Workshop
Department of Physics, University of Ulsan– IPCMS
October 9th 2017

LIA Franco-Coréen
Functional nanostructures: morphology, nanoelectronics and ultrafast optics
PROGRAM

Monday, October 9th

9h00-9h30
S. Haacke
Welcome and general presentation of IPCMS

9h30-10h00
S.C. Hong
Accomplishment for the last 8 years at Energy Harvest-Storage Research Center of University of Ulsan

10h00-10h30
A. Dinia
Functionalized this films oxides for photon conversion and photovoltaic solar cells

10h30-11h00 Break

11h00-11h30
Y.H. Shin
Computational evaluations of energy-harvesting and energy-storing nanocomposite materials

11h30-12h00
M. Boero
Simple but efficient method for inhibiting sintering of catalytic Pt nano-clusters on metal-oxide support

12h00-13h30 Lunch

13h30-14h00
L. Limot
Molecular spin coupling at the tip of a STM

14h00-14h30
J. Kim
STM study on the layered chalcogenide materials

14h30-15h00
B. Donnio
Ligand-Directed Self-Assembly Of Nanoparticles
15h00-15h30
S.L. Cho
2D SnSe single crystal for thermoelectric applications

15h30-16h00 Break

16h00-16h30
F. Banhart
In-situ electron microscopy at high spatial and temporal resolution

16h30-17h00
Y.S. Kim
Monolayer transition metal dichalcogenides growth and its applications

17h00-17h30
S. Berciaud
Optical spectroscopy of heterostructures made from graphene and related two-dimensional materials

October 10th 2017

Visit of IPCMS

October 11th 2017

9h00-12h00
Discussions
Prof. Stefan Haacke
University of Strasbourg
Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504, 67000 Strasbourg, France
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Homepage: http://www.ipcms.unistra.fr/?page_id=6777&lang=en
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Experience

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<td>2004.09 - present</td>
<td>Professor, University of Strasbourg</td>
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<td>1999.09-2004.08</td>
<td>Assistant Professor, University &amp; Swiss Fed. Inst. of Technology Lausanne</td>
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<td>1994.02 – 1999.08</td>
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<td>1988.09-1990.07</td>
<td>M.S., Physics; Technical University Berlin</td>
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<td>1986.09-1988.07</td>
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Research Topics

1. Instrumentation for ultrafast spectroscopy
2. Primary photochemical processes in retinal proteins and biomimetic systems
3. Ultrafast photophysics of molecules and nanostructures for energy conversion

Selected Publications

1. Full account on http://www.researcherid.com/rid/B-5554-2013
Interdisciplinary Research at Strasbourg Institute of Physics and Chemistry of Materials

Stefan Haacke
Director Strasbourg Institute of Physics and Chemistry of Materials (IPCMS)
University of Strasbourg

The Strasbourg Institute of Physics and Chemistry of Materials (IPCMS, [1]) is an interdisciplinary research centre, with a total staff of 230 people, jointly run by the CNRS and the University of Strasbourg. IPCMS brings together physicists and chemists, whose core of research is on the design of molecules, inorganic solids, nanostructures and thin films, and the investigation of these materials from the nano- to the macroscale, with particular attention to their functional properties and/or new fundamental science they may exhibit.

The scientific priorities and international recognition of IPCMS lie in the areas of i) the controlled design of molecular edifices & nanostructures including their self-organisation, ii) nano-magnetism & magneto-electric coupling, iii) spintronics and nano-electronics, iv) ultrafast processes in condensed matter, v) electron and scanning tunnelling microscopy, and vi) new nanomaterials for health & energy conversion applications. Strongly interlaced with notorious national and international partners from academia and industry, our strategy over the last years was to strengthen our position as an internationally renowned institute for interdisciplinary nanoscience covering fundamental and applicative research for innovations in communication technologies, health and energy.

The recent French excellence initiative PIA has brought three new priority programs to IPCMS, since the institute is in charge of the excellence cluster Labex NIE, and is laureate of the two Equipex projects UNION (in coll. with ISIS) and UTEM.

Prof. Soon Cheol Hong

Computational Physics Laboratory
Department of Physics, University of Ulsan
93 Daehak-ro, Nam-gu, Ulsan 44610, Republic of Korea
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Telephone: +82-52-259-23231

Experience

2017.01-present Editor-in-Chief, Physics & High Technology (published by the Korean Physical Society)
2009.09-present Director, Energy Harvest-Storage Research Center, University of Ulsan
1982.03-present Professor, University of Ulsan
1979.03-1982.02 Researcher, Korea Institute of Machinery and Metals
2015.01-2016.12 Editor-in-Chief, Journal of Magnetics (published by the Korean Magnetic Society)

Education

1988.08 Ph.D., Northwestern University
1979.02 M.S., KAIST
1977.02 B.S., Pusan National University

Research Topics

Surface magnetism, magnetostriction, and magnetocrystalline anisotropy using first principle calculation

Selected Publications


Awards

2001 The Year Professor of University of Ulsan
2007 Research Excellency Award given by Korean Magnetic Society
2015 Changsung Award given by Korean Magnetic Society
Accomplishment for the last 8 years at Energy Harvest-Storage Research Center of University of Ulsan

Soon Cheol Hong

Energy Harvest-Storage Research Center and Department of Physics, University of Ulsan

In this presentation I will introduce Energy Harvest-Storage Research Center, focusing on what we have accomplished for the last 8 years. The center has been supported since 2009 by Ministry of Education of Korea. Our main research interests are search for desirable renewable energy materials of solar cell, thermoelectricity, piezoelectricity, and magnetostriction.
Prof. Aziz Dinia
Institut de Chimie et Physique des Matériaux de Strasbourg
University of Strasbourg and CNRS UMR 7504, 23 Rue du Loess, F-67034 Strasbourg, France
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Homepage: http://www.ipcms.unistra.fr/?page_id=11090
Telephone: +33-3-88107067

Experience

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<td>Head of Materials Sciences Master at the University of Strasbourg</td>
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<td>1999.09-present</td>
<td>Professor, ECPM, University of Strasbourg</td>
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<td>1989.09-1999.08</td>
<td>Assistant Professor, University of Strasbourg</td>
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<td>1988.11-1989.08</td>
<td>Postdoc, University of Rennes</td>
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<td>Ph.D., University of Grenoble</td>
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<td>1983.09-1984.08</td>
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Research Topics

1. Thin films oxides for photon conversion and photovoltaic applications
2. Thin films and low dimensional systems for spintronic

Selected Publications

3. Insight into photon conversion of Nd3+ doped low temperature grown p and n type tin oxide thin films, RSC Advances, 6, 67157 (2016).
The synthesis of functional high-quality oxide thin films is a major current research challenge given their potential applications in electronic (flat panel displays, flexible electronics) and optoelectronic (LEDs, photovoltaic) sectors. In particular, transparent conducting oxides (TCOs) are of great interest for solar cells.

Herein, we first report on fabrication and characterization of rare earth (RE) doped TCOs such as ZnO, SnOx or CeOx. The structural, optical and electrical properties of such functionalized oxides will be thoroughly presented. An efficient energy transfer from the RE ions to the host matrix will be presented. The down shifting process will be demonstrated through the conversion of UV photons to infrared ones, which is favorable for reducing the thermalization losses in solar cells.

In a second part, we will quickly report on some alternative materials for solar cells. First the synthesis of a new class of ferroelectric oxide films that has high photons absorption and a moderate bandgap, making them very suitable for photovoltaic applications. Second on halide perovskite, CH$_3$NH$_3$PbI$_3$, that emerged as a light harvester. The power-conversion efficiency of halide perovskite solar cells has soared up to 22.1%\[^1\] earlier this year.
Prof. Young-Han Shin
Multiscale Materials Modeling Lab.
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Homepage: http://may.ulsan.ac.kr/M3L
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Experience
2009.09-present Professor, University of Ulsan
2006.09-2009.08 Research Professor, POSTECH
2001.09-2006.08 Postdoc, University of Pennsylvania, Sejong Univ.

Education
1996.03-2001.08 Ph.D., KAIST
1994.03-1996.02 M.S., KAIST
1990.03-1994.02 B.S., Yonsei University

Research Topics
1. Theoretical modeling of materials with functional properties such as ferroelectrics, piezoelectrics, thermoelectrics, etc.
2. Multiscale computational approaches

Selected Publications
1. bdus Samad, Young-Han Shin, Mo₇@VS₂ nanocomposite as a superior hybrid anode material. ACS Applied Materials & Interfaces 9, 29942-29949 (2017).
Computational evaluations of energy-harvesting and energy-storing nanocomposite materials

Young-Han Shin

Department of Physics, University of Ulsan, Ulsan 44610, Korea

Nowadays people easily bring several electronic devices while traveling in a short or long distance. To make them self-powered, external energy sources such as light, wind, heat might be considered to store their energy in secondary batteries. Depending on the external stimuli, the best responding physical properties can be chosen to find corresponding materials. Computational evaluations of these physical properties can help develop future energy materials. In addition to the energy-harvesting materials, the development of materials is also required for storing energy. In this presentation, I am going to show a series of researches in my research group on the piezoelectric, thermoelectric properties of low-dimensional materials as well as the ionic transport on top of the surface of the materials. Especially we focus on the two-dimensional materials such as graphene, h-BN, silicene, SnSe, SnS, GeSe, GeS, SnS₂, TiS₂, MoS₂, VS₂. For using as solid electrolyte, the structural properties of antiperovskite Na₃OCl will be also mentioned. Most results were obtained from first-principles calculations.

Two physical properties (piezoelectricity and thermoelectricity) for energy harvest that are obtained from total energy calculations. (a) Piezoelectricity of chair hydrogenated or fluorinated h-BN, (b) lattice thermal conductivity of monolayer SnSe₂
Mauro Boero
Institut de Chimie et Physique des Matériaux de Strasbourg

University of Strasbourg and CNRS UMR 7504, 23 Rue du Loess, F-67034 Strasbourg, France

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Experience

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<td>2008.12-present</td>
<td>Research Director, IPCMS University of Strasbourg-CNRS, France</td>
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<tr>
<td></td>
<td>Scientific director of the HPC Mesocenter Equip@Meso, Strasbourg</td>
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<tr>
<td></td>
<td>Visiting Full Professor, The University of Tokyo, Japan</td>
</tr>
<tr>
<td>2001.09-2008.11</td>
<td>Associate Professor, University of Tsukuba, Japan</td>
</tr>
<tr>
<td>1998.05-2001.08</td>
<td>Research Fellow, AIST Tsukuba, Japan</td>
</tr>
<tr>
<td>1996.07-1998.04</td>
<td>Postdoc, Max-Planck Institut für Festkörperforschung, Stuttgart, Germany</td>
</tr>
<tr>
<td>1995.07-1996.06</td>
<td>Postdoc, IBM Research Laboratory, Zurich, Switzerland</td>
</tr>
<tr>
<td>1994.09-1995.06</td>
<td>Postdoc, Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland</td>
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<tr>
<td>1991.09-1994.08</td>
<td>Ph.D., University of Torino (Italy) and EPFL Lausanne (Switzerland)</td>
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<tr>
<td>1989</td>
<td>“Laurea cum laude.” in physics, University of Turin (Italy),</td>
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Research Topics

1. Molecular modeling in materials sciences and biosciences
2. Computational approaches and massively parallel computing

Recent Selected Publications

Simple but efficient method for inhibiting sintering of catalytic Pt nanoclusters on metal-oxide support

Kenichi Koizumi¹,²*, Katsuyuki Nobusada¹,², and Mauro Boero³,⁴,⁵

¹Department of Theoretical and Computational Molecular Science, Institute for Molecular Science, Myodaiji, Okazaki 444-8585, Japan
²Elements Strategy Initiative for Catalysts and Batteries (ESICB), Kyoto University, Katsura, Kyoto 615-8520, Japan
³University of Strasbourg, Institut de Physique et Chimie des Matériaux de Strasbourg (IPCMS), CNRS UMR 7504, 23 rue du Loess, F-67034 Strasbourg, France
⁴Computational Materials Science Initiative (CMSI) Post-K Project, Dept. of Applied Physics, University of Tokyo, Hongo, Tokyo (Japan)

*Corresponding author: mauro.boero@ipcms.unistra.fr

The sintering is a major source of concern in precious metals nano-catalysts since it induces the formation of large nanoparticles and particles with negative consequences on the accessible active surface of the catalyst. We propose a simple and efficient method to inhibit aggregation and sintering of Pt clusters supported on metal-oxide. Our proposed workaround allows to solve this problem and preserves the accessible catalytic surface even at relatively high temperatures (~700 K), as the ones expected to experience by this class of catalytic systems. The key idea is the inclusion of transition metal atoms, such as Ni, into the Pt clusters. Ni atoms, in turn, realize an anchoring via the formation of strong chemical bonds with oxygen atoms present in the typical metal–oxide support. To elucidate the efficiency of the method, we use first-principles molecular dynamics enhanced with free-energy sampling methods. To this aim, we introduce a specific reaction coordinate to control the average coordination number of each cluster insensitive to periodic boundary conditions routinely adopted in this type of simulations. This allows for a precise description of the sintering processes and for an accurate estimation of the related free-energy barriers for aggregations. These virtual experiments show how doped Ni atoms, having a stronger affinity to O than Pt, anchor tightly the Pt nanocluster to the metal-oxide supports and inhibit the tendency of these clusters to aggregate on the support.
Dr. Laurent Limot
Institut de Physique et Chimie des Matériaux de Strasbourg
Université de Strasbourg, CNRS, IPCMS, UMR 7504, F-67000 Strasbourg, France
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Experience

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<td>2006.10-present</td>
<td>CNRS Researcher</td>
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<td>2006.03-2006.09</td>
<td>Postdoc, Université de Strasbourg, CNRS</td>
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<td>2001.01-2006.02</td>
<td>Postdoc, Kiel University</td>
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<td>1997.10-2000.12</td>
<td>Ph.D., Laboratoire de Physique des Solides, Université Parisi-Sud</td>
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<td>1995.10-1997.07</td>
<td>M.S., Université Parisi-Sud</td>
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<td>1992.10-1995.07</td>
<td>B.S., Université Parisi-Sud</td>
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Research Topics

1. Electronic and spin-polarized transport across single atoms and molecules, molecular magnetism, surface magnetism

2. Techniques: Scanning Tunneling Microscopy (STM) and Spectroscopy (STS), Inelastic Electron Tunneling Spectroscopy (IETS), Spin-Polarized STM (SP-STM)

Selected Publications

Molecular spin coupling at the tip of a STM

M. Ormaza¹, P. Abufager², B. Verlhac¹, N. Bachellier¹, M.-L. Bocquet³, N. Lorente⁴, and Laurent Limot¹

¹Université de Strasbourg, CNRS, IPCMS, UMR 7504, F-67000 Strasbourg, France
²Instituto de Física de Rosario, CONICET, Universidad Nacional de Rosario, Argentina
³Ecole Normale Supérieure, UPMC Univ. Paris 06, CNRS, 75005 Paris, France
⁴CFM/MPC and DIPC, 20018 Donostia-San Sebastián, Spain

Recent advances in addressing and controlling the spin states of a surface-supported object (atom or molecule) have further accredited the prospect of quantum computing and of an ultimate data-storage capacity [1]. Information encoding requires that the object must possess stable magnetic states, in particular magnetic anisotropy to yield distinct spin-dependent states in the absence of a magnetic field together with long magnetic relaxation times. Scanning probe techniques have shown that inelastic electron tunneling spectroscopy (IETS) within the junction of a scanning tunneling microscope (STM) is a good starting point to study the stability of these spin states [2]. STM-IETS allows for an all-electrical characterization of these states by promoting and detecting spin-flip excitations within the object of interest. It can also provide an electrical control over them, simplifying the information readout process. As spin excitations need however to be preserved from scattering events with itinerant electrons, single objects are usually placed on non-metallic surfaces such as thin-insulating layers or superconductors.

In this sense, new approaches to improve the detection of spin-flip excitations are desirable. With this purpose we present here a novel strategy based on the molecular functionalization of a STM tip. We study the surface magnetism of a simple double-decker molecule, nickelocene [Ni(C₅H₅)₂], which is adsorbed directly on a copper surface. By means of X-ray magnetic circular dichroism and density functional theory calculations, we show that nickelocene on the surface is magnetic (Spin = 1) and possesses a uniaxial magnetic anisotropy, while IETS reveals an exceptionally efficient spin-flip excitation occurring in the molecule [3]. Interestingly, nickelocene preserves its magnetic moment and magnetic anisotropy not only on the surface, but also in different metallic environments. Taking advantage of this robustness, we are able to functionalize the STM tip with a nickelocene, which can then be employed as a portable source of inelastic excitations. As we will show during the talk, IETS can then be used to probe the interaction between a surface-supported object and the nickelocene tip, including a magnetic interaction.

References
The center panel sketches the STM setups employed. With a metal tip, IETS reveals an exceptionally efficient spin-flip excitation for nickelocene adsorbed on a copper surface. Intense stepped-like features symmetric relative to zero-bias are in fact detected at ±3.2 meV in the tunneling spectrum (left panel). This energy corresponds to the uniaxial magnetic anisotropy of nickelocene, in other words below 3.2 meV the magnetic moment of the molecule is parallel to the aromatic rings, while above 3.2 meV the magnetic moment is along the principal molecular axis. Interestingly, the molecule preserves its magnetic moment and magnetic anisotropy in different metallic environments. By taking advantage of this property, we are able to functionalize the STM tip with a nickelocene molecule. Such a tip can then be employed as a portable source of inelastic excitations and used to produce, for example, a double spin-flip excitation (right panel).
**Prof. Jungdae Kim**

Nanoscale Surface Science Laboratory

Department of Physics, University of Ulsan
93 Dachak-ro, Nam-gu, Ulsan 44610, Republic of Korea

E-mail: kimjd@ulsan.ac.kr

Homepage: https://sites.google.com/site/nsslab6789/home

Telephone: +82-52-259-2324

**Experience**

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<td>M.S., Seoul National University</td>
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<td>1994.03-2000.08</td>
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**Research Topics**

1. Surface science using home-built scanning tunneling microscope (STM)
2. 2D layered chalcogenide materials

**Selected Publications**

1. Revealing the origin of p-type characteristics in a SnSe single crystal. *Appl. Phys. Lett.* (accepted).
STM study on the layered chalcogenide materials

Ganbat Duvjir¹, Trinh Thi Ly¹, Sunglae Cho¹, Young Jun Chang², Jaekwang Lee³, and Jungdae Kim¹,*

¹Department of Physics, BRL, and EHSRC, University of Ulsan, Ulsan 44610, Korea
²Department of Physics, University of Seoul, Seoul 02504, Korea
³Department of Physics, Pusan National University, Busan 46241, Korea

*Corresponding author: kimjd@ulsan.ac.kr

Layered chalcogenide materials (LCMs) have been intensively studied due to their versatile physical properties when prepared in a few monolayer thicknesses. Weak van der Waals coupling between layers allows simple mechanical exfoliation to fabricate two-dimensional LCMs. Scanning tunneling microscopy/spectroscopy (STM/S) is an ideal probe to investigate the microscopic nature of materials at the atomic scale. In this presentation, recent STM studies on SnSe, SnSe₁₋ₓSₓ will be discussed. SnSe is a IV-VI semiconductor with a band gap of ~1.0 eV. Recently, Zhao et al. [Nature 508, 373 (2014)] reported the ultra-high thermoelectric performance of SnSe single crystal with a maximum $ZT = S^2\sigma T/\kappa$ (figure of merit) value of 2.6 at 923 K, where $S$ is the Seebeck coefficient, $\sigma$ is the electrical conductivity, $\kappa$ it the thermal conductivity, and $T$ is the absolute temperature. Although this high $ZT$ value has attracted considerable attention, the microscopic origin of $p$-type character of SnSe has yet to be clearly understood. Here, we directly observed and identified intrinsic point defects existing on the SnSe via home-built STM, and investigated the role of defects on the electronic properties using density functional theory (DFT) calculations. In addition, we investigate the structural evolution of crystalline SnSe₁₋ₓSₓ on the atomic scale by combining STM measurement with DFT calculations. If time is allowed, interesting structural changes on monolayer VSe₂ will be discussed at the end of presentation.
Pictures of home-built low temperature scanning tunneling microscope (STM) system in Nanoscale Surface Science Lab (Prof. Jungdae Kim).
Dr Bertrand DONNIO
Institut de Physique et Chimie des Matériaux de Strasbourg
UMR7504 CNRS-University of Strasbourg
E-mail: bdonnio@ipcms.unistra.fr
Homepage: http://www.ipcms.unistra.fr/?page_id=25889&lang=en
Telephone: +33 (0)688107156

Experience

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<td>University of Strasbourg, F</td>
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<td>PhD</td>
<td>University of Sheffield, UK</td>
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<td>1992.09-1996.09</td>
<td>MS</td>
<td>University of Rennes, F</td>
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Research Topics

1. Supramolecular chemistry, liquid crystal self-assembly
2. Synthesis (oligomeric molecules, dendrons & dendrimers, coordination metal complexes, ..)
3. Functionalization and self-assembly of nanoparticles

Selected Publications

Ligand-Directed Self-Assembly Of Nanoparticles

E. Terazzi,† G. Nealon,‡ S. Buathong,† R. Gréget,† A. Graviluta,† T. Selvam,† C. Dominguez,† D. Jishkariani,‡ Katherine C. Elbert, ‡ B. T. Diroll,‡ M. Cargnello,‡ L. Malassis,‡ C. B. Murray,‡ J.L. Gallani,† B. Donnio†,*

U PENN-SOLVAY (USA)‡ & IPCMS (France)†

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Self-assembly of nanoparticles (NPs) into periodic superlattices is of relevance for engineering materials with new, tunable and reconfigurable functions, and are therefore much sought after for the emergence of innovative applications. The collective physical properties of NPs (especially optical and magnetic) and their interactions with the environment (sound, EM waves) are strongly modified when organized into such superlattices, and are essentially controlled by the symmetry, the nature (single or multicomponent systems) and the interparticle separations. Various strategies for NPs self-assembly have been developed so far with more or less success. We are currently developing a bottom-up chemical route for the fabrication of NP superlattices, whose self-assembly is directed by the surface functionalization (ligand shell) of the NPs. Illustrated by some examples, we will show how the ligand shell affects both self-assemblies and certain other physical properties.

i) Dendritic ligands of several generations tethered to the surface of NPs allow the control of their assemblies into 2/3D superlattices, whereas the change in the dendritic generation allows for a precise and stepwise control of NP separation. This offers potential for optimizing collective responses for applications including optical and magnetic. Dual mixing of dendronized species further produces unprecedented binary superlattices, whose properties are intrinsically modulated at the nm-scale. Multifunctionality in dendrons is readily achieved and leads to unique and original patchy NPs, with modulable surface and self-assembly properties.

ii) Hydrophobic colloidal NPs are mainly synthesized and manipulated with commercially available ligands. These remain invaluable but surface functionalization is typically limited to a small number of molecules. We have recently proposed a robust method using polycatenar ligands for the direct synthesis of a wide variety of monodisperse NPs. Self-assembly into single and binary NP superlattices demonstrates the excellent monodispersity of the so-produced NPs. In addition, some NPs self-assemble into bcc lattices that deviate from conventional close-packed structures (fcc or hcp) formed by the same NPs coated with commercial ligands. These polycatenar ligands impose interparticle spacings and specific attractions, engineering self-assembly, which is tunable from hard sphere to soft sphere behaviour.

Polycatenar and dendritic molecules therefore offer versatile and modular platforms for the development of ligands with targeted properties, bringing organic functionality to inorganic NCs. This subsequently controls aspects such as solubility, wettability, interparticle spacings, self-assembly, liquid crystalline behaviour, biological and physical properties. It is expected that structural complexities and practical utilities be achieved through a thoughtful exploitation of organic chemistry and expanded to various inorganic systems.
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Experience

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<td>2000.3-present</td>
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Education

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<td>Pusan National University</td>
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<td>Pusan National University</td>
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Research Topics

1. Thin film & superlattice thermoelectric materials
2. Magnetic thin film and artificial layers
3. Oxide thin film growth using atomic oxygen source

Selected Publications

2D SnSe single crystal for thermoelectric applications

Anh Tuan Duong, Van Quang Nguyen, Ganbat Duvjir, Van Thiet Duong, Suyong Kwon, Jae Yong Song, Jae Ki Lee, Ji Eun Lee, Su-Dong Park, Taewon Min, Jaekwang Lee, Jungdae Kim, and Sunglae Cho

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2 Division of Industrial Metrology, Korea Research Institute of Standards and Science (KRISS), Daejeon 305-340, Republic of Korea
3 Thermoelectric Conversion Research Center, Creative and Fundamental Research Division, Korea Electrotechnology Research Institute (KERI), Changwon 51543, Republic of Korea
4 Department of Physics, Pusan National University, Busan 605-735, Republic of Korea

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SnSe is a semiconductor with an indirect band gap energy of \( E_g = 0.829 \) eV at 300 K with orthorhombic \( Pnma \) phase, while it shows direct band gap of \( E_g = 0.464 \) eV with \( Cmcm \) structure phase at high temperature. It exhibits two dimensional (2D) layered structure with strong Sn-Se bonding along b-c plane and weaker bonding along a axis direction, resulting in a strong anisotropic transport properties. Recently, Zhao et al. reported that high thermoelectric power factor and low thermal conductivity at high temperature make SnSe as a very good \( p \)-type thermoelectric material; \( ZT \) values along b and c axes are up to 2.6 and 2.3 at 923 K, respectively. They attributed the remarkably high \( ZT \) value along the b axis to the intrinsically low lattice thermal conductivity in SnSe. More recently, two first-principles calculations predicted good thermoelectric performances in both \( n \)- and \( p \)-type SnSe’s and better \( n \)-type thermoelectric properties than \( p \)-type SnSe and J. Yang et al. predicted \( ZT \sim 3.1 \) in \( n \)-type SnSe. Here we report that \( n \)-type SnSe single crystals were successfully synthesized by doping for the first time and also \( n \)-type carrier concentration can be controlled by doping content. In this talk we will discuss on dopant type and thermoelectric properties of SnSe single crystals in detail.
Prof. Florian Banhart

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Experience

since 2007  Professor of Physics, University of Strasbourg
2003 – 2007  Professor of Physical Chemistry, University of Mainz, Germany
1999 – 2003  Staff Scientist, University of Ulm, Germany
1989 – 1999  Scientist, Max-Planck Institute of Metals Research, Stuttgart, Germany

Education

1988  PhD, University of Stuttgart, Germany
1985  Master in Physics, University of Stuttgart, Germany

Research Topics

1. Low-dimensional nanomaterials
2. Electron microscopy

Selected Publications

In-situ electron microscopy at high spatial and temporal resolution

Kerstin Bücker, Matthieu Picher, Ferdaous Ben Romdhane, and Florian Banhart*

Institut de Physique et Chimie des Matériaux de Strasbourg, CNRS, Université de Strasbourg

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In-situ transmission electron microscopy carries out experiments on small objects while they are under observation in the microscope. Dynamic phenomena in nanoobjects can thus be observed in real time and at atomic spatial resolution. Examples of our recent work in in-situ experimentation will be shown where the integration of an STM tip into the TEM specimen stage allowed the electrical characterization of nanomaterials. In such an arrangement, the electrical properties of chains of carbon atoms in the sp$^1$ hybridization have been studied. Among many other previously unknown features, a metal-semiconductor transition upon straining the atomic chains has been found (Nat. Comm. 6, 6636 (2015)).

While the spatial resolution of conventional in-situ TEM has reached the ultimate limits, the temporal resolution remained moderate. Now, with pulsed electron beams, the timescale down to the picosecond becomes accessible. A new ultrafast TEM has been installed at the IPCMS in the past years in the framework of a national excellence initiative. The microscope is able to operate in the stroboscopic as well as in the single-shot mode to study reversible as well as irreversible phenomena in nanomaterials with pico- to nanosecond time resolution. The potentials of this new technique will be presented on the basis of the first results obtained with this microscope (Ultramicr. 171, 8 (2016)).
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Experience

2016.01-present Chair, Department of Physics, University of Ulsan
2016.01-present Director, BK21+ program
2014.08-2016.07 Vice president, Natural Science College, University of Ulsan
2014.10-present Associate Professor, University of Ulsan
2013.08-2014.02 Visiting Scholar, State University of New York, Binghamton
2008.09-2014.09 Assistant Professor, University of Ulsan
1998.10-2008.08 Principle, Senior, and Junior Researcher, Memory R&D Division, SK-Hynix Semiconductor Inc.

Education

1993.03-1998.08 Ph.D., Seoul National University
1991.03-1993.02 M.S., Seoul National University
1987.03-1991.02 B.S., University of Ulsan

Research Topics

1. TMDC (Transitional metal dichalcogenides; MX$_2$) growth and electrical/optical characterization, especially nonlinear optical properties
2. Valleytronics & Bose-Einstein condensation with half matter-half photon, Polariton
3. Thin film solar cell with abundant materials, such as Cu$_2$ZnSnS(Se)$_4$ and organic material.

Selected Publications

Monolayer transition metal dichalcogenides growth and its applications

Chinh Tam Le,1 Farman Ullah,1 Joon. I. Jang,2 and Yong Soo Kim1,*

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Graphene, a single atomic layer of carbon atoms, has attracted grated attention because of its novel physical properties and potential for electro-optical technology. Recently this interest has expanded to the wide class of two-dimensional materials that occur naturally as 2D layers of van-der-Waals crystals. While preserving graphene’s flexibility and tenability by external perturbations, atomically thin layers of this broader set of materials provide access to more varied electronic and optical properties, including semiconductor and insulating behavior.

In this presentation, we will discuss some distinctive properties and large area continuous growth of atomically thin 2D semiconductor, especially transition metal dichalcogenide (MX2 where M=Mo, W and X = Se, S). [1,2] We also demonstrated monolayer Mo(S,Se)2 is next generation nonlinear optical material for its strong optical nonlinear properties with second harmonic generation characteristics. [3-5] Furthermore we will demonstrate the covalently bonded in-plane heterostructure (HS) of monolayer transition metal dichalcogenides (TMDs) possesses huge potential for high-speed electronic devices in terms of the new exciting field of valleytronics.

References
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Experience

2016-present  Professor, Université de Strasbourg
              Junior member of Institut Universitaire de France (IUF)
2010-2016     Assistant Professor, Université de Strasbourg
2007-2010     Postdoctoral research scientist at Columbia University (New York, USA)
2007          Postdoctoral research scientist at Université Bordeaux 1 (France)

Education

2006          PhD in Physics at Université Bordeaux 1 (France)
1999-2003     Ecole Normale Supérieure de Cachan (France)

Research Topics

• Graphene, transition metal dichalcogenides and low-dimensional heterostructures
• Nanophotonics, optical spectroscopy
• Nanodevices, optoelectronics, optoelectromechanics

Selected Publications

Optical spectroscopy of heterostructures made from graphene and related two-dimensional materials

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The recent rise of a vast family of two-dimensional materials (such as graphene, boron nitride and transition metal dichalcogenides) with unique electronic and optical properties has opened exciting perspectives for the design and study of van der Waals heterostructures [1]. At the same time, a variety of low-dimensional semiconductor nanostructures with size- and shape-tunable optical properties can be routinely synthesized using colloidal chemistry methods and combined with two-dimensional materials to form hybrid heterostructures [2-4]. The behavior of photoexcited carriers and excitons in both types of heterostructures is strongly affected by near-field coupling. In particular, photoinduced charge transfer [2] and/or Förster-type energy transfer [3,4] at a heterointerface may drastically alter the photophysical and optoelectronic properties. Unravelling the efficiency of these phenomena and their dependence upon the incoming photon flux or an externally applied field is of utmost importance for optoelectronic and energy-related applications.

In this presentation, we will introduce some unique physical properties of two-dimensional materials and review recent optical studies of charge and energy transfer in hybrid and van der Waals and heterostructures [4,5].

Figure 1: (a) Optical image of a MoSe$_2$/graphene (SLG) van der Waals heterostructure fabricated at IPCMS. Photoinduced charge and energy transfer from a two-level system to graphene are illustrated in (b). The map of the graphene Raman G-mode frequency (c) and of the MoSe$_2$ photoluminescence intensity (d) of this sample reveals clear signatures of interlayer coupling on the heterostructure (dashed contour in a, c, d). In particular, the significant stiffening of the Raman G-mode observed on the heterostructure (c) is assigned to photoinduced electron transfer from MoSe$_2$ to graphene (from [5]).

5 G. Froehlicher, E. Lorchat, S. Berciaud Arxiv 1703.05396