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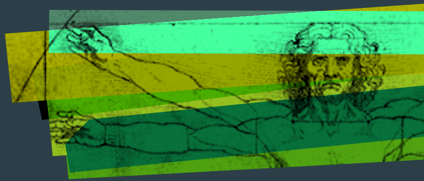
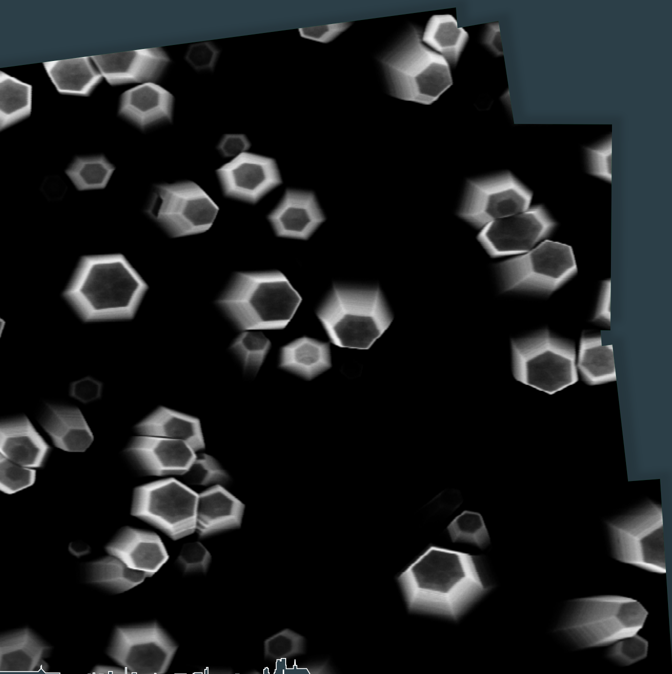


27-29 August 2018

Frontiers in Nanomaterials for Energy Harvesting and Storage



LOCATION

Hôtel de Ville de Tours,
Place Jean Jaurès,
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CONVENORS

Pr Emre Erdem

LE STUDIUM/MARIE SKŁODOWSKA-CURIE RESEARCH FELLOW

FROM University of Freiburg - Institute of Physical Chemistry - DE

IN RESIDENCE AT Research Group for Materials, Microelectronics, Acoustics and Nanotechnologies (GREMAN) / CNRS, INSA CVL, University of Tours - FR

Dr Guylaine Poulin-Vittrant

Research Group for Materials, Microelectronics, Acoustics and Nanotechnologies (GREMAN) / CNRS, INSA CVL, University of Tours - FR

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ABSTRACTS

Frontiers in Nanomaterials for Energy Harvesting and Storage

EDITO

Created in 1996 on the CNRS campus in Orleans La Source, LE STUDIUM has evolved to become a multidisciplinary Loire Valley Institute for Advanced Studies (IAS), operating in the region Centre-Val de Loire of France. LE STUDIUM has its headquarters in the city centre of Orleans in a newly renovated 17th century building. The amazing facilities are shared with the University of Orleans. In 2014 new developments and programmes linked to the smart specialisation of the Centre-Val de Loire region came to strengthen existing IAS cooperative relationships with the local and the international community of researchers, developers and innovators.

LE STUDIUM IAS offers to internationally competitive senior research scientists the opportunity to discover and work in one of the IAS's affiliate laboratories from the University François-Rabelais of Tours, the University of Orleans, National Institute of Applied Sciences (INSA) Centre Val de Loire and ESAD Orléans, as well as of nationally accredited research institutions located in the region Centre-Val de Loire (BRGM, CEA, CNRS, INSERM, INRA, IRSTEA). Our goal is to develop and nurture trans-disciplinary approaches as innovative tools for addressing some of the key scientific, socio-economic and cultural questions of the 21st century. We also encourage researchers' interactions with industry via the IAS's links with Poles of Competitiveness, Clusters, Technopoles, and Chambers of Commerce etc.

LE STUDIUM has attracted over one hundred and sixty LE STUDIUM RESEARCH FELLOWS and LE STUDIUM RESEARCH PROFESSORS for long term residencies. In addition to the contribution in their host laboratories, researchers are required to participate in the scientific life of the IAS through attendance at monthly interdisciplinary meetings called LE STUDIUM THURSDAYS and gathering members of the regional scientific community and industries.

For the period 2015-2020, LE STUDIUM operates with an additional award from the European Commission in the framework of the Marie Skłodowska-Curie Actions (MSCA) with the programme MSCA-COFUND for the mobility of experienced researchers. This co-funding instrument increases the number of LE STUDIUM fellowships to be awarded each year. LE STUDIUM is also the official partner of the Ambition Research and Development 2020 (ARD 2020) initiated by the region Centre-Val de Loire, that supports the specialisation strategy around 5 main axes: biopharmaceuticals, renewable energies, cosmetics, environmental metrology and heritage intelligence.

Researchers are also invited and supported by the IAS to organise, during their residency and in collaboration with their host laboratory, a two-day LE STUDIUM CONFERENCE. It provides them with the opportunity to invite internationally renowned researchers to a cross-disciplinary conference, on a topical issue, to examine progress, discuss future studies and strategies to stimulate advances and practical applications in the chosen field. The invited participants are expected to attend for the duration of the conference and contribute to the intellectual exchange. Past experience has shown that these conditions facilitate the development or extension of existing collaborations and enable the creation of productive new research networks.

The present LE STUDIUM CONFERENCE named "Frontiers in Nanomaterials for Energy Harvesting and Storage" is the 78th in a series started at the end of 2010 listed at the end of this booklet.

We thank you for your participation and wish you an interesting and intellectually stimulating conference. Also, we hope that during these three days some of you will see an opportunity to start a productive professional relationship with LE STUDIUM Loire Valley Institute for Advanced Studies and research laboratories in the region Centre-Val de Loire.

Yves-Michel GINOT

Chairman
LE STUDIUM

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Emre Erdem is LE STUDIUM / Marie Skłodowska-Curie Research Fellow at GREMAN laboratory, University of Tours (France). He obtained a PhD in Physics in 2006 from University of Leipzig (Germany). His PhD thesis was mainly about the investigation of size effects on ferroelectric $PbTiO_3$ nanoparticles via EPR spectroscopy. In 2010 he became a research group leader in University of Freiburg on spectroscopic studies of functional nanomatrials. He has a strong background in diverse fields, such as materials physics, physical chemistry, atomic physics, solid-state physics, defect chemistry, studies of electronic properties of energy materials and the synthesis and characterization of nanocrystals (functional nanomaterials, piezoelectrics, supercapacitors and, in particular, semi-conducting quantum dots). In addition, he has expertise not only in advanced spectroscopic methods, such as electron paramagnetic resonance (EPR), Raman spectroscopy, impedance spectroscopy, ultraviolet-visible (UV-VIS) and photoluminescence (PL) spectroscopies, but also on imaging techniques such as transmission/scanning (TEM/SEM) electron microscopy, both theoretically and experimentally. He won Eugen Grätz Prize in 2011 and won DAAD scholarship in 1999. He (co-)authored more than 70 publications in international journals and more than 50 communications in international conferences.

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Guylaine Poulin-Vittrant is full time researcher at GREMAN laboratory, University of Tours (France). She obtained a PhD in Electrical Engineering in 2004 from Paris XI University (France). Her PhD thesis was dedicated to human mechanical energy harvesting using bulk PZT ceramics. In 2005 she became full time researcher at Grenoble Electrical Engineering Laboratory (G2Elab) and joined GREMAN laboratory in 2008. Her research interests are experimental investigation and theoretical models development for piezoelectric materials and devices, for various applications: actuators for flapping wing micro air vehicles (MAVs), piezoelectric transformers, piezo-semiconducting nanowires for mechanical energy harvesting. She has participated and participates in European ("MIND" EU Network of Excellence, Piezo Institute, "EnSO" ECSEL JU project), national ("OVMI","EVA", "FLEXIBLE" ANR projects) and regional ("CEZnO", "MEPS", "CELEZ") projects. She (co-)authored more than 30 publications in international journals and more than 40 communications in international conferences.

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PhD in Physics in 2007 at University of Modena and Reggio Emilia under the supervision of Prof. S. Valeri ; Postdoc at CNR-NANO and visiting scientist at Fritz-Haber-Institut under supervision of Prof. H.-J. Freund and Dr. N. Nilius developing a consolidated experience on oxide thin films and metal nanoparticles growth, morphological, electronic and optical characterization with electron spectroscopies and scanning probe microscopies. Since 2012 researcher at CNR-NANO in Modena, with interests in metal/oxide nanosystem growth , electronic and optical characterization for application in plasmonics, photocatalysis and photovoltaics.

Tailoring plasmonic response in metal/oxide nanosystems

Co-authors: A. di Bona[1], G. Vinai[3], Andrea Perucchi[4], Paola Di Pietro[4], Stefano Lupi[3,4,5], A. Ruini[1,2] , S. Valeri[1,2], A. Catellani[1], P. Torelli[3], A. Calzolari[1]

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Coupling oxides with metals either through doping or by means of nanostructures has shown to be a versatile means to tune the properties of oxide materials for electronic, optical and chemical applications. In this framework transparent conducting oxides with high transparency, low electric resistivity and tunable IR plasmonic response are obtained doping wide-band gap semiconductors. However, the presence of structural defects results in an unpredictable complexity that prevents a clear identification of chemical and structural properties of the films, thus their identification and control is highly desirable.

We present here our recent works on ZnO coupled with metal to promote the rising of interesting properties with application in energy conversion and NIR telecommunications devices. We have exploited the chemical sensitivity of Hard X-ray Photoelectron Spectra and Near Edge X-ray Absorption Fine Structure in combination with DFT to determine the spectroscopic response of defects in Al-doped ZnO films and their role in the material response. Spectroscopic modifications have allowed to determine the concentration of embedded defects and to clarify the contributions coming from Al atoms, together with small lattice distortions. Consequences on the optical response in the UV-VIS and IR and band populations are discussed, fundamental for application as an alternative plasmonic material. Finally coupling with metal nanoparticles is presented in view of plasmonic applications.

Dr Thomas Defforge

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Thomas Defforge is currently assistant professor at the INSA – Centre Val de Loire and GREMAN – Université de Tours. His research interests are semiconductor nanostructures (especially porous silicon) obtained by chemical or electrochemical etching for microelectronics and energy storage.

Free-standing Si nanostructures for Li-ion battery anode application

Co-authors: Gaël Gautier, Joe Sakai, Erwann Luais, Fouad Ghamouss, François Tran Van

With a view to produce light and portable lithium-ion battery (Li-B), silicon is presented as an attractive material for anode electrodes owing to its high theoretical capacity (> 3500 mA.h/g). However, the large volume variations induced by lithium alloying/de-alloying during silicon anode test cycling strongly limits its lifetime. Thanks to its sponge-like structure, porous silicon has demonstrated improved volume change accommodation during battery cycling and thus enhanced performance stability. For this purpose, several silicon micro- and nanostructures have thus been studied as Li-B anodes. These structures were obtained by electrochemical etching of monocrystalline Si. The obtained macroporous and mesoporous layers were first covered by a copper current collector by electrochemical deposition. Then, the Cu/PSi bilayer was peeled off from the silicon substrate and used as Li-B anode. Macroporous layers showed interesting cycling stability (600 mA.h/g during 200 cycles @ 1.8A/g). Then, ionic liquid electrolyte have been used in order to improve the electrode stability. Stable performances have been obtained over 900 cycles @ 1000 mA.h/g without any capacity fade.

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Professor Robert Dorey holds the chair in Nanomaterials at the University of Surrey and is Fellow of the Institute Materials, Mining and Minerals (FIMMM) and the Higher Education Academy (FHEA) as well as being a Chartered Scientist and Engineer.
His research interests are focussed on the synthesis & manipulation of nanomaterials for the manufacture of functional devices for energy & environmental applications. Examples include thermoelectric and piezoelectric energy harvesters, solar thermal energy capture and storage, as well as sensors for detection of nanomaterials in the environment and acoustic structural health monitoring. His research has a particular focus on micro-scale processing, materials integration and manufacture to allow the creation of unique 3D micro and nanoscale structures. Within this context he has a particular interest in sustainable materials and manufacturing processes as well as understanding the fate of nanomaterials in the environment.
Professor Dorey joined the University of Surrey in 2014. Prior to this he was at Cranfield University and between 2003 and 2008 he held a prestigious Royal Academy of Engineering/EPSRC Research Fellowship.

Towards sustainable manufacture of functional materials and devices

Co-authors: Rebecca Townsend, Ewa Jakubczyk

The use of nano-suspensions in print manufacture holds much promise to reduce the environmental and energy impacts of manufacturing inorganic functional devices for energy conversion. Here we explore not only the potential to minimise such impacts through low temperature processing and direct writing, but also the potential to reduce these impacts during the production of nano-suspension.

The top down production and bottom up liquid phase synthesis of nanomaterials are reliant on the use of relatively dilute solutions and suspensions in order to produce and maintain stable and nano-scale products. Following processing or synthesis any unreacted reagents, by-products or stabilisers need to be removed from the system by washing before the nanoparticles can be used. This need to wash the materials and the dilute suspensions mean that significant amounts of liquid can be required during manufacture. Even where water is used in place of solvents or oils, the resultant contamination, means that it cannot simply be disposed of by flushing down the drain.

Large volumes of dilute suspensions are costly to transport to waste disposal stations and it is energy intensive to use thermal evaporation to remove the majority of the water prior to transportation. Here we explore the viability of different processing routes designed to minimise the volume of waste water produced and examine research on a closed loop water removal and recycling techniques aimed at reducing this to zero.

Dr Luis Fonseca

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Dr. Luis Fonseca was born in Barcelona, Spain, in 1966. He received his Ph.D. degree in Physics from the Autonomous University of Barcelona in 1992. He has developed his professional career in the National Center of Microelectronics (CNM). He is currently leading the 'MicroEnergy sources and Sensor Integration' research group, which deals with gas sensors, Si nanowire based thermogenerators, and micro fuel cells. He recently coordinated the FP7 SiNERGY project (FP7-NMP-2013 GA 604169), which focused in Silicon friendly materials and device solutions for microenergy applications.

Research on thermoelectric microgenerators based on Si and SiGe nanowires as thermoelectric material

Co-authors: Inci Donmez[1], Marc Salleras[1], Marc Dolcet[1], Andrej Stranz[1], Albert Tarancón[2], Alex Morata[2]

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Thermoelectricity can help in waste heat recovery scenarios for improving the energy efficiency of industrial processes or engines, and it can also play a role in energy harvesting, powering sensor nodes where hot surfaces are available. For the latter, small size may be necessary and micro-generators would be advisable. However, standard thermoelectric technology is not prone to miniaturization. Silicon technology is the archetypical miniaturization technology and enables device large-scale production. Silicon itself is not a good thermoelectric material because of its large thermal conductivity but low-dimension silicon may offer a way of circumventing this issue. In this context, our two groups have collaborated in an approach for devising all-silicon thermoelectric micro-generators.

This work deals with the optimization of a silicon compatible planar thermoelectric micro-generator based on the use of Si and SiGe nanowire arrays (for the first time) as thermoelectric material. Dense arrays of such nanowires have been monolithically integrated by means of VLS-CVD into a silicon micromachined device composed of a suspended microplatform and a surrounding bulk Si rim. A previous design has been optimized leading to a significant reduction in device thermal conductance and electrical resistance and, consequently, higher power output. Power output boosted even more after the integration of a mini heat exchanger on top of the device, featuring values of tens of μW/cm2 (@100 ºC heat source) that could help powering IoT nodes.

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Fabien Giovannelli received his PhD degree in material sciences from Caen University in 2002, and is assistant professor at University of Tours since 2005. He is in charge of the research group "Functional oxides for energy efficiency" of GREMAN Laboratory. His research activitiy is focused on solid state chemistry, especially the synthesis and characterization of oxide materials with remarkable properties (thermoelectrics, piezoelectrics, superconductors, ...). The objectives of the research undertaken are the understanding of all the mechanisms which control properties in oxides and their correlation with chemistry or manufacturing process for devices or application referred to energy transport, storage, conversion or saving. He has published 61 articles in international journals.

Improvement of thermal Properties of transparent conducting oxide ceramics by nanostructuring for thermoelectrics applications

Co-authors: Frédéric Schoenstein, Pablo Diaz-Chao, Raphael Dujardin, Cong Chen, Emmanuel Guilmeau, Isabelle Monot-Laffez, Fabian Delorme

Nanostructured ceramics can exhibit enhanced or new properties such as transparency, reduced thermal conductivity... To obtain nanostructured ceramics, it is necessary to first start from nanosized grain powders and second avoid the grain growth step that usually occurs during sintering at high temperatures. Therefore, new synthesis routes at low temperature in aqueous medium with high reaction yield have been developed for ZnO and SnO2.

SnO2 nanoparticles (4-6 nm) were obtained by precipitation at 100°C in water under reflux [1]. For SnO2, dense ceramics (relative density ≥ 94 %) were obtained by different SPS sintering route at 950°C) The average grain size is circa 60 nm. Nanostructured ceramics shows low thermal conductivity of 7 and 2 $Wm^{-1}K^{-1}$ at RT and 1000 K respectively, compared to 40 and 10 $Wm^{-1}K^{-1}$ for dense micron-sized grains SnO2 ceramics.

A simple precipitation method with soda addition allows obtaining various ZnO particle morphologies (nanoparticles of 50 nm, platelets, sand-roses) by changing temperature or aluminium content [2]. For Al doped ZnO powder, dense ceramics were obtained by Spark Plasma Sintering at 500°C. The effect of nanostructuring on thermal conductivity and their stability have been studied.

[1] R. Dujardin et al. Materials Letters 187 (2017) 151-153.

[2] F. Giovannelli et al. Powder Technology 262 (2014) 203-208.

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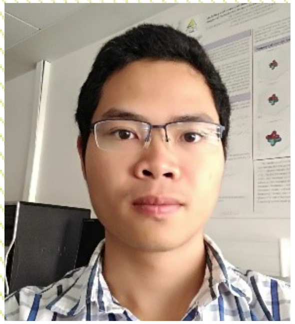
Dr. Noelle Gogneau, 41 years old, is a CNRS scientist working at Center for Nanosciences and Nanotechnologies (C2N-CNRS). She received her Ph.D. degree in Physics in 2004. After a post-doctoral position at the Laboratory of Physics of Nanostructures – EPFL – Lausanne, Switzerland, she joined the C2N-CNRS in 2006. From July 2011, her research activities are centered on the growth of III-nitrides nanowires by PA-MBE and their characterization for Nano-Energy applications, with an emphasis on the piezoelectric properties of 1D-nanostructures for the development of a new generation of nano/piezo-generators. N. G. is curently the Scientific coordinator of the "Properties and application of epitaxial systems" axis of the French research group PULSE.

High potential of III-Nitride nanowires for piezoelectric energy harvesting: Towards wireless sensors

The development of autonomous micro-devices for sensing, monitoring and nomad electronics is today a worldwide challenge. The III-Nitride nanowires (NWs) based piezo-generators have emerged as excellent candidates to fabricate new competitive electrical energy sources by harvesting surrounding mechanical deformations and vibrations.

Based on a systematic multi-scale analysis, going from single wire properties to macroscopic device fabrication and characterization, we demonstrate the high potential of III-N NWs for piezo-conversion and the relationship between the material properties and the piezo-generation. Hence, we establish that individual MBE-grown p-doped GaN NWs can generate an average output voltage of 228 ± 120 mV and a maximum value of 350 mV per NW. We also establish that, in the case of p-doped GaN NWs, the piezo-generation is achieved when a positive piezo-potential is created inside the nanostructures, i.e. when the NWs are submitted to a compressive deformation. Thank to this fine understanding of the piezo-conversion mechanisms, we propose an efficient piezo-generator design delivering a maximum power density of the order of few tens of mW/cm^3. This value settles the new state of the art for piezo-generators based on Nitride NWs, and offers promising prospects, since the generated power density is already interesting for real world applications such as remote wireless transceivers.



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Thien Hoang is a Research Engineer at the Advanced Research department of VERMON SA (Tours, France). He received his engineering degree from INSA Centre Val de Loire in 2015. He is currently pursuing a PhD thesis at GREMAN laboratory (UMR CNRS 7347, Tours, France) in Engineer Science. His research interests include energy harvesting applications.

An efficient tool for modelling piezoelectric cantilevers used for mechanical energy harvesting

Co-authors: Bavencoffe M., Poulin-Vittrant G., Ferin G., Levassort F., Bantignies C., Nguyen-Dinh A., Lethiecq M.

Ambient vibration energy harvesting by piezoelectric materials consists in converting wasted mechanical energy available in our environment into electrical energy in order to supply low consumption electronic devices. The two main structures of piezoelectric cantilever beams used for vibration energy harvesting are the unimorph, constituted of one PZT layer bonded on an elastic one, and the bimorph, made of two PZT layers separated with an inner elastic shim material. Further deepening the comprehension of these mechanical energy harvesters will facilitate their design. Numerical models are powerful tools and require an accurate set of material properties of the PZT layer. For this purpose, an original method has been introduced1, requiring only the electrical impedance measurement of the PZT layer in free-free mechanical boundary conditions: the effective values of the electrical, mechanical and piezoelectric tensors are identified using successively a one-dimensional analytical model and a three-dimensional finite element (FE) model of the electrical impedance.

The pursued goal is to build a 3D FE model for the design of our harvesters. Even if the PZT layer is investigated in free-free boundary conditions, our final devices will be clamped. Then the influence of the modification of the mechanical boundary conditions has to be determined. For each structure, a frequency domain study is performed between 60Hz and 145Hz on a 3D FE model in clamped-free mechanical boundary conditions to calculate the electrical impedance. Then these numerical results are compared to experimental measurements. The discrepancy between modelling and experiment results is less than 4% in frequency. This demonstrates the accuracy of our model to predict the electrical behavior of piezoelectric cantilevers in clamped-free mechanical boundary conditions. The next step of this work is to model and characterize the vibrational behavior of our clamped devices and the electrical output characteristics for mechanical energy harvesting.

References

[1]T. Hoang, G. Poulin-Vittrant, G. Ferin, F. Levassort, C. Bantignies, A. Nguyen-Dinh, M. Bavencoffe, Parametric study of a thin piezoelectric cantilever for energy harvesting applications, Advances in Applied Ceramics (2017) 6pp.

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Dr. Kim is currently working on low-temperature atomic force microscopy and bulk-/flexo-photovoltaic effect with Prof. Marin Alexe. His Ph.D. thesis, attained at Seoul National University, was about ferroelectric polarization switching with and without an external electric field. During the post-doc periods in Strasbourg, France and Lincoln, US, he studied MgO-based magnetic tunnel junctions, ferroelectric/multiferroic tunnel junctions and memristors, and domain wall conduction. His main research interest is in (multi-)functional materials/devices and energy harvesting.

Flexo-Photovoltaic Effect

Co-authors: Dr. Ming-Min YANG, Prof. Marin ALEXE

The conventional bulk photovoltaic (BPV) effect, which is free from the Shockley-Queisser (S-Q) detailed balance limit, is attributed to quantum mechanical processes asymmetric in momentum space arising only in noncentrosymmetric semiconductors. I like to show here that an inhomogeneous deformation breaks the materials' symmetry and induces a local BPV effect generating giant photovoltaic currents, even in centrosymmetric single crystals, which is named flexo-photovoltaic (FPV) effect. The FPV effect is demonstrated by showing that a sharp tip of atomic force microscopy or a probe needle of micro-indentation with a sufficient loading force enhances significantly the short-circuit photocurrent of centrosymmetric $SrTiO_3$, TiO_2 and Si single crystals and by showing a light polarization dependence of the enhanced photocurrent. The FPV effect does not need any Fermi level gradient as in p-n junctions of a proper band alignment, whereas only simple strain gradient generator, such as a sharp probe or possibly mechanical bending, is sufficient. The FPV effect is expected to be universal in all semiconductors and inherently free from the S-Q limit. This effect will extend remarkably present solar cell technologies by boosting the solar energy conversion efficiency of a wide pool of established semiconductors and an important strain engineering playground for improving the final performance of solar cells and optoelectronic devices is now open.

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Arnaud Le Febvrier has formal education in materials science and received his PhD from the university of Rennes 1 in 2012 (ferroelectric / piezoelectric thin films). His scientific carrier continued by a post-doctoral research in the National Institute of Materials Science (NIMS, Japan) in the environmental and energy materials division (optoelectronic materials / thin film). After 2 years of post-doctoral fellowship at the university of Linköping (Sweden, 2013-2015), he accepted, in 2017, a position of assistant professor in the same unit: energy materials, thin film division.
He is currently developing thin films (oxide / oxynitride / nitride) thin films for various applications but a main focus on thermoelectric applications. More recently, new projects started with close collaborations with industries for the development of fuel cells and specifically active/protection coating in fuel cells.

Thermoelectric CrN: from n-type to p-type semiconductor behavior

Co-authors: D. Gambino, M. A. Gharavi, G Abadias, D. Fournier, B. Alling, P. Eklund

Thermoelectric properties of chromium nitride (CrN) based thin films grown on c-plane sapphire and MgO substrate by dc-reactive magnetron sputtering were investigated. CrN is well known as a degenerate n-type semiconductor. In this work, aluminum doping was introduced in CrN using co-sputtering deposition. Under the present deposition conditions, over-stoichiometry in nitrogen (CrN_{1+x}) is obtained in the epitaxial rock-salt structure. Structural, morphology and electrical characterization were performed on the different Cr deficient CrN films. The thermoelectric properties of the films depend on the substrate nature and also on the aluminium content. The over-stoichiometry in nitrogen combined with aluminum doping lead to a p-type semiconductor behavior of CrN, with promising thermoelectric properties. For example, the $Cr_{0.96}Al_{0.04}N_{1.17}$ film exhibited a Seebeck coefficient of +140 µ.V/K and a power factor of 0.3 mW/(m.K) at 300 °C. Parallel DFT calculation on the effect of the different vacancies or interstitials confirmed the stability and the effect observed experimentally. Both, Cr vacancies and nitrogen interstitial are favourable and lead to a shift of the fermi level into the valence band, thus confirming the p-type character of the semiconductor material. The control of the semiconductor behaviour of CrN films can be tailored by controlling of the stoichiometry and/or aluminum doping. These results are a starting point for designing p-type and n-type thermoelectric materials based on chromium nitride thin film, a material cheap and routinely grown at industrial scale.

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Mario Maglione received the Ph.D. degree from the Federal Polytechnical School of Lausanne (EPFL),Lausanne, Switzerland. Following three years with IBM Zürich Laboratories,Rüschlikon Switerland and post-doctoral positions with Mainz University, Mainz, Germany, and IBM Zürich, Zürich, Switzerland, he joined, as a Junior CNRS Scientist, the Physics Laboratory, University of Burgundy, Dijon, France. In 2000, he joined the CNRS Institute for Condensed Matter Chemistry, University of Bordeaux, Pessac, France. He is currently the Director of the Institute for Condensed Matter Chemistry of Bordeaux, one of the major material science laboratories of the CNRS. He has coauthored more than 240 papers and has been invited to approximately 55 international conferences. His research interests are mostly concerned with the investigation of ferroelectric materials of any shape from single crystals to ceramics, nanocomposites and thin films. Dr. Maglione has chaired some major meetings such as the International Symposium on Integrated Ferroelectics (ISIF 2007) and the European Meeting on Ferroelectricity (EMF2011). He is a member of the European and of the International Steering Committees for Ferroelectricity. He was the recipient of the 2009 IKEDA award of the Japan IKEDA Foundation.

Universal behavior of BCTZ ceramics, thin films and single crystals

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BCTZ stands for the ternary solid solution $BaTiO_3$-$BaZrO_3$-$CaTiO_3$. This solid solution has been investigated first because it shows a continuous cross-over from ferroelectric close to $BaTiO_3$ towards relaxor when getting closer to $BaZrO_3$ or $CaTiO_3$ [1,2]. More recently a very interesting composition range was identified which shows piezoelectric activity compatible with the one of the archetypical PZT ceramics [3]. This composition range coincides with the collapse of the 3 transitions of $BaTiO_3$ to a single one [4]. Gathering data on ceramics [5], thin films [6] and single crystals [7], we show here that exceptional dielectric and piezoelectric performances are observed in the same BCTZ composition range whatever the materials shape. We ascribe this universal behavior to the continuous and soft ferroelectric to relaxor cross over in this lead-free material. Relating the onset of relaxor state to the nucleation and growth of polar clusters as the Zr and Ca content increases may explain the extreme electromechanical and non-linear dielectric features of BCTZ.

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Dr. Mathews is a Marie Skłodowska-Curie Research Fellow in the Photovoltaics Research Lab at the Massachusetts Institute of Technology. His research interests include high-efficiency tandem solar cells, solar-powered IoT systems, especially the use of solar cells to harvest indoor light to power wireless sensors and the use of machine learning in sustainable finance.
He previously earned a Ph.D. at the Tyndall National Institute, Ireland, an M.Sc. in Renewable Energy Systems from Loughborough University, UK, and a B.Eng. in Civil & Environmental Engineering at University College Cork, Ireland. After completing his Ph.D., he spent over two years as a Member of Technical Staff at Bell Labs developing energy-efficient photonic devices and took a lead role in cleantech commercialization as the founding CEO of Wattz.io, a company spun-out of his research into high-efficiency photovoltaics for self-powered wireless sensors.

High-efficiency indoor light-harvesting for self-powered wireless sensors

Given the limited lifetime of batteries, for ubiquitous sensing to become reality, low-cost but highefficiency power sources are required for wireless sensors. For the case of sensing environmental conditions inside buildings, the most obvious energy source is the harvesting of diffuse light from the artificial light sources in a room. Here we fabricate and compare GaAs and perovskite indoor light harvesters exhibiting up to 2x more power output than competing photovoltaic technologies when illuminated by artificial spectra (CFL and LED bulbs) benefitting from the close match between the cell absorption profiles and light source spectra and the strong optoelectronic performance of these materials.

Subsequently, we demonstrate the first wireless sensor powered by a perovskite indoor light harvesting module. The 3 cm^2 light harvester consists of three individual perovskite cells connected in series that at maximum power produce 19 μA at 1.8 V under 300 lux CFL illumination. We combine this harvesting module with an RFID temperature sensor requiring 10 μA to operate at a supply voltage great than 1.5 V, using the power source to increase the lifetime and range of the sensor by 10x.

Towards our ultimate goal of fully-integrated and extremely low-cost ubiquitous wireless sensors for building energy management applications, we present our results to date in transferring both the perovskite light harvesting layers and RFID antenna onto the same plastic substrate. The indoor light harvesting module is fabricated at low temperature on PET-ITO, while on the same substrate an RFID antenna is laser-patterned, integrating both power source and communication infrastructure on the same flexible substrate.

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Photoluminescence investigation of deep level defect states in ZnO nanorods

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Visible luminescence from ZnO nanorods (NRs) is attracting large scientific interest for light emission and sensing applications. We study visible luminescent defects in ZnO NRs as a function of post growth thermal treatments, and find four distinct visible deep level defect states (VDLSs): blue (2.52 eV), green (2.23 eV), orange (2.03 eV), and red (1.92 eV). Photoluminescence (PL) studies reveal a distinct modification in the UV (3.25 eV) emission intensity and a shift in the visible spectra after annealing. Annealing at 600 °C in Ar (Ar600) and O_2 (O600) causes a blue and red-shift in the visible emission band, respectively. All samples demonstrate orange emission from the core of the NR, with an additional surface related green, blue, and red emission in the the As-Prep, Ar600, and O600 samples, respectively. From PL excitation (PLE) measurements we determine the onset energy for population of the various VDLSs, and relate it to the presence of an Urbach tail below the conduction band due to a presence of ionized Zn_i or Zn_i complexes. We measured an onset energy of 3.25 eV for the as prepared sample. The onset energy red-shifts in the annealed samples by about 0.05 to 0.1 eV indicating a change in the defect structure, which we relate to the shift in the visible emission. We then used X-ray photoemission spectroscopy (XPS), and elastic recoil detection analysis (ERDA) to understand changes in the surface structure, and H content, respectively. The results of the XPS and ERDA analysis explain how the chemical states are modified due to annealing. We summarize our results by correlating our VDLSs with specific intrinsic defect states to build a model for PL emission in ZnO NRs. These results are important for understanding how to control defect related visible emission for sensing and electroluminescence applications.

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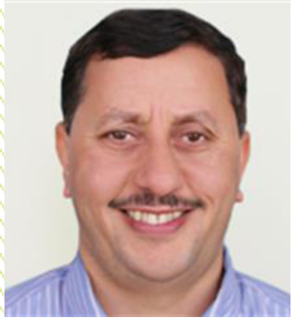

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Perovskite Nanocrystals with Different Dimensionalities: From Synthesis and Full Characterization to Light Applications

Colloidal perovskite nanocrystals (NCs) have recently gained substantial attention from the optoelectronic community due to their controllable size, bandgap and dimensionality as well as their high photoluminescence quantum yield (PLQY).(1-4) However, the resulting films prepared from these colloidal NCs always suffer from a drastic decrease in the PLQY and significant shortening of radiative carrier recombination time due to surface trap formation. Recently, we successfully developed simple strategies for fabricating perovskite NCs with different compositions and dimensionality in both solution and solid forms. We have also treated the surface of these NCs to enhance dramatically the PLQY. In Addition, We have reported a new approach to prepare ligand-free perovskite NCs of 3D and 0D perovskite structures with retained high photoluminescence quantum yield. To take our work one step further, these NCs were successfully utilized in light-emitting diode (LED) applications, and we found that the NC film demonstrated excellent device performance with an external quantum efficiency (EQE) exceeds 10%. Our synthetic strategy resolves a major chemical processing hurdle for perovskite NCs and provides a direct avenue for researchers to further develop this promising class of materials with different halides and cations for light emission.

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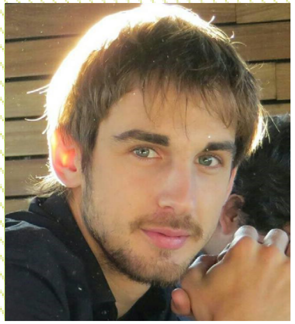

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Gonzalo Murillo received his Electronics Engineering BSc and MSc from the Universidad de Granada (Spain) in 2007, and his PhD from the Universitat Autònoma de Barcelona in 2011. In 2013, he joined the Microelectronics Institute of Barcelona (IMB-CNM, CSIC). He was named "Most Novel Innovator under 35 in Europe" by the MIT Technology Review. He found a start-up company in 2017 (www.energiot.com). Moreover, he has published more than 30 research articles and attended more than 45 international conferences. He has been invited as a speaker at numerous events, supervised 7 Master and graduate students and two on-going PhD student. He has participated in more than 30 research projects, managing 5 of them (> 600k€ in the last 3 years). His research is focused on energy harvesting for self-powered Internet of Things and smart nano and microdevices for biological applications.

From MEMS to nanogenerators, how to harvest energy from ambient vibrations

In the near future, hundreds of wireless sensor nodes spread all around our ambient and even our body will be continuously receiving and sending information, measuring data and working together to make more complex processes. The main difficulty to make this vision real is the way of powering all these tiny devices. The charge or replacement of batteries is not feasible when we have a large number of nodes or they are body implanted. The notion of energy harvesting has received a huge attention during the last years because of the need of finding an autonomous way of supplying this type of ultralow-power integrated systems. Solar, thermal and mechanical energy sources are commonly presented in our surrounding. This presentation will be focused mainly on ambient vibrations. We propose the development of miniaturized microscale energy sources that can harvest ambient mechanical energy and convert it into electricity. We have explored different piezoelectric materials, starting from the use of AlN as piezoelectric layer integrated with silicon or encapsulated in polymer, the use of ZnO nanowires and nanosheets (NWs and NSs), which offer better flexibility properties, low-cost production and compatible integration and, finally, piezoelectric nanofibers and films of PVDF and other piezoelectric nanocomposites and inks. These energy harvesting devices together with ultra-low-power microcontrollers, power management circuits and RF transceivers allow the integration of self-powered wireless sensor nodes that can be part of wearable/implantable devices or the future network of the Internet of Things (IoT).

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Dr. Cleva Ow-Yang is a Professor of Materials Science and Engineering at Sabanci University. Her research team develops optical materials via their structure-property relationships. To elucidate material structure, they apply a breadth of exciting new materials characterization methods. Her academic career began with bachelor's degree from MIT, master's and doctoral degrees from Brown University—all in Materials Science and Engineering. She was a Chauteaubriand Postdoctoral Fellow at Thomson-CSF (now Thales) in Orsay, France and Alexander von Humboldt Fellow at the Max Planck Institute for Metals Research in Stuttgart, Germany. Prior to joining Sabanci, she worked in the R&D department at JDS Uniphase in the Silicon Valley.

Nanoscale Engineering of Materials for Zero-Energy Consumption Lighting

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Zero energy consumption lighting is an attractive solution for efforts to live more sustainably with lower carbon consumption. One opportunity is the use of extremely long afterglow pigments in construction materials. To meet this challenge, my research team and team of collaborators have been developing long afterglow ceramic pigments, based on the structural design rules that enable Eu^{2+}, Dy^{3+}, and B co-doped strontium aluminate to support its well-known extreme afterglow. To elucidate these structural requirements, we began by focusing on the optically active Eu^{2+} ion, work that was begun by Blasse (1968) and more recently by Dutczak (2015). To understand the role of B in extending afterglow > 14 h, we examined how co-doping with Dy produces a structure that offered 10 minutes of afterglow, through the work of Matsuzawa (1996) and Nakazawa (2006), and the impact of B on their models. Finally, we evaluate the validity of a model in which clustering of the ionic point defects offer the extreme afterglow, through experiments to probe the effect of B on the microstructural evolution, dopant chemistry, and dopant distribution. We conclude with our current model of the material structure supporting long afterglow.

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Cristina Rusu received her PhD degree in Microtechnology from University of Twente (Netherlands) in 1998 followed by postdoctoral fellowship at same University developing MEMS-based tools for bio-medical applications. In 2000 she joined IMEC (Belgium) developing thick film SiGe for wafer-level packaging.
From 2002 she joined RISE Acreo AB as Senior Expert, focusing on both scientific work and business development for wireless and miniaturised sensors and energy harvesting for various applications, from agriculture to automotive, aircraft to medical. She is project leader for Swedish and European projects, Reviewer for International journals on sensors and microtechnology, member in assessment committees for PhD and Assistant Professor.

Energy harvesting sensor systems – Challenges and Opportunities

Internet of Things (IoT) has huge potential to impact the societal and economic structure worldwide through highly miniature, low cost wireless devices in a wide range of applications; sensing capability distributed throughout urban, industrial environments (pervasive sensing), and enhancement of passive artefacts with intelligence and connectivity (IoT). However, its spreading in the mentioned areas will follow difference paces, defined by articulated technological (e.g. limited lifetime, maintenance challenge of replacing and/or recharging huge numbers of batteries) and competitive factors. Energy-autonomous technologies making use of available energy from the surrounding environment is one of the solutions to this problem.

A functional energy harvesting system requires addressing simultaneously all the components of the system: the harvester device, the energy storage and the powering management circuits. These components are described through examples of miniaturized kinetic-based harvesting system for low-power applications with focus on energy harvester. These examples are from a H2020 project at RISE Acreo AB and industrial project at Mid Sweden University, with their potential and technological challenges.

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Carbazole Hole transporting materials for hybrid solar cells

Co-authors: Nicolas Berton, Rana Nakar, Fatima Al-Zohbi, François Tran-Van, Jérôme Faure-Vincent, Johan Bouclé, An-Na Cho, Nam-Gyu Park

Solar cells have become one of the most important sources of renewable energies. In recent years, several emerging photovoltaic technologies showed growing interests in terms of light weight, cheap process and flexibility. Among them, hybrid solar cell using perovskite structures as sensitizer became very promising. In 2009, T. Miyasaka and his team were the first to use the perovskites for replacing the classical dyes in solid state DSSCs and obtained a conversion efficiency of 3.8%[1]. Nowadays, the last record is around 22.2%[2]. The use of perovskites is usualy combined with a hole transporting material (HTM) in order to achieve high efficiency. However, spiro-OMeTAD is the only HTM available on the market and is costly for large-scale applications. That is why, the development of high-performance, simple and low cost molecular glasses present a challenge.

The aim of this work is the study of the structures/properties relationship of new carbazole based molecular glasses and to compare them to Spiro-OMeTAD as a reference. The design of these HTM is based on a specific carbazole moiety bearing dimethoxydiphenylamine groups[3,4]. In this presentation, we will show the chemical strategy used to control the properties of the carbazole HTM. Their thermal and electronic properties will be discussed as well as their use as HTM in perovskite solar cells.

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Dr. Sophie Tingry has formal training in Electrochemistry and received her PhD from the University of Grenoble in 1996. After postdoctoral research on solar cells in the laboratory of Pr. Grätzel (Switzerland) and A. Hagfeldt (Sweden), she got a permanent position as researcher at CNRS in 2000 at the European Institute of Membranes. In 2017, she was promoted director of research of CNRS and she is team responsible of the group "Interfaces & Electrochemistry" within the department IP2 of the Institute. She is currently developing processes with potential applications in environment and energy fields. Her research interest focus on bioelectrochemistry, electrocatalysis, electrode materials and microfluidics for the development of electrochemical systems for energy harvesting systems.

Gold nanoparticles: Application in hybrid biofuel cells for energy conversion

Co-authors: Y. Holade, D. Cornu, M. Bechelany, M. Cretin

Abstract = Gold nanoparticles (NPs) have been a subject of great interest due to their outstanding physical properties compared with their bulk counterparts. These NPs have found potential applications in different fields such as catalysis, optoelectronic devices, sensor, biosensors etc.

Hybrid biofuel cells represent an emerging and alternative technology able to convert chemical energy to electrical energy using naturally occurring renewable fuels, in the presence of abiotic and enzymatic biocatalysts. These energy conversion devices rely on electrocatalytic reactions at the solution / electrode material interface. The key element for the development of a biofuel cell is therefore the production of efficient electrodes. We develop hybrid biofuel cells working from abiotic oxidation of carbohydrates on metallic nanoparticle catalysts, combined with enzymatic reduction of O_2 to H_2O by enzyme multicopper oxidases.

This presentation describes our effort to design stable and homogeneous three-dimensional gold materials using different methods allowing very stable carbon-gold bonding [1, 2, 3], and shows the benefit of the Au particles to improve the electrocatalytic efficiency of the electrodes. The Au particles exhibit good activity toward glucose oxidation due to their chemical stability, good biocompatibility, high catalytic activity, and resistance to surface poisoning during electrochemical processes.

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Imaging and manipulation of ferroelectric domain walls by piezoresponse force microscopy

In ferroelectrics domain walls are interfaces separating regions with different orientation of spontaneous polarization. They are developed in the ferroelectric material to lower the electrostatic and elastic energies, which build up when the material is cooled from elevate to room temperature. Domain walls are dynamic interfaces; they have the ability to displace under external fields (electric and elastic). Such displacements contribute dominantly to the macroscopic piezoelectric response. Configuration of domains and their walls as well as their mobility can be efficiently determined using piezo-response force microscopy (PFM). In this contribution the ferroelectric domain structure of selected lead-based as well as lead-free ferroelectric ceramics and thin films will be reported, such as $Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$ and $(K_{0.5}Na_{0.5})NbO_3$-based materials. The domain structure of ferroelectrics in the poled state, i.e. the state in which the ferroelectrics are used in transducers, actuators and sensors, will also be presented. Furthermore, combination of PFM with other local techniques, such as conductive atomic force microscopy (CAFM) or magnetic force microscopy (MFM) will be discussed.

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Mario Urso was born on 21th of October 1992 in Catania, Italy. He attained his Master Degree in Physics with marks 110/110 cum laude from the University of Catania on 27th of October 2016. In November 2016 he started the Ph.D. course in Materials Science and Nanotechnology at the University of Catania. He is currently working under the supervision of Prof. Francesco Priolo and Prof. Salvo Mirabella at the Physics and Astronomy Department of the University of Catania and at the CNR-IMM. His main scientific interests are focused on the low-cost synthesis of Ni-based nanostructures for energy storage and sensing applications, and their characterization by scanning electron microscopy (SEM), X-ray diffraction (XRD), Rutherford Backscattering Spectrometry (RBS) and electrochemical analyses (cyclic voltammetry, electrochemical impedance spectroscopy,…).

Supercapacitive properties of Ni-based nanostructures grown by chemical bath deposition

Co-authors: Vincenzina Strano, Simona Boninelli, Francesco Priolo, Salvo Mirabella

In recent years Ni-based nanostructures have attracted great attention for electrochemical energy storage applications. One of the most promising nanostructure explored so far is represented by the $Ni(OH)_2$ nanowalls, a tight network of interconnected nanosheets grown by low-cost chemical bath deposition (CBD). Despite the impressive supercapacitive performances, the specific capacitance of the nanowalls is still below the theoretical value. In this work, we present a novel Ni nanostructure, called $Ni/Ni(OH)_2$ core-shell nanofoam, with a very high surface over volume ratio and superior features in terms of specific capacitance and stability. Scanning electron microscopy (SEM) reveals that after a reducing annealing the $Ni(OH)_2$ nanowalls is transformed into an ensemble of interconnected Ni nanoparticles (20-30 nm in size), called Ni nanofoam. Cyclic voltammetry (CV) in alkaline solution is used to electrochemically oxidize the surface of the Ni nanofoam, producing an outer shell of $Ni(OH)_2$ active species, as confirmed by transmission electron microscopy (TEM). The supercapacitive behaviour of the $Ni(OH)_2$ nanowalls and $Ni/Ni(OH)_2$ core-shell nanofoam is investigated by CV, galvanostatic charge-discharge tests, and electrochemical impedance spectroscopy (EIS) in 1 M KOH. Superior specific capacitances are achieved by the $Ni/Ni(OH)_2$ core-shell nanofoam for all the investigated current densities. The enhanced supercapacitive properties are related to the metallic core of the core-shell architecture, which improves the overall charge transport. This work offers a new strategy to enhance the energy storage performances of conventional $Ni(OH)_2$-based nanostructured electrodes.

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I am graduated in Chemistry and obtained the PhD in Materials Science (2016) at the University of Santiago de Compostela (USC), Spain. My research is framed in the area of Nanomaterials to study the growth and characterization of epitaxial functional oxide thin films synthesized by chemical solution deposition methods. After a doctoral stay in the Center for Research in Biological Chemistry and Molecular Materials (CiQUS), I joined in 2016 the Institut d'Electronique et des Systèmes (IES) in Montpellier, France, as a postdoctoral fellow. My current research interests include integration of functional oxides nanostructures on Silicon by chemical routes in the group NanoChemLab leaded by Dr. Carretero-Genevrier.

Enhanced functionalities in epitaxial oxide thin films on silicon by combining physical and chemical processes

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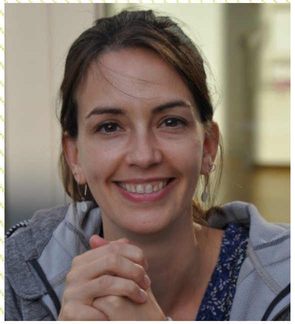
Transition metal oxides boost nanotechnology as they present a large variety of properties promising many technological applications, whereas epitaxial oxide thin films are highly appealing because the physical properties of the material can be tuned by different ways (strain, thickness, synthesis conditions, etc.). However, silicon is to-date the most important material in the electronics industry. Therefore, integrating high quality epitaxial oxide thin films and nanostructures on silicon is a milestone. Notwithstanding, integrating epitaxial oxides on silicon is extremely difficult due to the structurally, thermally, and chemically dissimilarities. For this reason, the integration of epitaxial thin films on silicon is exclusively made by methods that imply the use of high vacuum chambers to prevent the formation of an amorphous SiO_2 interfacial layer. The common feature is the use of a buffer layer to accommodate the epitaxial oxide to the silicon substrate. In 1998 McKee et al.[1] demonstrated the possibility to grow epitaxial STO films on Si, setting the basis to integrate other perovskites by Molecular Beam Epitaxy (MBE). Contrarily, chemical solution deposition (CSD) methods do not require high vacuum, are low-cost, versatile to grow many different compositions, and very appropriate for large are coatings. In this presentation, we show a hybrid strategy of combining MBE to grow a $SrTiO_3$ (STO) template on silicon and then to deposit other perovskites by CSD.[2] As an example, we present the synthesis of ferroelectric $BaTiO_3$, multiferroic $BiFeO_3$ and ferromagnetic $La_{0.7}Sr_{0.3}MnO_3$ thin films (<100 nm) in STO-buffered Si by alternating combination between MBE and CSD. We show that is possible to combine CSD and physical methods to obtain the epitaxial integration of perovskite oxides on silicon and additional enhanced functional nanostructures not able to achieve in a single route.[3]

[1] R.A. McKee et al., Phys. Rev. Lett., **1998**, 81, 3014.
[2] J.M. Vila-Fungueiriño et al., Front. Phys, **2015**, 3, 38.
[3] A. Gómez et al., Small, **2017**, 13, 1701614.



Dr Elizabeth von Hauff

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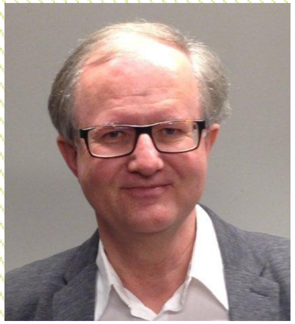
Elizabeth von Hauff studied Physics at the University of Alberta in Edmonton, Canada. She completed her PhD in 2005 at the University of Oldenburg, Germany, with focus on charge carrier transport in organic semiconductors. In 2011 Elizabeth completed her habilitation in experimental physics, and then accepted a joint appointment as Associate Professor between the Institute of Physics at the University of Freiburg and the Fraunhofer Institute for Solar Energy Systems (ISE). In 2013 Elizabeth was appointed Associate Professor in Physics at the VU Amsterdam. She is interested in fundamental questions in physics and chemistry within the context of real applications.

Organic and hybrid systems for solar energy conversion

Organic, hybrid, and nanostructured semiconductors offer many advantages for innovations in opto-electronics, energy conversion, and storage applications. However, in order to enable real devices, much research is still required into the complex electrical properties of these materials. In this talk I will present our work on applying optical and electrical spectroscopic techniques, together with modelling, to study charge carrier transport and recombination in new materials and devices. By applying impedance spectroscopy and modelling we developed dedicated diagnostic approaches to locate and study specific electron transfer, transport, and recombination phenomena in complex device architectures. I will then present our more recent results on fundamental studies on charge carrier transport, including the development of a new measurement approach that enables us to identify the role of electron-phonon coupling on electronic transitions in soft semiconductors.



Pr Magnus Willander

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Professor Willander is active in the area of synthesis, characterization and applications of nanomaterials. He is working on both solid and soft materials. Magnus Willander is working particularly on applications for energy materials, sensors materials, optical and electrical materials. He covers physical and chemical aspects. In the 80s and 90s Professor Willander did pioneering work on Si/SiGe and polymer devices, tunnelling devices etc. He covered experimental, theoretical and mathematical aspects in these areas. He has been chair professor in Gothenburg university and Linköping university and visiting professor/scientist in many different countries. Professor Willander also spent 5 years in international big industries working on predevelopment. He also started up several entrepreneur companies and worked in entrepreneur companies. He has published more than 1000 scientific papers, 10 international scientific books and he has about 20 000 citations (Google scholar). He has guided more than 50 students to their PhD degree.

Flexible and Non-Flexible Materials for Energy Harvesting

I will present our 2-3 years latest results regarding harvesting mechanical energy from piezoelectric and triboelectric nanogenerators. The choice and synthesis of the nanomaterials, will be discussed from different aspects, as e.g. flexible or non-flexibile materials as well as device design. The applications like water splitting, hydrogen evolution, desalination, sterilization and photodegradation will be discussed, including photocatalytic and electrochemical driven processes. Storage of the energy and supercapacitors will be discussed. Finally, use of chemical energy to power chemical sensors on paper and textile substrates and on solid substrates will be discussed.

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Band structure tuning via interface chemical modulation in $La_{0.7}Sr_{0.3}MnO_3$/$SrTiO_3$/ Pt junctions

Co-authors: A. Ruyter,[1] B. Negulescu,[1] P. Andreazza,[2] C. Autret,[1] J. Sakai,[1] and X. Wallart,[3]

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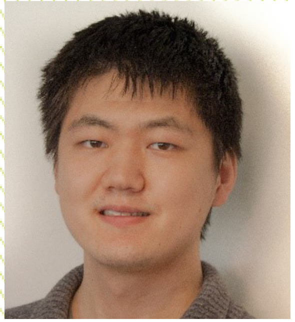
The Schottky barrier that usually occurs at metal/dielectric junctions can be detrimental for current collection in piezoelectric, photovoltaic or thermoelectric energy harvester. Band engineering at the interface is one solution to circumvent this issue as it was extensively shown in semiconductors. We propose to extend this approach to oxide epitaxial heterostructures using a combinatorial modulation of the interface composition over a few monolayers (ML) to tune the electronic affinity and band gap of the dielectric and the work function and carrier doping of the electrode. These parameters control the band structure of the heterojunction through the alignment of the Fermi levels.

We chose $Ba_{1-x}Sr_xTiO_3$ as the dielectric material, $La_{1-y}Sr_yMnO_3$ (LSMy) as the electrode material and $SrTiO_3$ as the substrate to obtain an epitaxial growth by Combinatorial Pulsed Laser Deposition (CPLD). Here we report on $La_{0.7}Sr_{0.3}MnO_3$ / $La_{1-y}Sr_yMnO_3$ (3 ML) / SrTi03 (1-12 ML) paraelectric heterostructure in order to focus on the effects of carrier concentration and work function modulation avoiding convolution with polarization effects. Photo electron spectroscopies (XPS/UPS) confirmed the continuous variation of LSMy work function with the carrier content y. In-situ local electric and electrostatic characterizations carried out in a UHV AFM revealed a non-monotonous and correlated y-dependence of both the threshold voltage and the KPM potential. These results clearly show the non-monotonic dependence of the barrier height on the interface chemical modulation. Effects of the combinatorial interface chemical modulation on the junction band structure will be discuss versus composition and thickness.



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Tianqi ZHU is a third year PhD student of University of Lille, works in CNRS laboratory of IEMN (Institute of Electronics, Microelectronics and Nanotechnology). He is currently working on an EU project of Micro-Thermoelectric Converter based on thermos electronic emission. In 2013, he graduated from university of science and technology of China and came to France as an engineer student at ISEN. Then he got his engineer degree and first article as co-authors accepted in Surface Science. From then on, he started his PhD work on non-conventional thermoelectricity based on thermionic emission with ultra-low work function material electrodes, which is an European research projects starting from 2013.

Alternative low work function thin film materials for nonconventional thermoelectric micro/nanogenerators

Co-authors: F. Morini[1], V. Giorgis[2], T. Zhu[3], J-F. Robillard[3] and E. Dubois[3]

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Keywords: Energy conversion, thermoelectric generator, thermionic emission, work function, alkali metal oxides

Efficient and stable materials integrated devices are a permanent challenge in thermoelectric micro/nano generators. Alkali metals thin films and their oxides present an ultra-low work function compatible with high efficiency thermionic energy converter (TEC) operating near room temperature. Among them, potassium oxide (K_2O_2) and cesium oxide (Cs_2O) have been preliminary studied in a thermochemical stability context to determine the synthesis conditions then deposited by CVD as thin film on (100) oriented silicon wafer [1]. Their respective work function has been measured in the same vacuum conditions of by using a Kelvin probe combined to UV-visible photo emission and thermionic emission [2]. Complementary characterizations allowed us to determine the oxidation level of Cs and K at room temperature standard pressure and independently evaluate the current density produced by the heated oxides. Our study demonstrates these alternative materials as low temperature electron emitters give work function equal to 1.33 eV for cesium oxide and 1.68 eV for potassium oxide below 800 K. The barrier height has been significantly decreased by almost 3 eV triggering significant thermionic currents densities at relatively low temperatures range and low applied voltages.

[1] F. Morini *et al.*, "Low work function thin film growth for high efficiency thermionic energy converter: Coupled Kelvin probe and photoemission study of potassium oxide," in *Physica Status Solidi (A) Applications and Materials Science*, vol. 211, no. 6, pp. 1334–1337, 2014.

[2] V. Giorgis *et al.*, "Synthesis and characterization of low work function alkali oxide thin films for unconventional thermionic energy converters," *J. Appl. Phys.*, vol. 120, no. 20, 2016.

POSTERS

• Improvement of piezoelectric properties of ZnO nanowires synthesized by a fast solution method

Christelle Alié[1], Chellda Exantus[1], Kevin Nadaud[2], François Morini[2], Guylaine Poulin-Vittrant[2], Benoît Heinrichs[1], Nathalie Job[1]

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• TiO_2/Polyaniline nanocomposite through Diazonium Chemistry: Design and photocatalytic performances

Fatima Mousli[1,2], Abdelaziz Kadri[1], Mohamed M. Chehimi[2]

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• Cyclable and non-volatile electric field control of magnetism in BiFeO3 based magnetoelectric heterostructures

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• Influence of the synthesis parameters on hydrothermally grown ZnO nanowires dedicated to mechanical energy harvesting

Camille Justeau, S. Boubenia, A. S. Dahiya, E. Erdem, K. Nadaud, F. Morini, G. Poulin-Vittrant, D. Alquier

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• Zinc oxide nanowire-parylene composite nanogenerators for low frequency mechanical energy harvesting

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• Scope and outcomes of the EnSO project

Guylaine Poulin-Vittrant[1], Daniel Alquier[1] (Dissemination managers), Raphaël Salot[2] (Coordinator), Ramon Jane[3] (Exploitation manager)

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Pr Mario Maglione

PUBLIC LECTURE

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Mario Maglione est Docteur de l'Ecole Polytechnique Fédérale de Lausanne (Suisse) depuis 1987.
Après trois ans de travail doctoral au laboratoire IBM de Zürich et deux post-doc à l'Université de Mayence (Allemagne) et IBM Zürich, il a été recruté en tant que chargé de recherches au CNRS au laboratoire de Physique de l'Université de Bourgogne en 1988. Il a ensuite rejoint en 2000 l'Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB) en 2000. Il est actuellement directeur de ce laboratoire. Ses recherches concernent les matériaux ferroélectriques sous toutes leurs formes, cristaux, céramiques, composites, couches minces. Il est co-auteur de 240 articles et a été invité dans 55 conférences internationales. Il a présidé deux conférences internationales : International Symposium on Integrated Ferroelectics (ISIF 2007) et European Meeting on Ferroelectricity (EMF2011). Il est membre des comités Européens et Internationaux pour la ferroélectricité et il a reçu en 2009 le prix IKEDA de la fondation Japonaise IKEDA.

Réduire la taille des matériaux pour améliorer leurs performances et leur efficacité énergétique

La recherche et le développement sur les matériaux a de nombreuses implications dans notre vie quotidienne. Une des tendances générales de cette recherche est la diminution de la taille des matériaux pour augmenter l'efficacité des dispositifs dans lesquels ils sont intégrés. L'exemple le plus flagrant concerne les technologies de l'information et de la communication qui ont grandement bénéficié de cette course à la réduction de la taille qui a rejoint le monde du nanomètre depuis de nombreuses années. Cette tendance a non-seulement pour objectif d'augmenter les performances mais aussi elle peut permettre de réduire l'impact environnemental des nouvelles technologies.

D'autres exemples seront abordés sur l'utilisation des nanomatériaux en optique, en imagerie médicale et dans les énergies renouvelables. Sur ce dernier point, la problématique du recyclage des composants des éoliennes sera exposée.

Enfin, l'application du principe de précaution à ces matériaux spécifiques au sein d'un laboratoire de recherche tel que l'ICMCB sera décrite.

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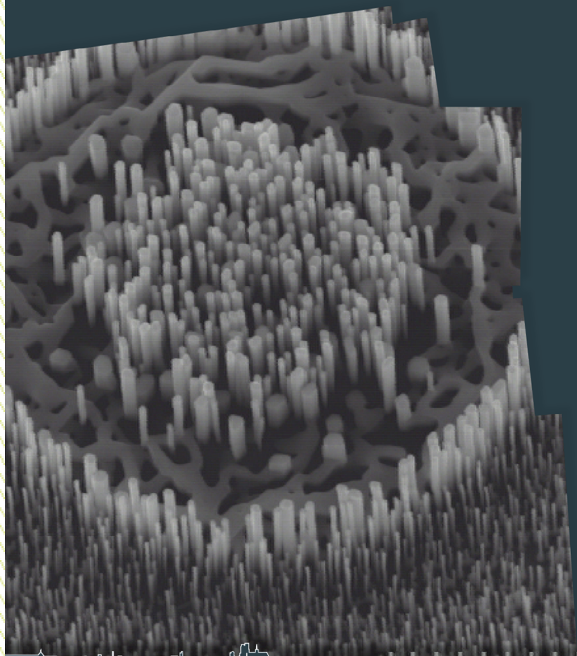
Réduire la taille des matériaux pour une meilleure efficacité énergétique



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Directeur de l'Institut de Chimie de la Matière Condensée de Bordeaux CNRS, Université de Bordeaux, Bordeaux INP - France

Cette lecture publique est organisée dans le cadre de la conférence : Frontiers in Nanomaterials for Energy Harvesting and Storage

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Pr Bilal Haider Abbasi, Pr Nathalie Guivarc'h & Dr Christophe Hano
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Discrete Models of Complex Systems
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2017

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11-13 December 2017

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15-16 March 2012

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Life and innovation cycles in the field of raw material supply and demand — a transdisciplinary approach
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10-12 June 2010

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