spectroscopy and time-resolved pump-probe spectroscopy and microscopy. He is the coordinator of

CRIMSON (www.crimson-project.eu), a pan-European H2020 project to develop the next-generation microscopy platform to study the cellular origin of diseases. He published >100 scientific papers on international journals, cited >5000 time. His H-index is 35. He has been awarded an ERC Consolidator grant (www.vibra.polimi.it) in 2015. He is passionate about science divulgation to the public. He is co-founder of NIREOS (www.nireos.com) and Specto Photonics (http://spectophotonics.com/) photonics startups. More info on http://polli.faculty.polimi.it/ and www.linkedin.com/in/dariopolli/

For further information please contact: carlo.casari@polimi.it

ERC-2016-CoG No. 724610

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, March 16th, 2021 at 16.00 a.m. (CET Time)
(in teleconference at this link: Join Microsoft Teams Meeting)

$CuFeO_2$–Water Interface under Illumination: Structural, Electronic, and Catalytic Implications for the Hydrogen Evolution Reaction

Matteo Ferri

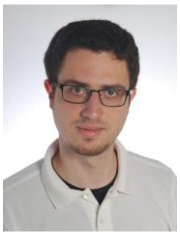
Scuola Internazionale Superiore di Studi Avanzati (SISSA), Trieste
Present address : *Politecnico di Milano,* Laboratory of Catalysis and Catalytic Processes

Delafossite $CuFeO_2$ is a *p*-type semiconductor that has been recently identified as a promising photocathode material for photoelectrochemical water splitting [1,2,3]. $CuFeO_2$ can absorb solar light and promote the hydrogen evolution reaction (HER), even though the photocurrents achieved so far are still well below the theoretical upper limit [2]. While several experimental and theoretical works have provided a detailed characterization of the bulk properties of this material, surfaces have been largely unexplored.
We performed first-principles simulations based on Density Functional Theory (DFT) to investigate the structure, electronic properties, and thermodynamic stability of $CuFeO_2$ surfaces both in vacuum and in an electrochemical environment [4]. To estimate the alignment of the band edges on the electrochemical scale, we performed ab-initio molecular dynamics simulations in explicit water, unraveling the structure of the solid/liquid interface for various surface terminations. We considered the system both in the dark and under illumination, showing that light absorption can induce partial reduction of the surface, giving rise to states in the gap that can pin the Fermi level, in agreement with recent measurements [5]. Using the free energy of adsorption of atomic hydrogen as a descriptor of the catalytic activity for the HER, we showed that hydride species formed at oxygen vacancies can be highly active and could therefore be an intermediate of reaction.

References

[1] Read et al., *J. Phys. Chem. Lett.* **3**, 1872 (2012)
[2] Prevot et al., *ChemSusChem* **8**, 1359 (2015)
[3] Sivula and van de Krol, Nature Reviews Materials **1**, 15010 (2016)
[4] Ferri et al., *ACS Catalysis* **11**, 4, 1897 (2021)
[5] Hermans at al., *Adv. Funct. Mater.* **30**, 1910432 (2020)

About the speaker:



Matteo Ferri is a postdoctoral fellow at the LCCP lab of the Department of Energy of Politecnico di Milano. He obtained the Master Degree in Physics at Università degli Studi di Milano in 2016. In 2020, he received the Ph.D. magna cum laude in Condensed Matter Physics at SISSA (Trieste). His research activity is mainly focused on the prediction of properties of novel materials with applications of technological relevance using first-principles atomistic calculations.

For further information please contact: carlo.casari@polimi.it

ERC-2016-CoG No. 724610

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, March 23rd, 2021 at 4.00 p.m. (CET)

(in teleconference at this link: Click here to join the meeting)

Probing strong-field Quantum Electrodynamics with ultra-intense lasers

Luca Fedeli

LIDYL, CEA-Université Paris-Saclay, CEA Saclay, 91 191 Gif-sur-Yvette, France

Quantum Electrodynamics is a cornerstone of modern Physics and has passed the scrutiny of the most stringent tests. Yet, its strong field regime (SF-QED) remains mostly out of reach of experimental investigation. Indeed, exploring SF-QED would require electromagnetic fields of the order of the so-called "Schwinger field": 1.32×10^{18} V/m. This value is more than three orders of magnitude higher than the strongest fields available on Earth: those delivered by ultra-intense femtosecond lasers. At LIDYL we study a strategy to overcome this obstacle: a scheme based on optical devices called "plasma mirrors" curved by radiation pressure to boost the intensities of existing ultra-intense lasers by the Doppler effect and focus them to extreme field intensities [1]. If a secondary target is placed at the focus of those curved plasma mirrors, the boosted beam should accelerate the electrons of the secondary target to relativistic energies, so that the Schwinger field could be attained in their reference frame [2]. We have simulated this scenario with the Particle-In-Cell code WarpX+PICSAR [3], on the Summit supercomputer (#2 in the Top500). Our simulations show that it would be possible to explore SF-QED in otherwise unattainable regimes, with existing or upcoming PetaWatt laser systems, obtaining clear experimental signatures.

References

[1] H.Vincenti, Phys. Rev. Lett. 123, 105001 (2019).

[2] L.Fedeli et al., arXiv:2012.07696, under review (2020).

[3] A.Myers et al. arXiv:2101.12149, under review (2020). https://ecp-warpx.github.io/

About the speaker:

Luca Fedeli obtained his Master's degree in Physics at the University of Milano-Bicocca and his Ph.D. at the University of Pisa. After a first post-doc at Politecnico di Milano, where he worked on laser-driven hadron sources, from 2019 he is a post-doc at CEA-Saclay (France). He studies how to explore the strong-field regime of Quantum Electrodynamics in ultra-intense laser-plasma interaction, mainly through numerical simulations on top supercomputers.

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NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, May 25th, 2021 at 16.00 (CEST)
(in teleconference at this link: Click here to join the meeting)

Hybrid Perovskite Solar Cells: a game changer for near future Photovoltaics

Giulia Grancini

University of Pavia, Department of Chemistry, Via T. Taramelli 16, 27100 Pavia, Italy

The development of low-carbon technologies for energy generation is key to our energy future. Within the Photovoltaics (PVs) framework, the last decade has been facing a revolution with the advance of a breakthrough technology which can radically transform the energy sector: hybrid perovskite (HP) solar cells. HP have been skyrocketing in terms of conversion efficiency, nowadays beyond 25%, approaching those of crystalline Si cells[1]. As opposed to Si, HP solar cells are processed with low-temperature and low-cost solution-processes and less technologically intensive methods[2]. However, presently, the technology is still not mature for industrialization. Silicon cells last 25 years, while HPs cells have yet to be sufficiently proven under such environmental stressors as moisture and heat. Many strategies, as the ones I will present are now revolutionizing this intensely investigated field, making perovskite durable.[3]

In this talk I will discuss the enormous potential of this class of materials used in advanced solar cells, presenting the current strategies to bring HPs cells an active player in the near future PV scene. In particular, engineering low dimensional HPs is nowadays a popular way for efficient and stable devices[4]. Used in combination with standard HPs, such class of materials can offer a stability boost acting as a sheath to physically protect the HP underneath. [3] The judicious choice of the material constituents is decisive to control the device interfaces and improve the device lifetime, closing the gap to their market uptake.

References

[1] http://www.nrel.gov/ncpv/images/efficiency_chart.jpg.

[2] G. Grancini et al., Nat. Comm. 8, 15684 (2017)

[3] G. Grancini & M. K. Nazeeruddin, Nat. Rev. Mater. 4, 4–22(2019)

Giulia Grancini is associate professor at Chemistry Dept. of the University of Pavia, leading the PVsquared2 team and the ERC Project “HYNANO” developing advanced hybrid perovskites solar cells. She obtained her Ph.D. in physics from Politecnico di Milano in 2012 and worked as a postdoc researcher at IIT in Milano. From 2015 to 2019, she joined the EPFL awarded by SNSF with the Ambizione Energy Grant. She is currently the Italian USERN ambassador and a board member of the Young Academy of Europe. Since 2019, she has been among the highly cited scientists from Web of Science with h-index of 47 and more than 17000 citations. She has been recently appointed “Cavaliere della Repubblica” for scientific merits by the President Mattarella. More information can be found at https://pvsquared2.unipv.it.

For further information please contact: carlo.casari@polimi.it

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NanoLab Talk

POLITECNICO MILANO 1863 DIPARTIMENTO DI ENERGIA

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, June 8th, 2021 at 16.00 a.m. (CEST Time)
(in teleconference at this link: Click here to join the meeting)

A Novel Source for Ultrafast X-ray Spectroscopy: High-order Harmonic Generation in Glass Chip Fabricated by Femtosecond Laser Micromachining

Caterina Vozzi

Istituto di Fotonica e Nanotecnologie
Consiglio Nazionale delle Ricerche

Ultrafast X-ray spectroscopy allows the study of light-matter interaction with unprecedented temporal and spatial resolution with the further advantages of being element-selective and oxidation- and spin-state specific. The investigation of the properties of core electrons at ultrafast time scales promises to enlighten the dynamics occurring in complex materials.

I will discuss the recent developments we implemented toward attosecond X-ray spectroscopy based on tabletop sources [1]. In particular, I will present some original results on efficient high-order harmonic generation in fused-silica chips fabricated by femtosecond laser micromachining and the development of the transient absorption/reflectivity beamline for the study of materials.

References

[1] A.G. Ciriolo et al., J. Phys. Photonics 2, 024005 (2020).

About the speaker:

Caterina Vozzi is Research Director at Consiglio Nazionale delle Ricerche (CNR). She currently leads the Ultrafast dynamics in matter group at the Institute for Photonics and Nanotechnologies (IFN) of CNR. Her research interests focus on ultrafast spectroscopy and attosecond science. Her contribution to high-order harmonic spectroscopy and Attosecond Science and in the development of high-energy IR parametric source with passive carrier-envelope phase stabilization for strong field application is recognized worldwide.

For further information please contact: carlo.casari@polimi.it

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NanoLab Talk

POLITECNICO MILANO 1863 DIPARTIMENTO DI ENERGIA

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, June 29th, 2021 at 16.00 (CEST)
(in teleconference at this link: Click here to join the meeting)

Polymer adhesion: fundamentals and molecular simulations

Guido Raos

Dipartimento di Chimica, Materiali e Ingegneria Chimica « G. Natta », Politecnico di Milano

Adhesion is about the mechanical properties of the interface between two materials. Any discussion of adhesion must deal with the thermodynamics, the structure and the mechanical response of interfaces, from the macroscopic down to the atomic scale. It is a vast, important and very active research area. In this talk I will try to present it by addressing a few questions:

- What is special about polymer that makes them useful as adhesives?
- What are the current challenges in the development of new adhesive materials?
- What can molecular simulation tell us about adhesion phenomena?

I will present examples from my group's simulations of the mechanical deformation of pressure-sensitive adhesives (i.e. scotch tape) [1] and the breakup of single polymer chains under tension.

References

[1] Baggioli, A.; Casalegno, M.; David, A.; Pasquini, M.; Raos, G. Polymer-Mediated Adhesion: Nanoscale Surface Morphology and Failure Mechanisms. *Macromolecules* **2021**, *54*, 195–202.

About the speaker:

Guido Raos is professor of chemistry at the Politecnico di Milano. He has a degree in chemistry from the Università degli Studi di Milano and a Ph.D. in theoretical chemistry from the University of Bristol. His scientific interests revolve around the theory and computer simulation of polymers and soft matter in general.

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NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, July 20th, 2021 at 16.00 (CEST)
(in teleconference at this link: Click here to join the meeting)

On-surface synthesis of 2D materials with Dirac cones and semiconducting properties

Giorgio Contini[1,2]

[1] Istituto di Struttura della Materia-CNR (ISM-CNR), Via Fosso del Cavaliere 100, 00133 Roma, Italy
[2] Department of Physics, University Tor Vergata, Via della Ricerca Scientifica 1, 00133 Roma, Italy

This Talk will report about the on-surface synthesis tool, that represents an opportunity to synthesize one- and two-dimensional (1D, 2D) nanostructures. A key characteristic of this approach is the possibility to change the materials' characteristics, in particular the electronic band structure, by varying the monomer building blocks (e.g. changing constituent atoms and symmetry). On-surface synthesis permitted the synthesis of mesoscale ordered 2D π-conjugated polymers on Au(111) with semiconducting properties showing Dirac cone structures and flat bands [1], theoretically predicted [2]. Although the 2D polymers have been obtained on a metal surface, they can be transferred to other substrates to be used in devices. These results overcome the major barriers to the application of 2D π-conjugated polymers due to small domain size and high defect density. Dirac cones, present in the band structure of graphene and responsible of its remarkable charge-transport properties, are not exclusive to graphene but require that the material presents specific symmetry and delocalized electrons. Efforts have been devoted to identifying 2D materials beyond graphene that offer a non-zero band gap while retaining high carrier mobility [3].

References

[1] G. Galeotti, …, G. Contini, Nature Materials, 19, 874 (2020).
[2] Y. Jing and T. Heine, J. Am. Chem. Soc. 141, 743 (2019).
[3] K. Asano and C. Hotta, Phys. Rev. B 83, 245125 (2011); J.Wang et al., Natl Sci. Rev. 2, 22 (2015).

About the speaker:

Giorgio Contini is Researcher and Laboratory Head of the SAMOS (Self-Assembled Materials On Surfaces) Lab at ISM-CNR and Acting Professor at the Physics Department, Tor Vergata University, Roma, Italy. He got a MSc in Physics from La Sapienza University, Roma, Italy and a PhD in Materials for Health, Environment and Energy from Tor Vergata University, Roma, Italy. Its main research activity concerns on low-dimensional organic nanostructured materials with the aim of developing molecular electronic devices and sensors.

For further information please contact: carlo.casari@polimi.it

ERC-2016-CoG No. 724610

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, September 7th, 2021 at 16.00 p.m. (CEST Time)
(in teleconference at this link: Click here to join the meeting)

Stryker Trauma and Extremities: Company overview and Medical Device Products development process

Edoardo Besozzi

Stryker T&E - R&D Engineering Services – Selzach (CH)

Stryker is a global market leader in the medical device industry with a wide product diversification in orthopedics, medical and surgical equipment, neurotechnology and spine. The customer focus and company's culture, together with science and innovation that run through Stryker's history since more than 80 years, are at the hearth of the Stryker's mission to make healthcare better. In this regard, Stryker is always looking for engaged, passionate and talented people who seek the innovation, growth and opportunities that are offered.

The first part of the talk will focus on the company overview, on its culture and mission and on career opportunities. To give insights on R&D activities performed at Stryker T&E, the second part of the presentation will provide a general overview of the medical device products development process.

Links

https://www.stryker.com/

About the speaker:

Edoardo Besozzi holds a master's degree in Nuclear Engineering and a PhD in Nuclear and Energy Science and Technology both from Politecnico di Milano, with a specialization in the deposition and characterization of nanostructured films for nuclear fusion applications. Outside of academia, he worked as management consultant at the Italian consulting firm Business Integration Partners before joining Stryker in 2019, where he is currently working in the R&D organization of the Trauma and Extremities division. Here, his main duties are covering biomechanics, digitalization, and regulatory projects.

For further information please contact: carlo.casari@polimi.it

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, October 26th, 2021 at 10.00 a.m. (CEST Time)
(in teleconference at this link: Click here to join the meeting)

$Ti_3C_2T_x$ MXene-Epoxy composite for Joule Heating Application

Subrata Ghosh

School of Materials, The University of Manchester, Manchester M13 9PL, The United Kingdom
Dipartimento di Energia, Politecnico di Milano, Via Ponzio 34/3, Milano, Italy

Electric heating systems have been used in daily life applications such as local heating, de-icing, and other thermal management. Electrothermal materials are used in this context to convert electrical energy into heat energy via Joule heating. Thus, the necessray criteria for those materials should be resistive, good thermally conducting, high-temperature sensitive, low energy consumption and good cycle stability. Although polymer composites are promising, an open challenge is construction of a continuous conductive network of fillers. Hence, $Ti_3C_2T_x$ MXene aerogel is synthesized to provide the interconnected conducting network of 2D materials onto which epoxy resin is infiltarted and shown to be a promising candidate for electrothermal heaters. The aerogel composite shows outstanding Joule heating performance with a surface temperature of 167 °C at a relatively low applied voltage of 3V. In 3D epoxy/MXene aerogel composite, MXene serves as a nanoheater and the epoxy resin spreads the heat. Such epoxy/MXene aerogel composites, prepared by a simple and cost-effective manner, offer a potential alternative to the traditional metal-based and nanocarbon-based electrothermal materials. The result also indicate promising potential for the application of the as-constructed graphene-based aerogel composite in thermal management, energy-storage, electromagnetic interference, microwave shielding and biomedical applications.

References

[1] P. Yang, T. Xia, S. Ghosh*, *et al.*, *Realization of 3D Epoxy resin/$Ti_3C_2T_x$ MXene Aerogel Composites for Low-Voltage Electrothermal Heating* 2D Materials 8, 025022 (2021)

[2] G. Tontini, M. Greaves, S. Ghosh, V. Bayram, S. Barg*, *MXene-Based 3D Porous Macrostructures for Electrochemical Energy Storage*. J. Phys. : Mater. 3, 022001 (2020)

About the speaker:

Subrata Ghosh is a Seal of Excellence Awardee at the Politecnico de Milano, Italy. He has quite significant experiences from his previous positions at the University of Manchester, UK; Chungbuk National University, South Korea and Indira Gandhi Centre for Atomic Research, India. His research accomplishments are designing smart nanostructures such as nanocarbons, 2D materials and metal oxides composites; understanding the growth mechanism of nanostructures; and exploring them for next-generation energy storage, electrothermal and wastewater applications. Till Now, he has published 24 SCI-indexed research articles, 3 review articles, 2 book chapters and 2 conference proceedings. His google scholar citations is 890 and h-index of 19. He gave 7 invited talks in various platform and presented his research in around 19 international conferences. He also served as a peer reviewer for ACS, IOP, RSC, Elsevier and MDPI journals. Notably, he bagged many prestigious awards such as Brain Korea 21 plus postdoc fellow, Dr. K.V. Rao Young Scientist Award, IOP publishing Top cited paper award (India), Outstanding thesis award from Homi Bhabha National Institute and outstanding contribution in reviewing award from Applied Surface Science.

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ERC-2016-CoG No. 724610

NanoLab

NanoLab Talk

POLITECNICO MILANO 1863
DIPARTIMENTO DI ENERGIA

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, November 2nd, 2021 at 10.00 a.m. (CET)
Hybrid mode: in presence in Classroom 19.0.1 (Green Pass required) and in Webex teleconference at this link: Click here to join the meeting

A novel Fourier-Transform spectrometer and its application to Time Resolved Fluorescence and Hyperspectral Imaging.

- From the lab to a start-up company -

Fabrizio Preda
NIREOS s.r.l., Via Giovanni Durando 39, 20158 Milan

Optical spectrometers can be generally divided into two categories: frequency-domain ones, which are based on a dispersive approach, and time-domain ones, based on a Fourier-Transform (FT) approach. Frequency-domain spectrometers are compact and easily available in the visible spectral range, but they typically suffer from low sensitivity levels. On the other hand, FT spectrometers have prominent advantages over dispersive ones, as they can provide higher sensitivity and accuracy levels and a variable spectral resolution. However, commercial FT spectrometers are cumbersome and limited to the infrared spectral region.

In this talk, I will introduce a novel time-domain device, which overcomes the previously mentioned limitations and allows one to unlock all the advantages of FT spectroscopy down to the visible and near-infrared spectral range in a compact design. The instrument is based on a common-path birefringent interferometer, which guarantees excellent light throughput, stability, and accuracy. Such significant performances as well as its versatility have recently led to a commercial product, commercialized by NIREOS, a spin-off company of Politecnico di Milano university. In the second part of the talk, I will discuss the main applications of the interferometer in time-resolved fluorescence spectroscopy and hyperspectral imaging.

About the speaker:

Fabrizio Preda studied Physics Engineering in Politecnico di Milano, where he worked as a research fellow for 5 years after receiving his Master's degree in 2015. He is author of several peer-reviewed articles and co-inventor of three international patents. Since 2018, he is co-founder and Chief Executive Officer at NIREOS (www.nireos.com), a start-up and official spin-off company of Politecnico di Milano. NIREOS develops novel devices in the spectroscopy and photonics sector, both for the scientific and the industrial market.

For further information please contact: carlo.casari@polimi.it

NanoLab Talk

Politecnico di Milano, Department of Energy, Cesnef (Building 19), via Ponzio 34/3, Milan

Tuesday, November 23rd, 2021 at 10.00 a.m. (CET)
Hybrid mode: in presence in Classroom 19.0.1 (with Green Pass) and
in Webex teleconference at this link: Click here to join the meeting

Nonlinear optics in atomically thin materials

Giancarlo Soavi

Institute of Solid State Physics, Friedrich Schiller University Jena

Nonlinear optics is of paramount importance in several fields of science and technology: it is commonly used for frequency conversion, self-referencing of frequency combs, crystal characterization, sensing, and ultra-short pulse generation and characterization. Large efforts have been devoted in the last years to realizing electrical and all-optical modulation of the nonlinear optical response of atomically thin materials, which are easy to integrate on photonic platforms and thus ideal for novel nanoscale devices [1]. In this talk, I will present two approaches to achieve a large modulation of the harmonic generation in graphene and in transition metal dichalcogenides (TMDs). The first method is based on the electrical control of the graphene's Fermi energy. This allows to tune the nonlinear multi-photon resonances occurring within the Dirac cone and thus to achieve a large electrical modulation of the third harmonic generation [2]. The second example regards a new approach for broadband all-optical modulation of the second harmonic generation. The concept is based only on symmetry considerations and thus it is applicable to any material of the D_{3h} symmetry group and with deep sub-wavelength thickness, such as all monolayer TMDs. With this approach we demonstrated a 90° rotation of the second harmonic polarization on a time-scale limited only by the fundamental pulse duration. In addition, this ultrafast polarization switch can be immediately applied to realize all-optical second harmonic amplitude modulation with depth close to 100% [3].

References

[1] N. An et al., Nano Letters 20, 6473 (2020).
[2] G. Soavi et al., Nature Nanotechnology 13, 583 (2018).
[3] S. Klimmer et al., Nature Photonics (2021)

About the speaker:

Giancarlo Soavi obtained his PhD from Politecnico di Milano (group of Prof Giulio Cerullo) in 2015 with a thesis on the ultrafast photophysical properties of quantum confined systems. Subsequently, he worked as a Research Associate at the Cambridge Graphene Centre (University of Cambridge, group of Prof Andrea Ferrari), focusing on the nonlinear optical properties of graphene and related 2D materials. Since 2019 he is a tenure-track Junior professor at the Friedrich Schiller University Jena. He has been a Junior Research Fellow of the Darwin College (University of Cambridge) and he is currently a fellow of the Daimler und Benz Stiftung. He is the leader of the "Lasers and Sources" working group of the European Graphene Flagship and the PI of two DFG projects.

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ERC-2016-CoG No. 724610

NanoLab Talk

Politecnico di Milano, Building 19 (Cesnef), via Ponzio 34/3, Milan

Tuesday, December 14th, 2021 at 11.30 a.m. (CET)

Hybrid mode: in presence in Classroom 19.0.1 and
in Webex teleconference at this link: Click here to join the meeting

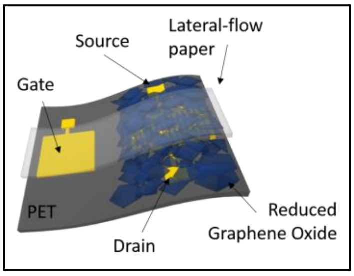
Organic Thin-Film Transistors: from organic semiconductors to 2D materials

Stefano Casalini

Department of Chemical Sciences, Università degli Studi di Padova (Italy)

Electronics is supporting our modern lifestyle in many fields such as telecommunication, the internet of things, sensors, wearables etc. Thin-film transistors are one of the most relevant components in many devices. My research field is focused on organic transistors, whose active material takes advantage of organic semiconductors[1-2] and/or 2D materials[3]. Furthermore, I focused my activity on a specific transistor layout capable to exploit some of the outstanding properties of water, which acts as the gate dielectric.

Here, it is shown some analog applications such as a (bio-)chemical sensor[4] and a flexible device[5], which exploit the electronic feature of 2,8-Difluoro-5,11-bis(triethylsilylethynyl)anthradithiophene (diF-TES-ADT) blended with polystyrene (PS) and a thin-film (few layers thick) of reduced graphene oxide. Finally, it is briefly outlined the ongoing activities focused on the double gate organic transistors as well as the physical transport of graphene nanoribbons.



References

[1] A. Facchetti, Materials Today, 28-37, 10, 3 (2007)
[2] A. A. Virkar et al. Adv. Mater. 3857-3875, 22 (2010)
[3] F. Schwierz et al. Nanoscale 8261, 7 (2015).
[4] S. Ricci et al., Biosens. Bioelectron. 112433, 167(2020).
[5] R. F. de Oliveira et a. Adv. Funct. Mater.1905375 (2019)

About the speaker:

Dr. S. Casalini got his PhD in Chemistry at the University of Modena and Reggio Emilia (2008). He worked in field of Molecular Electronics from 2009 to 2014 at the Institute of Nanostructured Materials (ISMN-CNR, Bologna, Italy). Furthermore, he got a Marie-Curie COFUND fellowship (2015 to 2018) for the development of potentiometric sensors (ICMAB-CSIC, Barcelona, Spain). He has been involved in the Graphene Flagship (2018-2019) to built-up a wearable platform (I.S.I.S. Strasbourg, France). Up to date, he is tenure-track assistant professor at the University of Padua. He is author of more than 40 peer-reviewed papers (h-index 18, more than 1400 citations).

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ERC-2016-CoG No. 724610