Tuesday, November 23th

Session 1D & 2D Nanomaterials

10:50 - 11:20 Keynote

Hélène BOUCHIAT, CNRS - LPS, France

Abstracts

Keynote Speakers

Hélène BOUCHIAT

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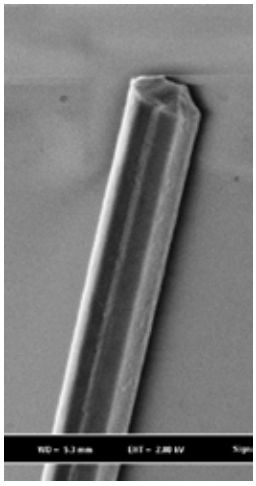
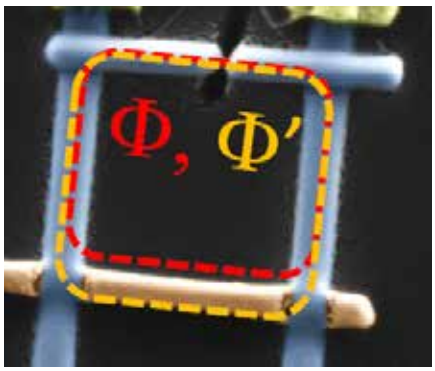
Biography

CNRS Research Director since 1998, Hélène Bouchiat is working in Laboratory of Solid State Physics in Orsay (France). In 2005, she was awarded with CNRS silver medal for her work on quantum electricity. From 2007 to 2012, she was member of the evaluation panel on condensed matter Physics of the European Research Council (ERC). Since 2010, she is a member of French Academy of Science. Her research activity covers the study of electronic properties in mesoscopic physics including mesoscopic Quantum transport, Carbon Nanotubes, Graphene, Topological insulators.

REVEALING THE TOPOLOGICAL NATURE OF TRANSPORT AT MESOSCOPIC SCALES WITH QUANTUM INTERFERENCES

We show that basic fundamental properties of mesoscopic quantum interferences can be used to reveal the existence and the physical location of 1d protected states in topological insulators. This method is illustrated in the case of crystalline bismuth nanowires which were found to belong to a class of newly discovered higher order topological insulators with helical ballistic hinge states coexisting with trivial bulk and surface diffusive states. In particular we discuss SQUID like periodic magnetic oscillations observed in Bi based Josephson junctions.





References

[1] (A. Murani et al, Nature Communications 8, 15941 (2017).
[2] Frank Schindler et al, Nature Physics 14, 918–924 (2018).
[3] A. Murani et al, Phys. Rev. Lett. 122, 076802 (2019).

Keywords: quantum transport; carbon nanotubes; graphene; popological insulators.

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December, 8, 9 and 10

Thematic Session: 2D Materials
Keywords: Monolayer WSe_2, magneto-transport, Landau levels, Shubnikov-de Haas oscillations

High magnetic field spin-valley-split Shubnikov–de Haas oscillations in a WSe_2 monolayer

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We study Shubnikov-de Haas oscillations in a p-type WSe2 monolayer under very high magnetic field. The oscillation pattern is complex due to a large spin and valley splitting, in the non-fully-resolved Landau level regime. Our experimental data can be reproduced with a model in which the main parameter is the ratio between the Zeeman energy and the cyclotron energy. The model takes into account the Landau levels from both valleys with the same Gaussian broadening, which allows predicting the relative amplitude of the resistance oscillation originating from each valley. The Zeeman energy is found to be several times larger than the cyclotron energy. It translates into a large and increasing effective Landé factor as the hole density decreases, in the continuity of the values reported in the literature at lower carrier density.

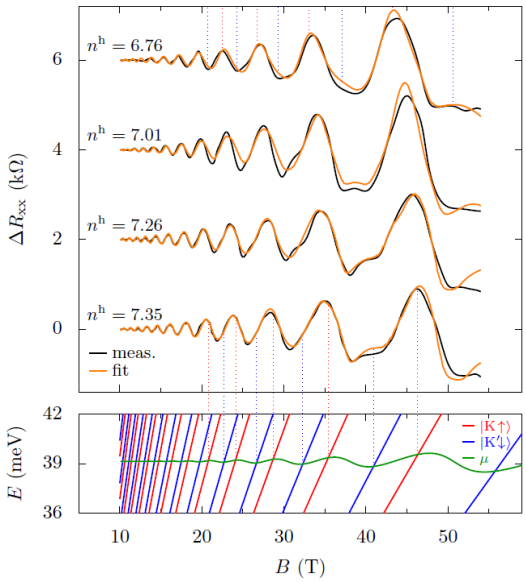

Figure : Experimental magneto-resistance (black lines) are compared to the model output (orange lines) for selected hole densities n_h (given in unit of 10^{12} cm^{-2}). Bottom frame: Landau level spectrum and evolution of the chemical potential μ(B) for $n_h = 7.35\times10^{12}$ cm^{-2}.

References (max. 5): H. C. P. Movva et. al. Phys. Rev. B 118, 247701 (2017) ; M. V. Gustafsson et. al. Nat. Mater. 17, 411 (2018) ; J. Lin et. al. Nano Letters 19, 1736 (2019).

Acknowledgment: ANR under project MoS2ValleyControl (ANR-14-CE26-0017) and financial support through the EUR grant NanoX (ANR-17-EURE-0009) in the framework of the "Programme des Investissements d'Avenir"

Thematic Session: 2D Materials

Keywords: Colloidal nanoplatelets, density of states, electron/exciton localization, tunneling spectroscopy

What is the electron behavior in two-dimensional CdSe nanoplatelets ?

Nemanja Peric[1], Yannick Lambert[1], Dominique Deresmes[1], Maxime Berthe[1], Zeger Hens[2], Iwan Moreels[2], Christophe Delerue[1], Bruno Grandidier[1], Louis Biadala[1]

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Abstract : Colloidal nanocrystal technologies exploit dimensionality effects and surface functionalities to precisely tune the optical transitions in semiconductor crystals and produce materials with custom-tailor optical properties[1]. Among all these nanocrystals, nanoplatelets stand out due to their intense optical transitions, high color purity, large binding exciton energies. Although they imitate the typical optical characteristics of epitaxial quantum wells[2], their anisotropic lateral dimensions make the understanding of the electron localization more subtle than initially thought. Here, with scanning tunnelling spectroscopy, we examine the conduction band density of states of colloidal CdSe nanoplatelets. Consistent with a recent study[3], the conduction band density of states does not consist of a step-like function, typical of two-dimensional electron states. Instead, we show the existence of an oscillating electron density of states modulated by van Hove singularities, that rules out a free in-plane electron motion, in agreement with tight binding calculations. This finding, along with the detection of deep trap states located on the edge facets, which also restrict the electron motion, provides a detailed picture of the actual lateral confinement in quantum wells with finite length and width.

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Acknowledgment: This study was financially supported by the European Community's H2020 Program (Grant No. PITN-GA-2016-722176, "Indeed" Project), the EQUIPEX program Excelsior (Grant No. ANR-11-EQPX-0015), the RENATECH network, the Agence National de la Recherche (Grant No. ANR-19-CE09-0022, "TROPICAL" Project) and I-SITE.

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December, 8, 9 and 10

Thematic Session: 2D Materials

Keywords: Graphene, Phosphorus, Raman, DFT, Placzek approximation

First-principle approach to multi-wavelength Raman spectroscopy of 2D-nanomaterials

Anthony Impellizzeri[1], D. Rybkovskiy[2], E. Picheau[3], V. Koroteev[3], M. Bayle[1], J.-Y. Mevellec[1], B. Humbert[1], A. C. Torres-Dias[4], J.-L. Duvail[3], P. Puech[4], A. Okotrub[4], M. Monthioux[4], A. Pénicaud[3], C. P. Ewels[1].

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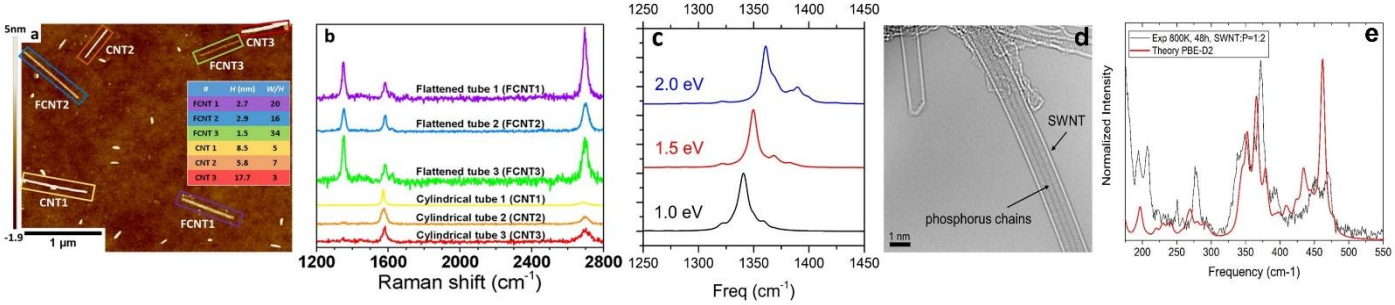
Abstract

We developed one methodology to simulate non-resonant Raman spectra by using the Placzek approximation based on semi-classical formulation of electronic and vibrational energies [1]. Upon calculated frequency dependent dielectric tensors through Density Functional Theory, we computed polarized Raman intensities by averaging over all in- and out-plane directions, depending on the backscattering laser geometry set-up used in the experiment. Our *first-principle* investigation covered a broad family of nanocarbons with the benefit to probe any modification of initial symmetry due to the presence of defects or structural deformation, as directly observed in the experiments. In this context, we discovered: *(i)* the appearance of an intense defect-free D-band in fully flattened carbon nanotubes, folded and scrolled graphene [2]; *(ii)* the phase transition of 3D bulk phosphorus into 1D-chains after the encapsulation inside single-walled carbon nanotubes.

Figure 1: (a) Atomic Force Microscopy image of flattened SWCNTs with corresponding (b) experimental and (c) theoretical Raman spectra. (d) Transmission electron microscopy of SWCNT filled with phosphorus chains with its (e) experimental Raman characterization (black line) with theoretical



support.

References:

[1] Walter, M. and Moseler, M. *J. Chem. Theory Comput.* 2020, 16, 1, 576-586.

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Thematic Session: (eg. Nanophotonics & nano-optics, nanomaterials, …)
Keywords: Nanopores, MoS_2, Time Series, Protein, Sequencing

Identifying Protein Sequence Motifs from Peptide Translocation in Silico Experiments through Solid-state Nanopores

Adrien Nicolaï, Patrice Delarue & Patrick Senet

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Solid-state nanopores have emerged as one of the most versatile tools for biomolecule detection and characterization. Nanopore sensing is based on measuring the variations in ionic current as charged biomolecules immersed in an electrolyte translocate through nanometer-sized channels, in response to an external voltage applied across the membrane. The passage of the biomolecule through the pore yields information about its structure and chemical properties, as demonstrated experimentally with sub-microsecond temporal resolution. However, extracting the sequence of the biomolecule such as the primary structure of a protein without the information about its position remains challenging due to the fact there is a large variability of translocation events de- tected. In this paper, we present a new procedure applied to ionic current time series extracted from microsecond time scale all-atom non-equilibrium Molecular Dynamics simulations of peptide translocation through single-layer MoS_2 nanopores . This procedure based on permutation entropy (PE) algorithm is used to detect protein sequence motifs related to ionic current drop velocities. PE is a technique used to quantify the complexity of a given time series and it allows to detect regular patterns. Here, PE patterns were associated to protein sequence motifs composed of 1, 2 or 3 amino-acids. Finally, we showed that this very promising analysis of ionic current time series is consistent with independent simulations of peptides with different amino-acid sequences for the detection of biological mutations. The procedure presented here could also be applied to detect protein sequence motifs from experimental measurements of peptide translocation through solid-state nanopores.

Acknowledgments:

The work was supported by a grant from the Air Force Office of Scientific Research (AFOSR), as part of a joint program with the Directorate for Engineering of the National Science Foundation (NSF), Emerging Frontiers and Multidisciplinary Office (grant No. FA9550-17-1-0047), the EIPHI Graduate School (contract ANR-17-EURE-0002) and the Conseil Régional de Bourgogne-Franche-Comté (ANER NANOSEQ).

Thematic Session: 2D-Materials
Keywords: organic polymer, magnetism, Carbon doping, carrier mobility

Collective Magnetism in 2D Polymer Made of C-doped Triangular BN Nanoflakes

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Polytechnique Montréal, Engineering Physics Department, Montréal, Canada

Abstract

We have investigated the electronic and magnetic properties of 2D polymer built from triangular boron nitride monomers (t-BN, t'-BN) doped with C with the help of first-principles calculations. A polymer made of pure t-BN (t'-BN) is an insulator as pristine h-BN but substituting B (N) by C atom in t-BN (t'-BN) spontaneously leads to the creation of a spin-polarized ground state polymer. In fact, unpolarized (singlet state) C-doped polymer is a semi-metal with graphene like Dirac cone; while the polarized (triplet) ground state is a semiconductor, where both Dirac and flat bands coexist in the vicinity of Fermi level. The triangular shape of the monomer and the respective position of the C-dopant within the 2D polymer contribute to create a strong collective magnetism. In addition, polymer made of N-edge terminated monomer (t-BN) becomes n-type with only spin-α electrons as mobile charge carriers when B is substituted by C, and it becomes p-type with only spin-β holes as mobile charge carriers when N is replaced by C atom in the B-edge terminated monomer (t'-BN). However, the mobility for the α-spin holes in C_t-BN is found to be the highest (1997.40 $cm^{-2}V^{-1}s^{-1}$) among all the configuration. In agreement with Lieb's theorem, this collective magnetism is totally suppressed in a (t-BN + t'-BN) copolymer arrangement, where the resulting material becomes a semiconductor with no spin polarized ground state and perfect flat bands near Fermi level. Our results suggest the existence of long-range metal free magnetic ordering, where the coexistence of Dirac bands and flat bands open the door for 2D organic spintronic applications.

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Thematic Session: 2D Materials
Keywords: Raman spectroscopy – Collapsed carbon nanotubes – Defects – Raman D band

Intense Raman D band without disorder in flattened carbon nanotubes

Emmanuel Picheau,[1] Anthony Impellizzeri,[2] Dmitry Rybkovskiy,[3] Maxime Bayle,[2] Jean-Yves Mevellec,[2] Ferdinand Hof,[1] Hassan Saadaoui,[1] Laure Noé,[4] Abraao Cefas Torres Dias,[4] Jean-Luc Duvail,[2] Marc Monthioux,[4] Bernard Humbert,[2] Pascal Puech,[4] Christopher P. Ewels,[2] Alain Pénicaud[1]

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Above a critical diameter, single or few-walled carbon nanotubes (CNTs) spontaneously collapse as flattened carbon nanotubes (FCNTs). FCNTs can be consider as few layer graphene nanoribbons (GNRs), with continuity at the edges forming two lateral cavities. FCNTs overcome the as-yet unsolved difficulty to obtain scalable GNRs with atomically smooth edges, critical for electronics.[1]

FCNTs can be obtain in solution by reported methods,[2,3] and has been deposited on a surface. A close correlation between atomic force microscopy and Raman spectroscopy allowed to measure Raman spectra of isolated self-collapsed FCNTs. Strikingly, the collapse provokes the appearance of an intense and narrow D band (see figure 1), independent of the presence of topological defects. It arise solely as a signature of folding, as shown by experimental and theoretical evidences.[4]

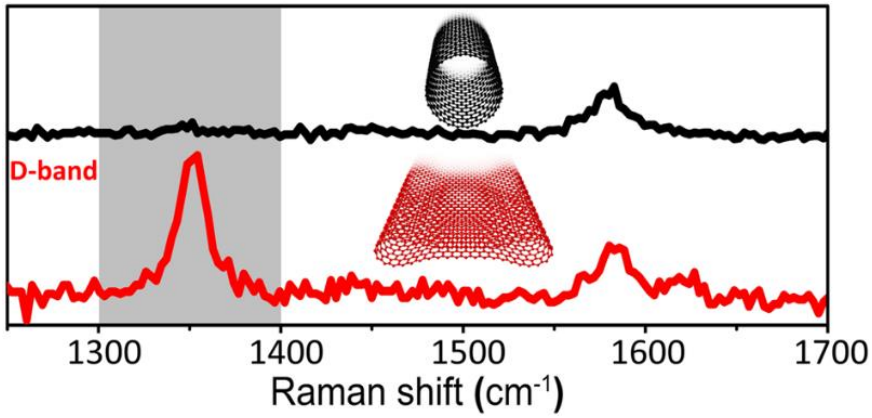

Figure 1 Raman spectra of a cylindrical (black, top) and of a collapsed (red, bottom) carbon nanotube

This conclusion should have wide repercussions for the field of graphene and related materials regarding defect quantification and serve as a basis to revisit materials comprising structural distortion where poor carbon organization was concluded on Raman basis. Our finding also emphasizes cultural differences in understanding of a defect between chemists and physicists, a possible source of confusion for researchers working in nanotechnologies.

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Acknowledgment: We thank the CNRS (momentum project) and Agence Nationale de la Recherche (ANR, project Edgefiller) for financial support.

Tuesday, November 23th

Session 1D & 2D Nanomaterials

15:00 - 15:30 Keynote

Erik BAKKERS, Eindhoven Univ. of Technology, Dpt of Applied Physics, Netherlands

Abstracts

Keynote Speakers

Erik BAKKERS

Professor at Eindhoven University of Technology
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Biography
After obtaining his PhD in nanoelectrochemistry at the University of Utrecht, Erik started working at Philips Research in Eindhoven in 2000. He started his own research group, and the team focused on nanowires- lines of material with a width of several tens of nanometers- an area he continues to research, looking at integration into semiconductors in particular. In 2010, his growing interest in fundamental research resulted in Erik joining the Technical University of Eindhoven as well as Delft Technical University as part-time professor in the Quantum Transport group. His current interest is in Quantum Materials, to detect and manipulate Majorana states, and in Hexagonal Silicon, to demonstrate and exploit the predicted direct band gap in this material. He has received the Technical Review award from MIT, VICI grant, ERC CoG, ERC AdG, the Science AAAS Newcomb Cleveland Prize 2013, and the 'Breakthrough of the Year 2020 award' by Physics World

EFFICIENT LIGHT EMISSION FROM HEXAGONAL SIGE

E.P.A.M. Bakkers

Department of Applied Physics Eindhoven University of Technology, Eindhoven, The Netherlands

Silicon and germanium cannot emit light efficiently due to their indirect bandgap, hampering the development of Si-based photonics. However, alloys of SiGe in the hexagonal phase are predicted to have a direct band gap. In this work, we exploit the unique feature of the nanowire growth mechanism to control the crystal structure by tuning the contact angle of the catalyst particle and demonstrate the optical properties.[1] We show efficient light emission up to room temperature accompanied by a short radiative life time, the hallmarks of a direct band gap material. The band gap energy is tunable in the range of 0.35 till 0.7eV opening a plethora of new applications. We have found the first signatures of lasing in this material. We finally discuss possible routes to integrate this material in Si- technology.

References

[1] E.M.T. Fadaly *et al.*, ***Nature*** 580, 205 (2020).

Keywords: nanowires; hexagonal SiGe; crystal growth; photonics.

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Thematic Session: 1D Nanomaterials
Keywords: nanowire heterostructures, germanium, 1D hole gas, transparent contacts, Josephson Junction.

Transport properties of a highly transparent Al-Ge/Si-Al core/shell nanowire heterostructures.

Jovian Delaforce[1], Masiar Sistani[2], Roman B. G. Kramer[1], Nicolas Roch[1], Martien I. den Hertog[1], Eric Robin[3], Cécile Naud[1], Alois Lugstein[2], Olivier Buisson[1]

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Abstract
Hybrid superconducting-semiconducting systems are of significant interest for experimental investigations of quantum transport and have great potential in quantum devices as gate tuneable Josephson junctions. Further, the exploitation of the geometrical confinement in nanowire heterostructures allows researchers to investigate ballistic transport in quasi one-dimensional systems. The performance of such hybrid systems is strongly dependent on the quality of the interface at the superconductor semiconductor junction. Through annealing, we have realised highly transparent nanowire heterostructures consisting of tuneable germanium segments with atomically precise contacts to crystalline Aluminium leads encased by a Silicon shell (see *Fig 1)*. We will present the gate tuneable transport properties of an ultra-scaled device with a Ge segment length of 40 nm, discussing observations of quantised conductance, Josephson current and multiple Andreev reflections as well as possible applications as quantum devices[1].

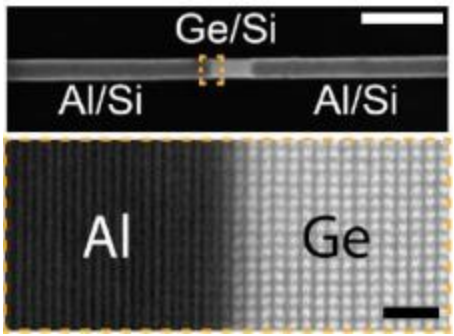

Fig 1: (*Above*) SEM image of a nanowire heterostructure, scale bar is 200 nm. (B*elow*) STEM image of the atomically precise interface between c-Al and Ge, scale bar is 1 nm.

References:

[1] Sistani, M.; Delaforce, J.; Kramer, R. B. G.; Roch, N.; Luong,M. A.; den Hertog, M. I.; Robin, E.; Smoliner, J.; Yao, J.; Lieber, C.M.; Naud, C.; Lugstein, A.; Buisson, O. Highly Transparent Contacts to the 1D Hole Gas in Ultrascaled Ge/Si Core/Shell Nanowires.ACSNano2019, acsnano.9b06809.1314145

Acknowledgment:
Jovian Delaforce acknowledges the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement no. 754303.

Thematic Session: Nanomaterials
Keywords: Nanocomposites, magnetism, photoswitching, plasmonic

Opto-magnetic study of Gold@Spin Crossover Nanocomposites

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Rod-like gold nanoparticles were directly embedded in a 1D polymeric Spin CrossOver material leading to singular Au@SCO nanocomposite. These resulting architectures are designed to promote synergetic effect between ultrafast spin-state photo-switching and photothermal properties of plasmonic nanoparticles.

Spin crossover (SCO) materials are based on coordination complexes of switchable electronic configuration upon external stimuli (temperature, light, pressure…), associated with memory effects (hysteresis loops). Photoswitching of such materials at room temperature remains a challenge, especially when ultrafast and weakly energetic switching is targeted. Based on the pulsed irradiation inside thermal hysteresis loops, photothermal effects can be achieved[1]: this intense laser pulse induces a short and huge local heating allowing the materials to experience the spin crossover. Strategies to reduce the energy and time needed for this switching focus on composite nanoparticles[2]. These composite architectures are based on a strong interplay between surface plasmon resonance of metallic nanoparticles that act as local nanoheaters[3] and optical thermo-induced switching of spin state.

In this presentation, we will show the strong synergy between the surface plasmon resonance of metallic nanoparticle and the spin crossover behavior through a strong modulation of the SPR and an efficient photoswitching of spin state in a nanocomposite material of Au@SCO[4]. We will also report a study on ns-laser pulse excitation of the nanocomposite material through optical measurement.

References (max. 5):
[1] (a) G. Gallé, et al, Appl. Phys. Lett. 102, 063302 (2013); (b) F. Guillaume, et al Chem. Phys. Lett, 604, 105 (2014).
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Acknowledgment:
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Thematic Session: 1D Nanomaterials
Keywords: II-VI nanowires, ZnS, polytypes, TEM, cathodoluminescence

Growth mechanisms and highlights of 15R structure in ZnS nanowires: from VLS to VSS

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Abstract:
Au-assisted ZnS nanowires (NWs) were grown by MOCVD, on GaAs (111)B substrate, and on ZnS (buffer)/GaAs (111B). Growth mechanisms, structural properties, as well as cathodoluminescence are carefully investigated, with the aim to achieve high-quality ZnS nanowires as a building brick for innovative light-emitting devices in the blue-UV range. Using GaAs substrate, Ga is able to diffuse into the Au droplet which results in the formation of an alloyed nanoparticle, liquid at NW growth temperature (550° C). Thus, the NW growth mode in such a case is called VLS. On the other hand, by depositing a buffer layer of ZnS on GaAs (111)B, the gold droplet is prevented from the diffusion of Ga from the substrate. The catalyst droplet remains solid and therefore the growth may proceed as a VSS [1]. ZnS nanowires with length up to 1.4 µm and diameter in the range 10–34 nm were successfully achieved. Their structural characterization using TEM allowed to compare the two growth modes. NWs grown directly on GaAs (VLS mode) show the 15R crystal structure (Figure 1) which is also observed for SiC [2]. This structure is highlighted for the first time in ZnS NWs. Regarding nanowires grown on ZnS buffer (solid catalyst), a different crystal structure made of pure ZB and WZ phases was observed. A 15-20 nm thick ZnMgS shell was deposited around the NWs to passivate the surface and with CL measurements the luminescence from the core at 329 nm and from the shell at 309 nm was observed.

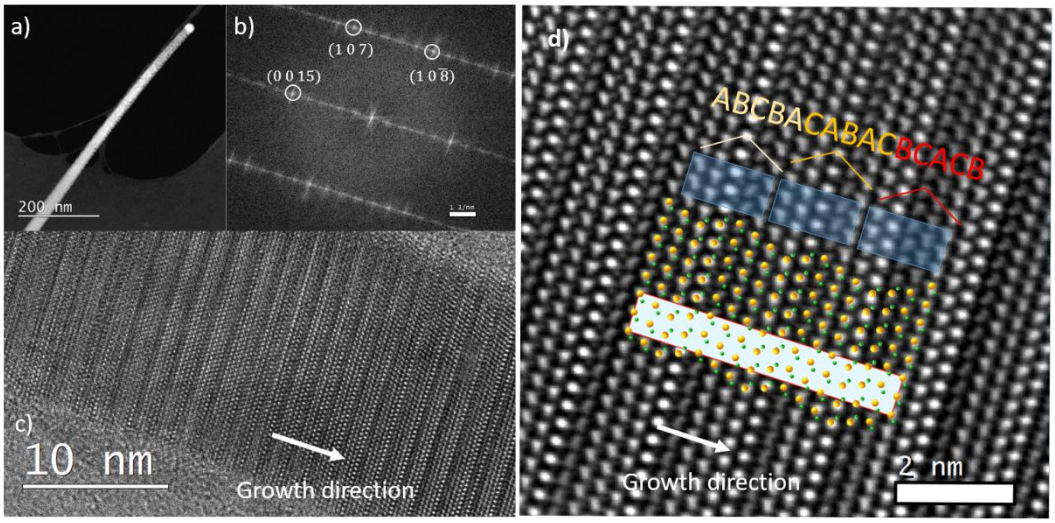

Figure 1 a) STEM/HAADF image of single nanowire grown on GaAs (111)B, b) FFT image, c) HRTEM image of nanowire, d) Fourier filtered image of nanowire superposed with 15R structure model and the respective stacking sequence.

References :

[1] P. Rueda-Fonseca et al., Nano Lett. 14, 1877-1883 (2014)

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December, 8, 9 and 10

Thematic Session: 1D Nanomaterials
Keywords: Nanotubes, Aluminosilicates, Wall polarization, XPS, Work function

Quantification of the intra-wall electric field in aluminosilicate nanotubes using XPS under vacuum

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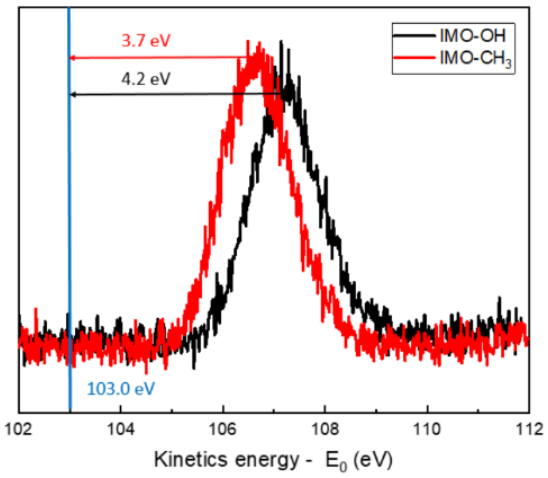

1. Measured kinetic energy - incident photon energy (E_0 = 150 eV) spectra for Si2p. The blue line is the binding energy of Si2p determined in other aluminosilicate minerals (103.0 eV)

Imogolites are synthetic monodisperse hydrated aluminum silicate nanotubes[1,2] which can be prepared with both an internal hydrophilic (IMO-OH) or hydrophobic cavity (IMO-CH_3). Silicon tetrahedra make up the internal surface while the external face consists of aluminum octahedra. Their huge curvature is predicted to be at the origin of a permanent intra-wall electric field which could be in favor of charge separation[3]. The presence of such field has already been qualitatively demonstrated in the case of IMO-CH_3[4]. But to our knowledge, no experimental work has measured the charge separation phenomenon in imogolites up to now.

X-ray Photoelectron Spectrometry (XPS) performed under vacuum on the PLEIADES beamline at Soleil synchrotron allowed for the determination of Al2p and Si2p photoelectron kinetic energies. Combined with laboratory XPS spectra and binding energies of Al2p and Si2p measured for other aluminosilicate minerals, kinetics energy variation through the wall was determined, enabling the first experimental quantification of the electric field variation.

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Wednesday, November 24th

Session 1D & 2D Nanomaterials

10:50 - 11:20 Keynote

Bernard GIL, CNRS - L2C, France

Abstracts

Keynote Speakers

Bernard GIL

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Biography

Bernard Gil, born 1957, is Director of Research of Exceptional Class at CNRS. He is an experimentalist working on light-matter interaction processes in III-V and II-VI semiconductor compounds. After some years spent working on cubic semiconductors, he shifted his interest in 1994 to wurtzite wide bandgap semiconductors for understanding the emission of light in compact solid-state diodes based on nitrides. Since 2015 he is more intensively focused to boron nitride and other two-dimensional semiconductors of the III-VI family, namely InSe, GaSe and GaTe. Gil contributed to the organization of tens of international events and contributed to the launching of several series semiconductor conferences: Int. Conf. on Nitride Sem., Int. Workshop on Nitride Sem., Phys. of Light Matt.Coupling in Nanostructures, ... Gil is Doctor Honoris Causa of the Saint Petersburg Univ. and of the Meijo Univ.of Nagoya. He was awarded the Welker Prize (*wikipedia.org/wiki/Welker_Award*) in 2018.

INTRINSIC AND EXTRINSIC LIGHT MATTER INTERACTION PROCESSES IN HEXAGONAL BORON NITRIDE

Boron nitride is a fascinating material, today found to be particularly useful for conceiving advanced optoelectronic devices as well for hyper-lensing applications in the far infra-red thanks to the marked hyperbolic nature of the phonon-polariton [1], to antiviral applications in line with its efficient emission of an ultraviolet radiation at wavelengths near 200 nm [2], the condition for optimal sterilization from aggressive pathological biological agents that are under the lime lights of the information. Boron nitride is also an excellent platform for quantum technologies with a lot of efficient single photon emitters [2,3]. The fundamental bandgap of this semiconductor exhibits a cross over from indirect between **~K** valence state and **M** conduction state to a direct one at **K**, from a bulk stacking to a single monolayer [4-7]. The exceptional radiative recombination rate of about 50% at room temperature, comparable to what is found for the direct wide bandgap semiconductor ZnO [8] is partly correlated to the efficient exciton-phonon interaction [9-12]. Besides many photoluminescence studies, complementary reflectance and transmission experiments have recently revealed a huge oscillator strength (and thus a particularly broad Reststrahlen band) for the optical transition at the energy of the direct bandgap of BN. This seems to be related to the high internal quantum efficiency alluded to earlier [13].

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Keywords: boron nitride; wide bandgap; 2D semiconductors.

Thematic Session: 1D Materials

Keywords: Semiconductor heterostructure nanowires, selective area growth, band offset multiple probe scanning tunneling microscopy and spectroscopy

Morphology and band offset in InGaAs/InP nanowires grown by selective area molecular beam epitaxy

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Abstract: Selective area epitaxy of semiconductor heterostructures takes place on a crystal inside predefined patterns obtained by lithography inside an oxide mask. This technique, which is highly scalable, allows the growth of complex networks of planar nanowires. Foreseen as potential building blocks of a quantum computer, their integration into complex circuits requires a higher control over their shape and their electronic properties. Here, we will consider InGaAs nanowires grown on an InP substrate. We will first discuss the morphology of the nanowire and will show how adatom diffusion processes shape the nanowires at intermediate stages of the growth. Then, using multiple-tip scanning tunneling microscopy, we will describe a new technique to measure the band alignment between the InGaAs nanowires and the InP epilayer underneath. While the measurements provide consistent band offsets with the literature, the method is direct and does not require any fitting procedure.

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Thematic Session: (1D & 2D materials)
Keywords: (transition metal dichalcogenides, 2D materials, dielectric antennas, Mie resonance)

Investigating the parameters influencing the light emission of TMD monolayers transferred on dielectric nanoantennas

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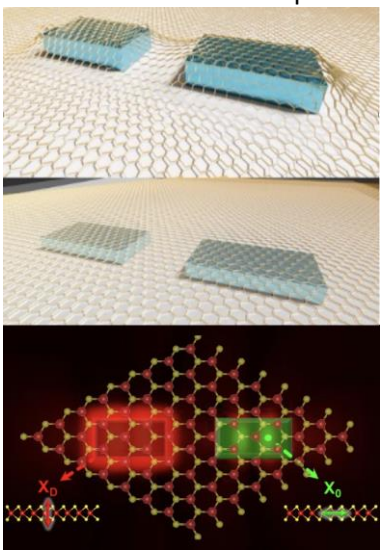
Abstract
Mie nanoresonators such as silicon nano-structures (Si NS) can be used to enhance the emission rate and modify the emission directivity of quantum emitters placed in the NS near-field. In this context, monolayers of TMDs transferred on Si NS are promising candidates to develop integrated quantum light sources. As it is difficult to identify the different parameters governing the modification of the light emission from the TMD-Si NS hybrid system (strain, antenna effect, etc.), we investigate different TMD-MLs (WSe_2 and $MoSe_2$) transferred on Si NS with various designs in order to separate these parameters.
For WSe_2 and $MoSe_2$, we address the effects of Mie resonances and strain in the monolayer by using either planarized or nonplanarized Si NS (See figure). For WSe_2, an important additional contribution comes from out-of-plane exciton dipoles. This paves the way for more targeted designs of TMD-Si nanoresonator hybrid structures for room-temperature applications.



Reference : J.-M. Poumirol *et al*., ACS Photonics **7**, 3106-3115 (2020).

Acknowledgment: This work was supported by ANR grant HiLight, EUR NanoX grant 2D Light, ITN 4PHOTON, RENATECH network, and CALMIP computing facility.

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Thematic Session: 2D Materials
Keywords: boronic acid, boroxine, surface-assisted polymerization,

Sequential processing of 2D covalent networks on metal substrates

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La chimie des acides boroniques est actuellement une des voies utilisées pour la formation de réseaux covalents 3D (COF). Notre objectif est d'appliquer ce concept à la formation de nanostructures organiques 2D sur des surfaces métalliques pour s'en servir comme masques nanoporeux de tailles variables. Les travaux précédents entrepris dans notre laboratoire sur l'acide 1,4-diboronique benzène (BDBA) ont conduit à l'observation par STM d'un réseau en nid d'abeille avec une taille de pores de 15 Å. Cependant du fait de l'irréversibilité de la liaison covalente, des défauts sont présents dans le film. Pour améliorer la régularité du réseau 2D, une approche prometteuse a été envisagée qui consiste à contrôler la cinétique de la réaction par l'utilisation d'une réaction séquentielle. Dans ce but, nous avons récemment combiné deux réactions variant par leur mécanisme et étant activées à des températures différentes c'est-à-dire la formation de cycle boroxine par déshydratation à température ambiante suivie de la formation de liaison C-C via le couplage d'Ullmann à des températures supérieures à 200°C.

Ici nous présenterons nos résultats obtenus à partir de la polymérisation séquentielle de l'acide 1-boronique 4-bromobenzène (BBBA) sur une surface Au(111) (Fig.1). En utilisant cette stratégie en étape, un polymère de meilleure qualité a été obtenu avec des pores hexagonaux de 23 Å.

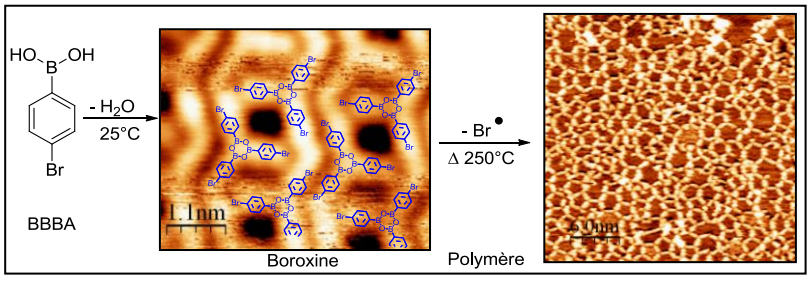

Figure 1 : Mécanisme de polymérisation et images STM des boroxines et du réseau polymère 2D obtenu à partir de la molécule de BBBA sur une surface Au(111)

Thematic Session: 1D Nanomaterials.
Keywords: Tellurium, silver telluride, nanostructures, chemical synthesis.

Single crystalline Te and Ag_2Te nanostructures for thermoelectric conversion

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Abstract
Among the thermoelectric materials, Tellurium has a high positive Seebeck coefficient (500 $\mu V.K^{-1}$) at room temperature but with a relative high thermal conductivity (3 $W.m^{-1}K^{-1}$). Nanostructuring is a solution to improve thermoelectric performances, as the lattice part of the thermal conductivity can be independently lowered **[1]**. In this work, we synthesized self-standing Te nanostructures by electrodeposition technique, taking advantage of the templating properties of ionic liquids solvents. Single crystalline hexagonal nanostructures were systematically obtained with a preferential orientation along the [001] direction. By varying the conditions of electrodeposition, shape and size of nanostructures can be tuned: nanorods, nanowires and nanotubes were synthesized **[2,3]**. Finally, small rods of 70±15 nm in diameter and less than 300 nm long were grown by applying a small charge density. Tellurium nanorods were used as precursors of an additional synthesis step. Indeed, by simple cementation reaction in Ag(I) aqueous solution, Te nanostructures have been transformed into Ag-rich Ag_2Te. Final outstanding monoclinic single crystalline nanorods were obtained thanks to the following topotactic reaction: $2Ag + Te \rightarrow Ag_2Te$ **[4]**. The aspect ratio is almost the same between the starting and the final nanostructures, the width being slightly increased of about 30%, with final width value of 100 nm. Here we have demonstrated that single crystalline Te-based 1D nanostructures can be obtained by soft chemistry routes. These results paves the way for the elaboration of flexible hybrid organic/inorganic thermoelectric thin films, combining nano-Te thermoelectric properties and high electric/low thermal conductivity of conducting polymers **[5].**

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