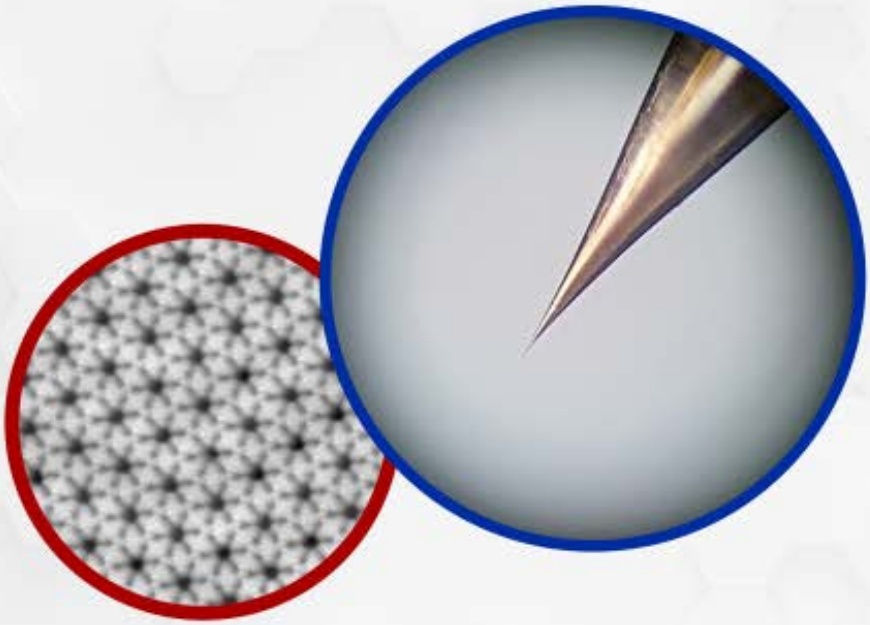
Transpyrenean Nanotechnology Workshop

7-9 April 2021



Tr-Nano 2021

Interreg TNSI

UNIÓN EUROPEA
UNION EUROPÉENNE

M²OZART

Organizers

David Serrate

Vero Langlais

Pilar Cea

INMA
INSTITUTO DE NANOCIENCIA Y MATERIALES DE ARAGÓN

CEMES

Christophe Gatel

César Magén

Sponsored by ICMAB ICN2 Facultad de Ciencias Universidad Zaragoza

PROGRAM AT A GLANCE

Interreg TNSI

Tr-Nano 2021

M²OZART

April 7, Wed				
		MOZART annual meeting Organized by C. Magén, C. Gatel and L.M. Lacroix		
April 8, Th				
	Time	Speaker	Affiliation	Title
Invited	**09:10**	**J.A. Martín Gago**	**ICMM, CSIC, Madrid**	**Nanoscience for understanding dust and molecular complexity in the cosmos**
Trends in Nanotechnlogy instrumentation (10:00-13:15) chair: J. Lobo	10:00	Valvidares, Manuel	ALBA synchrotron, Barcelona	Soft X-ray magnetic dichroism and scattering synchrotron approaches for magnetic nano materials
	10:20	Orús, Pablo	INMA, CSIC-Universidad de Zaragoza	Recent findings in superconducting W-C nanostructures using Focused Ion Beams
	10:40	Pablo-Navarro, Javier	Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	Focused-electron-beam deposition assisted by an electrically-biased patterned metal structure
	11:00			Coffey Break
	11:30	Diego, Lander	Antec (SME), Bilbao	Antec Magnets & Nanotechnology
	11:45	Sarmiento, Gustavo	Suprasys (SME), Bilbao	SUPRASYS, your partner for sample environment
	12:00	Zurutuza, Amaia	Graphenea (SME), San Sebastián	Graphene foundry
	12:15	Herrero Gómez, Pablo	DIPC, San Sebastián	Liquid injection of macromolecules in ultra-high vacuum
	12:35	Peña-Díaz, Marina	CFM, CSIC-UPV/EHU, San Sebastián	Potential Induced Structure Changes at Au(111) Surface in Acidic Solution
	12:55	Pelaez-Fernandez, Mario	LMA, Universidad de Zaragoza	Tuning of plasmonic response of high aspect-ratio Au Nanowires through laser irradiation: a STEM/EELS study
	13:15			Lunch
On surface synthesis of nanomaterials (15:00-17:40) chair: J.I. Pacual	15:00	Salvador, Alba	INMA, CSIC-Universidad de Zaragoza	Ultrafast growth of metallic deposits by focused ion beam induced deposition under cryogenic conditions (Cryo-FIBID)
	15:20	Hernández-López, Leyre	INMA, CSIC-Universidad de Zaragoza	Searching for edge states in a predicted organic topological insulator
	15:40	Schneider, Kathrin	CEMES, CNRS, Toulouse	UV assisted synthesis of poly-para-phenylene on Ag(100)
	16:00	Tenorio, María	ICN2, Barcelona	Built-in atomically precise heterojunctions from hybrid Nanoporous graphene
	16:20			Coffey break
	16:40	Berdonces-Layunta, Alejandro	DIPC, San Sebastián	Adressing the stability of chiral graphene nanoribbons
	17:00	Lauwaet, Koen	IMDEA Nanociencia, Madrid	Diradical Organic One Dimensional Polymers Synthesized on a Metallic Surface
	17:20	Durán, Jose Ramón	ICN2, Barcelona	Transferring and Contacting Atomically Precise Graphene Nanostructures
	20:00			**On-line event (beer friendly): Juggling and Maths (by Serendipia Productions)**
April 9, Fr				
	Time	Speaker	Affiliation	Title
Invited	**09:10**	**Maria Varela**	**Universidad Complutense de Madrid**	**Tales from the Nanoworld**
Nanostructured funcional oxides (10:00-12:50) chair: C. Rogero	10:00	Hettler, Simon	LMA, Universidad de Zaragoza	STEM-EELS analysis of Fe3O4@CoFe2O4@Fe3O4 core-shell-shell nanoparticles
	10:20	Crespo Villanueva, Adrián	ICMAB, CSIC, Barcelona	Structural characterization of the anatase-TiO2(001) film surface
	10:40	Fuentes, Victor	ICMAB-ICN2, Barcelona	Effects of the dimensionality driven metal-insulator transition on strontium iridate memristors
	11:00			Coffee break
	11:30	Domínguez-Celorrio, Amelia	CEMES, CNRS, Toulouse	Controlled gating of graphene nanoribbons onto intercalated MgO monolayers
	11:50	Bernechea Navarro, María	ARAID/INMA, CSIC-Universidad de Zaragoza	Opportunities of using NiOx nanoparticles to grow thin films
	12:10	Louiset, Antonin	CEMES, CNRS, Toulouse	Thin film transfer of piezoelectric LiTaO3 on Si : focus on structural and chemical modifications
	12:30	Boix, Raúl	INMA, CSIC-Universidad de Zaragoza	New nanostructured metal oxides for use in photocatalysis
	12:50			Lunch
Nanomagnetism (15:00-16:20) chair: E. Snoeck	15:00	Gracia-Abad, Rubén	INMA, CSIC-Universidad de Zaragoza	Magnetotransport Phenomena in Bi2Se3 Thin Films
	15:20	Andersen, Ingrid Marie	CEMES, CNRS, Toulouse	Field tunable 3D magnetic states in CoNi nanowires
	15:40	Martín-Rio, Sergi	ICMAB, CSIC, Barcelona	Ferromagnetic Resonance exposed: magnetization dynamics and applications
	16:00	Bartolomé, Fernando	INMA, CSIC-Universidad de Zaragoza	Magnetism of a Cr10 molecular wheel with S=9 ground-state

Contents

Zoom links

Thu 8 | 9:00-13:15 | Invited talk J.A. Gago + Trends in Nanotech. Inst

Thu 8 | 15:00-17:40 | On Surface Synthesis of Nanomaterials

Thu 8 | 20:00-21:00 | On-line social event ‘*Juqgling with Maths*’

Fri 9 | 9:00-12:50 | Invited talk M. Varela + Nanostructured Functional Oxides

Fri 9 | 15:00-16:20 | Nanomagnetism

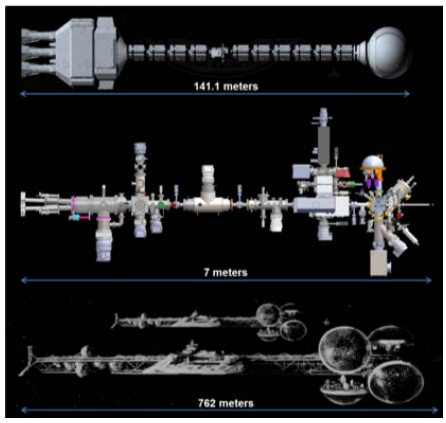
M²OZART Restart Virtual Meeting 2021

10 :30	**C. Gatel (CEMES)**	*General introduction on M²OZART: aim & review*
10 :50	**David Serrate / Véronique Langlais**	*Presentation of TNSI project*
11:10	**Cesar Magen (INMA, Zaragoza)**	*Overview on activities at Zaragoza*
11:40	**Raul Arenal (INMA, Zaragoza)**	*Recent works on carbon and related nanomaterials: atomic structure, chemical and optical properties studies*
12:05	**Alvaro Mayoral (INMA, Zaragoza)**	*Towards local and averaged structural solution of catalysts at atomic level*
12:30	***Break'***	
14 :00	**L.-M. Lacroix (LPCNO)**	*Overview on activities at LPCNO*
14:30	**Irene Mustieles-Marin (LPCNO)**	*Catalysis induced by physical means*
14:55	**Clémence Chinaud-Chaix (LPCNO)**	*Self-assembly of nanoparticles*
15:20	**Christophe Gatel (CEMES)**	*Overview on activities at CEMES*
15:50	**Sophie Meuret (CEMES)**	*Time-resolved electron microscopy for nano-optics*
16:15	**Bénédicte Warot-Fonrose (CEMES)**	*Transmission Electron Microscopy investigations for innovative solar cell materials*
16:40		*Conclusion*
17:00	***Break'***	

J. A. Martín-Gago: “Nanoscience for understanding dust and molecular complexity in the cosmos”

ESISNA group, Instituto Ciencia de Materiales de Madrid-CSIC, Spain
gago@icmm.csic.es

INVITED TALK



Evolved stars are a factory of chemical complexity, gas and dust, which contribute to the building blocks of planets and life. However, the dust and gas formation processes remain poorly understood. Different laboratory techniques are used to produce analogs of cosmic dust being based the majority of them on uncontrolled combustion or plasma decomposition of molecular precursors in conditions far removed from those in star photospheres.

We have designed and built an unprecedented ultra-high vacuum machine combining gas aggregation sources with in-situ advanced surface science characterization techniques (as STM, XPS or IRAS) and mass spectroscopy [1]. We show that astrochemical problems can be successfully addressed and understood using surface science methodologies. This combination opens the door to the investigation and modelling of processes related to dust particles and its interaction with the gas in different regions of the universe [2,3].

References

[1] L. Martinez, Sci Rep. 8 (2018) 7250. / G Santoro, Review of Scientific Instruments 91 (2020), 124101
[2] L. Martinez, Nature Astronomy, 4 (2020), 97-105 /M Accolla, The Astrophysical Journal 906 (2021),44
[3] Merino P., et al. Nature Communications 5, (2014), 3054.

Live streaming of this talk at INMA YouTube channel

Manuel Valvidares: “Soft Soft X-ray magnetic dichroism and scattering synchrotron approaches for magnetic nano materials”

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This talk will provide an overview of the capabilities for investigating magnetic nano materials at the Beamline for X-ray Resonant Absorption and Scattering at ALBA synchrotron, BOREAS BL29. At BOREAS, experiments use either the beamline X-ray Magnetic Circular Dichroism vector-cryomagnet or a multipurpose UHV reflectometer in combination with x-ray photons of energy on the range of 100 eV to 4000 eV (VLS-grating monochromator) and full-polarization control (Apple II EPU). Example of studies range from in-situ investigation of the magnetism of isolated atoms or single molecules, to the properties of oxide materials in thin-film or bulk crystal form, topological insulators, or 2D materials such as Graphene. Present limitations and opportunities for development will be briefly discussed.

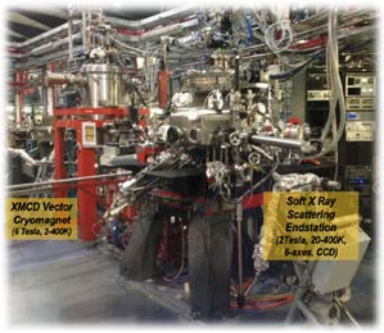

Figure 1: The XMCD and XRS endstations at ALBA BL29

Pablo Orús: “Superconducting properties of W-C nanowires grown by He+ FIBID”

Instituto de Nanociencia y Materiales de Aragón, CSIC-Unizar, 50009 Zaragoza, Spain
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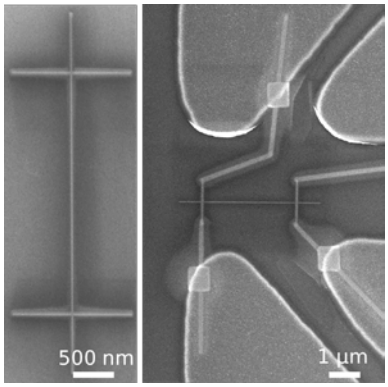
Focused Ion Beam Induced Deposition (FIBID) is a nanopatterning technique that makes use of a focused beam of charged ions to decompose a gaseous precursor, yielding great versatility in the fabrication of functional nanostructures. In this contribution, the fabrication of and characterization of superconducting in-plane tungsten-carbon (W-C) nanostructures by He^+ FIBID of the $W(CO)_6$ precursor is reported. W-C nanowires with line widths down to 10 nm have been grown, and those with widths of 20 nm and above exhibit superconducting properties in the vicinity of 4 K, including the capability to sustain long-range controlled non-local superconducting vortex transfer.



Javier Pablo-Navarro: "Focused-electron-beam deposition assisted by an electrically-biased patterned metal structure"

Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany
Instituto de Nanociencia y Materiales de Aragón, CSIC-University of Zaragoza, 50018 Zaragoza, Spain
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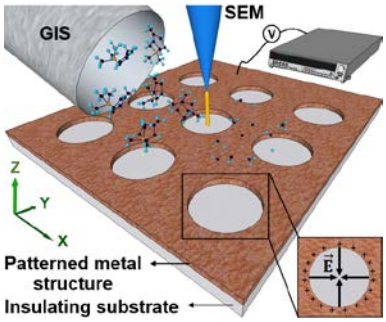

Focused Electron Beam Induced Deposition (FEBID) consists of the decomposition by a finely- focused electron beam of the molecules of a precursor gas, producing a solid deposit [1]. Since FEBID is based on charged particles, it presents some limitations on insulating substrates. The charge accumulation produces beam deflections which impede their practical application [2]. To overcome this, we report an approach based on an electrically-biased metal structures patterned on top of insulating substrates, called ARchitectural Adjustment by Grid Overlay Nanotechnology (ARAGON) Chip [3]. Following this strategy, a Cu layer patterned with a periodic array of holes on top of MgO and quartz substrates has been found to be efficient to suppress charging effects. Finally, the application of an electric field has a huge impact on the trajectories of the electrons responsible for the molecules dissociation. Therefore, tunable spatially-dependent electric fields can be used to tune the dimensions of 3D nanowires.

[1] J. M. De Teresa, Nanofabrication: Nanolithography techniques and their applications. *IOP Publishing Ltd* (2020).
[2] W.-Q. Li, K. Mu, R.-H. Xia, *Micron* 42, 443 (2011).
[3] J. Pablo-Navarro, S. Sangiao, C. Magén, J. M. De Teresa, *Nanotechnology*, 30, 505302 (2019).

Lander Diego: "Antec Magnets & Nanotechnology"

ANTEC MAGNETS S.A.U, 48920 Portugalete, Spain
magnets@antecsa.com

COMPANY ACTIVITIES AND SKILLS

Resistive and permanent magnet design and manufacture, with water or air cooled windings, and high precission laminated or solid magnetic yokes. Main applications include particle accelerators, magnetic separation and nanotechnology, among others.

Design and manufacture of superconducting magnets, including the cryogenic system design, for applications such as particle accelerators, med-tech (protontherapy, radiopharmacy, MRIs etc.), motors/generators etc.

All necessary facilities are avaliable at our workshop, including: winding machines, vacuum-pressure impregnating devices, ovens, yoke manufacturing and assembly areas, testing laboratory and a 250 m^2 clean working area.

NANOTECHNOLOGY RELATED PROJECTS

- Design and manufacture of a new concept of a wet basis magnetic separator.
- Design and manufacture of a permanent magnet system (Halbach) for the magnetic-size particle separation and classification. Privately funded (das-Nano).
- Design and manufacture of an electromagnet. for the magnetic-size particle separation and classification. Universidade do Porto.

OTHER R&D PROJECTS

- Design and manufacture of a Superconducting compact cyclotron for radioisotope production for PET medical applications. Project funded by CDTI (CENIT).
- Design of a Superconducting 4m long Quadrupole for Hi-Lumi Project (CERN). UE funded.

Gustavo Sarmiento: “SUPRASYS, your partner for simple environment”

SUPRASYS S.L., 48014 Bilbao, Spain
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Control of conditions in sample environment is basic in order to keep reproducible results in any experiment. This desirable situation uses to be not direct when new devices are required for upcoming and demanding on-the-edge experiments.

SUPRASYS offers it know-how from the beginning of the conceptual design of the test device and experiment, where either electromagnetism, vacuum or cryogenics or any combination of them are requested. Our talk will present this approach.

Amaia Zurutza: “Graphene foundry”

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Graphene has been the subject of intense research during the past decade. In an attempt to accelerate the development and the introduction of graphene technologies into the market, we decided to launch the Graphene Foundry. Following a pure-play model, we offer different process flows to manufacture a wide range of device applications, tailored to different customers’ specifications, especially suited for biosensing (figure 1) and photonic/ optoelectronic applications.
Figure 1: The GFETs S20 (left) and S22 (right), dedicated graphene biosensors.

[1] D. Akinwande *et al.* Nature 573, 507 (2019).
[2] M. Lanza *et al.* Nature Communications 11, 5689 (2020).

Pablo Herrero: “Liquid injectio of macromolecules in ultra-high vacuum”

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Abstract. Deposition of molecules on surfaces has many applications, such as building devices, on-surface synthesis and catalysis among others. The most common deposition method in ultra-high vacuum (UHV) consists in sublimating a powder of the molecules and exposing a surface to the resulting gas. However, this method is not suitable for all molecules. Some large molecules may lose their structure and/or properties when heated, some others degrade from exposure to air, some others are simply too fragile or too large and break before sublimation. In order to deposit these molecules in UHV, we have optimized an alternative technique: the Atomic Layer Injection (ALI) [1]. This method allows injecting minimal amounts of solution while keeping the UHV conditions. With this method, molecules remain intact and the solvent can be pumped away. We present results on the optimization of the injection process as well as the surface analysis performed on two molecular systems. With them, we illustrate the reliability of the methods and its potential applications.

[1] Sobrado, J. M., and J. A. Martín-Gago. ‘Controlled Injection of a Liquid into Ultra-High Vacuum: Submonolayers of Adenosine Triphosphate Deposited on Cu(110)’. Journal of Applied Physics 120, no. 14: 145307. https://doi.org/10.1063/1.4964434.

Marina Peña-Díaz: “Potential induced structure changes at Au(111) surface in acidic solution”

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Developing new materials with improved catalytic properties is one of the most critical challenges facing the sustainable production of clean and renewable energy sources. In order to achieve this long-standing goal, an atomistic understanding of the processes that place at the electrode-electrolyte interface is required. Here we introduce our customized experimental set-up which enables structural, chemical and electrochemical characterization on exactly the same sample, by allowing the transfer of the catalyst from ultra-high vacuum (UHV) –compatible with surface science techniques- to an electrochemical cell in a controlled argon gas atmosphere. This optimized approach enables the direct correlation between the surface composition (X-Ray photoemission spectroscopy, XPS) and structure (Low energy electron diffraction, LEED, and Scanning tunneling microscopy, STM) at the atomic scale, and the macroscopic response of the catalyst (Cyclic Voltammetry, CV, Linear Sweep Voltammetry, LSV, and Chronoamperometry, CA.).

We applied experimental approach to study the potential induced structure changes during the electrochemical oxidation of Au(111) in 0.05M H_2SO_4, which results in the formation of an oxide film that influences the catalytic performance of the material.

Mario Peláez: “Tuning of plasmonic response of high aspect-ratio Au Nanowires through laser irradiation: a STEM/EELS study”

[1] *Laboratorio de Microscopias Avanzadas, Universidad de Zaragoza, Spain*
[2] *Instituto de Nanociencia y Materiales de Aragón (INMA), CSIC-U. de Zaragoza, Spain*
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Within the field of plasmonics, the study and tuning of localized surface plasmon resonances (LSPRs) in metallic nanowires has been of importance due to their application versatility. Additionally, recent works have shown it is possible modify the morphology of these nanowires by means of laser irradiation, hence providing a new realm of high aspect-ratio nanostructures with potential new properties.
Low-loss electron energy loss spectroscopy (EELS) is a very fitting technique regarding the study of plasmonic resonances, combining an accurate spatial and spectral resolution. The EELS studies shown in this work, combined with theoretical modelling, show how the plasmonic response of these. nanostructures can be tuned by means of coupled and non-coupled Au nanoparticles. Specifically, these studies have been carried out on high aspect-ratio gold nanowires, half-dumbbells and dumbbells by performing a non-negative matrix (NMF) decomposition of EELS spectrum images.

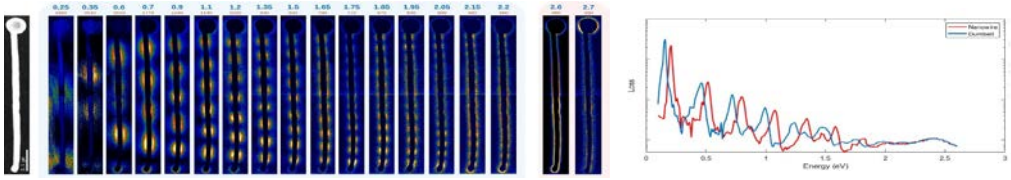

Figure 1: Left: Spatial distribution of the plasmonic modes for the Au half-dumbbell. From left to right: STEM HAADF image: NMF components corresponding to FP modes in ascending order of resonance energy (blue background), and NMF components corresponding to the transversal modes of the Au NW and the Au NP at 2.6 and 2.7 eV. Right: Modelled low-loss EEL spectra for a dumbbell nanostructure and a Au NW of the same dimensions as the dumbbell NW. Results show a red shift of the dumbbell when compared to the bare NW

Alba Salvador: “Ultrafast growth of metallic deposits by focused ion beam induced deposition under cryogenic conditions (Cryo-FIBID)”

Instituto de Nanociencia y Materiales de Aragón (INMA), Universidad de Zaragoza-CSIC, 50009, Zaragoza (Spain)
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Focused ion beam induced deposition under cryogenic conditions, also named Cryo-FIBID, is a powerful technique which has been, in the last few years, applied to grow metallic nanostructures. Using this technique, W-C metallic deposits were fabricated from a W(CO)6 condensed layer with an enhancement of the growth speed up to three orders of magnitude if compared to standard FIBID processing carried out at room temperature. In the present contribution, we will discuss the results obtained using the (CH3)3Pt(CpCH3) precursor, which is commonly found in commercial FIB equipment. As shown in Figure 1, a 30 nm-thick precursor condensed layer in combination with a 30 keV Ga+ FIB is suitable to create Pt-C deposits that exhibit quasi-metallic behavior. As conclusion, Cryo-FIBID is a very desirable technique to grow deposits at the micro and nanoscale, given its high growth rate and the minimized ion-induced damage.

Leyre Hernández-López: “Searching for edge states in a predicted organic topological insulator”

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Topological insulators are a recently discovered class of materials exhibiting interesting properties for applications such as quantum computation devices. Recently, metal-organic coordination networks (MOCN) have been theoretically proposed as the organic counterpart of topological insulators [1]. Despite the experimental achievement of several of the proposed MOCN, their edge state visualization, which is the fingerprint of 2D topological insulator, remains elusive [2,3]. We have formed one of these proposed MOCN with expected topological insulator character using 9,10-dicyanoanthracene molecules and Cu adatoms on a Cu(111) substrate. The lattice extends throughout the surface as single-domain and exhibits an almost perfect order. By means of scanning tunneling spectroscopy and angle-resolved photoemission spectroscopy we have studied in depth its electronic structure, but find total absence of an edge state despite the excellent MOCN order. Functionalized tip measurements and tight-binding calculations suggest that structural asymmetries drive the networks into a topologically trivial case that destroys its edge state.

Kathrin Schneider: “UV assisted synthesis of poly-para-phenylene on Ag(100)”

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Centre d'élaboration de matériaux et d'études structurales (CEMES)-CNRS, Toulouse (France)
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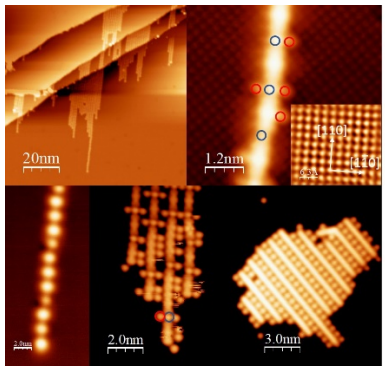
During the past decade, *on-surface-synthesis* has gained increasing research attention to build nanoarchitectures not achievable by conventional wet chemistry. One of the key parameters to achieve covalent coupling is the temperature at which the reaction takes place. Several strategies have been imagined to lower the temperature, such as the co-deposition of reactive adatoms such as Ni or Ag together with dibromo-biphenyl and diodo-biphenyl molecules to synthesize stable intermediates. Here, we show that using UV light during the different steps allows lowering the reaction temperature by 50ºC not only for debromination of the dibromo-*ter*-phenyl precursors but also for transforming the organometallic intermediate into long *poly-para-phenylene* (PPP) wires.



María Tenorio: “Built-in atomically precise heterojunctions from hybrid nanoporous graphene”

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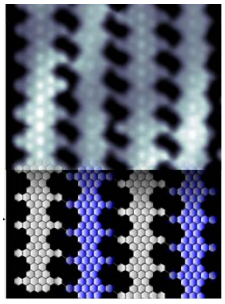
Here we report a hierarchical on-surface synthesis method for the fabrication of graphene-based superlattice heterojunctions by laterally coupling alternating doped/undoped graphene nanoribbons. For that we harness our ability to create parallely-aligned graphene nanoribbons superlattices in order to guide the synthesis of a second GNR component, in this case an N-doped isostructural counterpart, within the empty channels of the superlattice. The final step consists on fusing the hybrid GNR array into a hybrid nanoporous graphene (h-NPG).



Alejandro Berdonces-Layunta: "Addressing the instability of zigzag graphene nanoribbon edges"

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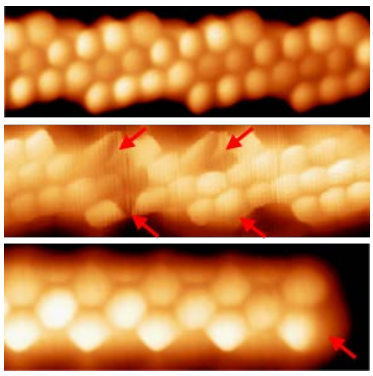
Materials Physics Center (MPC), CSIC-UPV/EHU, 20018 San Sebastián, Spain
ABerdonces95@gmail.com

Graphene nanoribbons (GNR) zigzag edges are closely related with the hosting of spin-polarized states. However, the unpaired π-orbitals hosting the uncompensated spin, whilst being one of their most interesting characteristics, may also be their weakest point when it comes to surviving in ambient conditions. In this study, we have performed STM/AFM experiments that demonstrate the characteristic reactivity of zigzag edges, even for ribbons with a limited radicalary character. Their exposure to ambient conditions rendered oxidized ribbons with dramatically affected electronic properties. Further experiments were performed with reference oxidizing and reducing agents at low pressures as idealized models of the GNR degradation. Different chemical structures are proposed for these defects, supported by HR-STM measurements and theoretical calculations.



Koen Lauwaet: "On-surface synthesis of diradical organic one-dimensional polymers"

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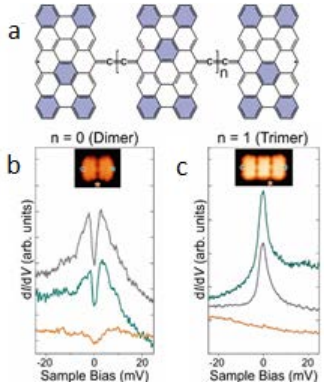
Over the last decades, the precise structural control of organic polymers has become a primary subject of research in polymer science. In this work, we present the on-surface synthesis of one-dimensional polymers based on cumulene-bridged peripentacene units, resulting from on-surface reactions of the 13,13'-bis(dibromomethylene)-13H,13'H-6,6'-bipentacenylidene molecular precursor on a bare Au(111) surface under ultra-high-vacuum conditions. The structural and electronic characterization of the polymers has been realized experimentaly, and is complemented by theoretical calculations, revealing that the polymers present an experimental band gap of 0.8 eV and pure diradical character, exhibiting one unpaired spin at each end. We observe a transition from an antiferromagnetic ground state for peripentacene dimers to a paramagnetic ground state for trimers or longer polymers.



Open-shell non-Kekulé structure (a), as well as split-peak (b) and zero-bias feature (c) acquired at dimer and trimer edges.

José R. Durán: Transferring and Contacting Atomically Precise Graphene Nanostructures”

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The recent synergy between chemistry and physics has enabled structurally uniform and atomically precise graphene nanostructures ranging from single graphene molecules, graphene nanoribbons to nanoporous graphene. The unprecedented atomic-control over the edges and self-assembly of the nanostructures is provided via a novel bottom-up approach based on chemically-tailored monomers and metal surface-assisted synthesis that is controlled by means of scanning tunneling microscopy and spectroscopy. Such nanostructures exhibit a plethora of unique properties associated to their chirality, edge termination, width, length, which are not found in graphene, leading to a rich platform for exploring novel paradigms and fundamental physics. Conversely, top-down approaches that pattern graphene induce damage and cannot resolve atomic features due to the fundamental limits of i.e. e-beam, nanotip or laser-beam. Therefore, to access these atomically-induced unique properties is compulsory to preserve the nanostructure pristine quality during the transfer process. However, the atomic nanostructure strong interaction with the underlying metallic substrate (i.e. Au(111)) sets a cornerstone for decoupling both systems. In this regard, we first review dry-transfer methods that preserve the nanostructures atomic-quality and avoids residues. Second, we explore polymer-assisted wet-transfer methods that provide mechanical support during the transfer but render carbon-related residues. Third, we look into direct wet-transfer methods that solely involves chemical etchants. Moreover, low-resistivity ohmic contacts are a key enabling parameter for any practical electronic and optoelectronic device. In particular, contacting 2D-materials via metal evaporation suffer of Fermi level pinning and induced-damage. To ensure ohmic contacts, several engineering strategies adapted from 2D materials including 2D-2D contacts, tunneling contacts, edge contacts, lateral contact, and side gates are adopted to overcome the challenges. In conclusion, we provide a guide to transfer and contact unperturbed atomically precise graphene-based nanostructures for the future development of electronic and optoelectronic devices that unravel their unique properties.

María Varela: “Tales from the Nanoworld”

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INVITED TALK

The fast pace of technological development of our society continuously demands new materialssystems for applications areas such as data storage, sensors, spintronic devices or energy applications. Functionalities of interest can result from mechanisms related to static equilibrium (crystal structure, ground state electronic properties, etc), or also from dynamic processes involving mass or electronic transport under external stimuli. For instance, an electric bias can change the local concentration of O vacancies within the lattice of oxide materials, causing structural instabilities and changes of crystal symmetry, oxygen electromigration or other processes. Other examples may include local chemical fluctuations, strong electronic correlations, unusual cooperative behaviours like high Tc-superconductivity, colossal magnetoresistance, ferroelasticity or colossal ionic conductivity. In order to harness such phenomena, we need to be able to *both visualize and quantify* atomistic phenomena in conditions similar to those found in working environments. Now, durnamore than ever, we need to be able to watch and track the properties atoms at work. This is a task that demands real space probes that can inspect matter at the atomic scale in both static and dynamic regimes, on an atom-by-atom basis. Aberration corrected scanning transmission electron microscopy (STEM) combined with electron energy-loss spectroscopy (EELS) has brought sub-Ångstrom electron beams to bear on this task resulting in unprecedented sensitivity for imaging and spectroscopy, including the feasibility of mapping electric and magnetic fields at the atomic scale. This talk will review some examples of applications of these techniques to interfaces and nanomaterials. Examples include local measurements of electronic and magnetic properties of ultrathin epitaxial films based on the ferromagnetic manganite $La_{0.7}Sr_{0.3}MnO_3$ (LSMO). STEM-EELS combined with density-functional calculations can be used to study the role of local structural distortions and electronic phenomena associated with point defects such as O vacancies on stabilizing interfacial magnetism. A second example including imaging of systems out of equilibrium can be found the study of Ni_3Fe nanoparticles for supercapacitors. Room temperature annealing in the objective lens magnetic field (close to 3T) induces a segregation of Ni and Fe species, in the form of small nanoclusters. Further heating induces Fe oxide segregation, resulting in core-shell like systems and Ni/NiO nanoclusters that have been identified as a major culprit for the pseudocapacitance enhancement. Work carried out in collaboration with G. Abellan, J. I. Beltran, E. Coronado, J. Grandal, A. Guedeja-Marron, C. Leon, S. G. Miralles, M. C. Muñoz, H. Prima-Garcia, J. Romero, J. Santamaria, J. Tornos. Research at UCM sponsored by grant# RTI2018-097895-B-C43.

Live streaming of this talk at INMA YouTube channel

Simmon Hettler: “STEM-EELS analysis of Fe3O4@CoFe2O4@Fe3O4 core-shell nanoparticles”

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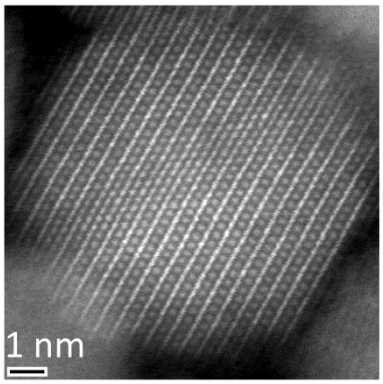
Nanoparticles made from various magnetic phases open up wide perspectives due to their intrinsic properties and synergistic interactions at interfaces in core-shell structures. We present the in-depth analysis by scanning transmission electron microscopy (STEM) and electron energy-loss spectroscopy (EELS) of iron oxide and cobalt ferrite core-shell-shell nanoparticles synthesized following a three-step thermal decomposition pathway, which offer interesting magnetic properties. STEM analysis shows single-crystalline nanoparticles with no structural boundaries between core and shells. The EELS data reveals the Fe and Co distribution within the nanoparticles as well as the influence of the local environment on the O bonding chemistry on a sub-nm scale.



STEM image of a Fe_3O_4 / $CoFe_2O_4$ core/shell nanoparticle

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Adrián Crespo: “Structural characterization of the anatase-TiO_2(001) film surface”

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Titania is of interest among others for the photovoltaic conversion of light to electricity [1-2]. The two most studied surfaces of TiO_2 are the rutile (110) and the anatase (101). Rutile provides the most thermodynamically stable surface at higher temperatures (a=4.5845 Å, c=2.9533 Å), whereas anatase, a natural polymorph, the most stable one at room temperature [3] as well as the most photoactive (a=3.7842 Å, c=9.5146 Å). However, currently anatase-TiO_2(001) holds promises of greater photocatalytic activity than anatase-TiO_2(101) [4]. This anatase (001) surface has the higher number of Ti active sites (all of them are coordinated to five oxygen neighbors) [5,6]. On the other hand, it is known that the formation of Ti^{3+} ions may improve the photocatalytic activity by acting as hole traps eventually suppressing the recombination. These ions are normally formed by reduction of Ti^{4+} ions to Ti^{3+} due to the formation of oxygen vacancies. In this work we grow (100) and (001)-oriented anatase films by Pulsed Laser Deposition on ferroelectric $BaTiO_3$/$SrTiO_3$ (001) heterostructures and on $SrTiO_3$(001) in view to investigate the coupling between the ferroelectricity and the photocatalytic efficiency. The analysis of LEED patterns indicates the development of a (4x1)/(1x4) surface reconstruction, which is a manifestation of oxygen deficiency. X-Ray diffraction indicates that only the anatase (001) crystal orientation is obtained. The surface topography of anatase films can be tuned as function of temperature as observed from AFM measurements. Moreover, synchrotron grazing incidence X-Ray diffraction shows that the lateral dimension of the ordered domains extends up to the 100-200nm range. [1] B. O’Regan and M. Gratzel, Nature, 353, 737–740 (1991). [2] F. Sauvage et al., ACS Nano, 4, 4420–4425 (2010). [3] U. Diebold, Surf. Sci. Rep. 48 (2003) 53. [4] X.Q. Gong, A. Selloni, J Phys Chem B. 109 (2005) 19560-2. [5] J. Liu et al., Chem. Mater. 29 (2017) 5591. [6] M. Lazzari et al., Phys. Rev. B 63 (2001) 155409.

Víctor Fuentes: "Effects of the dimensionality driven metal-insulator transitions on strontium iridate memristors"

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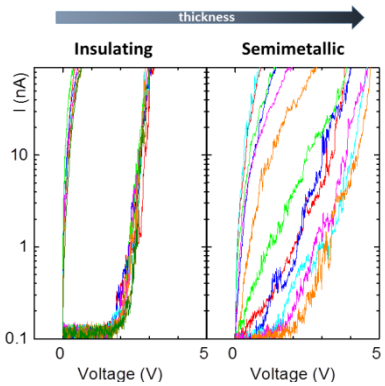

Resistive switching (RS) describes the phenomena where a material can switch between two resistance states by the application of an external voltage. RAM memory devices based on this effect (memristors) have been spotted as an appealing solution for the problems of miniaturization and energy consumption. In this context, materials possessing Metal-Insulator Transitions (MITs) are considered excellent candidates for this type of applications. In this work novel RS properties of Strontium Iridates Ruddlesden-Popper phases, a family of materials near diverse MITs, are studied. In particular, the Anderson MIT triggered by the reduction of the thickness in the $SrIrO_3$ phase is examined. Moreover, the influence of this MIT in the RS characteristics is analyzed and explained considering the changes in the films band structure.

Amelia Domínguez-Celorrio: "Gateable three terminal device based on individual graphene nanoribbon on MgO"

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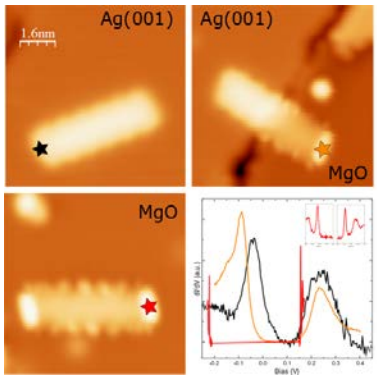

Chiral graphene nanoribbons (chiral GNR) manipulated on top of monolayer islands of MgO were investigated using low-temperature scanning tunneling microscopy. The electronic characterization of chiral GNR on Ag(001), during the atomic manipulation into MgO ML island and fully on MgO/Ag(001) system, allows to follow the energy shift of observed orbital states due to the presence of the ultrathin dielectric film. The reported combination of the bottom-up synthesis of chiral GNRs and manipulation onto dielectric films is an important step towards the integration of atomically designed GNRs into electronic devices. Once the ribbon is on the island, its one-dimensional electronic bands can be shifted in a controlled manner by tuning the tip induced electric field in the tunneling gap.

María Bernechea: "Opportunities of using NiOx nanoparticles to grow thin films"

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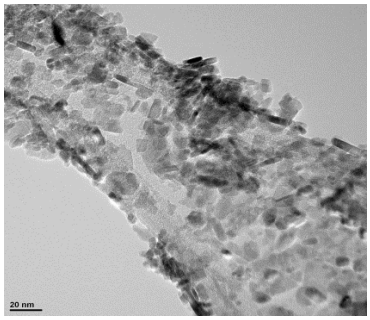
Non-stoichiometric nickel oxide (NiOx) is a transparent conductive oxide (TCO) with interesting properties for many optoelectronic applications, among them photovoltaics. It has a band gap of 3.8 eV, a transmittance of almost 90%, a resistivity of less than 10^3 Ω·cm, and an excellent chemical stability. Moreover, contrary to most TCOs used in solar cells, it exhibits a p-type behaviour.

NiOx thin films have been fabricated using Pulsed Laser Deposition (PLD), d.c. sputtering, e-beam evaporation and sol- gel techniques. The synthesis of NiOx nanoparticles (NPs) and their use to grow thin films offer additional advantages that will be discussed in this presentation.



TEM micrograph of NiOx NPs

Antonin Louiset: Thin film transfer of piezoelectric $LiTaO_3$ on Si : focus on structural and chemical modifications"

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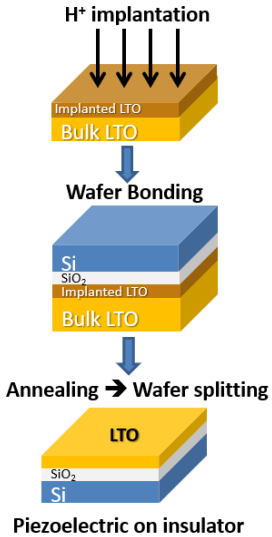
Lithium Tantalate ($LiTaO_3$ or LTO) obeys promising piezoelectric properties for use in Surface Acoustic Wave (SAW) filters, especially for Radio Frequency applications. New generation SAW filter requires a thin single crystal LTO layer over a SiO_2/Si substrate. Such structures can be manufactured by a transfer of a LTO layer on a SiO_2/Si substrate by the Smart Cut™ technology, which is based on Hydrogen ions implantation, wafer bonding and annealing. Being a polar material, the reaction of LTO on H^+ ions implantation and annealing is expected to be very complex and so far, little is known about such interaction in LTO crystals.



Here, we focus on the structural and chemical modifications induced by H+ ions implantation in off-axis (c-axis being rotated around the [11-20] axis) LTO single crystals. We developed a protocol to extract depth profiles of all strain tensor components based on combination of high-resolution XRD measurements, simulations (RaDMaX) and analytical theory. The so extracted strain profiles were compared to the hydrogen ones measured by SIMS. We were able to highlight the appearance of strong shear strain in implanted regions, as well as a non-trivial relation between H fluence, H concentration and strain. We evidenced some intriguing Li and O composition depth redistribution in implanted regions by using STEM-EELS and Glow Discharge Optical Emission Spectroscopy (GDOES) techniques.

Raúl Boix: “New nanostructured metal oxides for use in photocatalysis”

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An important variety of metallic oxides are solid photoactive semiconductors with the capacity to generate Reactive Oxygen Species (ROS) in aqueous media. The great oxidizing capacity of these ROS has been studied by the scientific community in various applications such as the elimination of pollutants, bacteria, viruses, or cancers, among others.

Our work in this field has focused on the synthesis of hybrid photocatalysts based on the combination of TiO_2 nanoparticles with lower band gap semiconductor nanocrystals. In this way, these new materials become less dependent on UV radiation and more efficient under sunlight. Moreover, we are currently investigating other metal oxides that can be photoactivated with visible - NIR light, which could also be very useful in biomedical applications.

Rubén Gracia-Abad: "Omnipresence of Weak Antilocalization (WAL) in Bi_2Se_3 thin films: a review on its origin"

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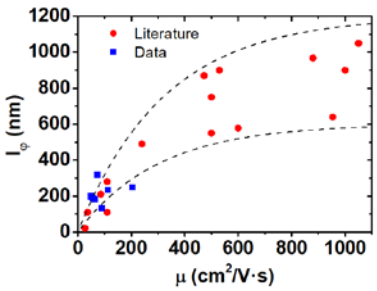

Topological insulators are materials with an insulating bulk surrounded by protected Dirac-like surface states. Among them, Bi_2Se_3 has attracted special attention due to its relatively large band gap that should enhance the contribution of surface transport. However, defects in the system usually prevent the observation of the surface states. To avoid this, several features such as the weak-antilocalization effect, can be explored through magnetotransport experiments. Here, we present our work on the study of transport in Bi_2Se_3 thin films. At the same time, we review existing literature of this material, paying thorough attention to the weak-antilocalization effect, which is omnipresent no matter the film quality. Finally, we compare the data found in literature to shed light on the intrinsic properties of Bi_2Se_3, finding a relationship between the mobility and the phase coherence length of the films that could trigger further experiments on transport in topological systems.

Ingrid Marie Andersen: "Field-tunable 3D magnetic states in CoNi nanowires"

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To gain precise control of magnetic configurations for technological advances in nanomagnetism, it is crucial to consider "real-structure" effects, e.g., from unwanted changes in texture, anisotropy, morphology, or other defects in a system. This can greatly affect magnetic configurations and their properties, e.g., domain wall velocities, in real-life materials systems. The presented work shows a 3D reconstruction of the magnetic configurations in a single cylindrical CoNi nanowire (NW) with the dominating *hcp c*-axis oriented almost perpendicular to the NW axis. For this, holographic vector-field electron tomography is compared with detailed micromagnetic simulations using the NW's real shape. Two characteristic remanent states are identified after applying a saturation field (i) perpendicular or (ii) parallel to the NW axis. We give a detailed analysis of the observed domains and their peculiar domain walls, and of their structure and energies.

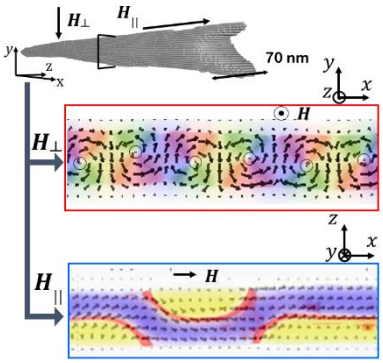

Figure: The two characteristic remanent states from micromagnetic simulation results using the real shape of the observed nanowire

Sergi Martín: Ferromagnetic Resonance Exposed: Magnetization Dynamics and Applications

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Ferromagnetic resonance (FMR) spectroscopy has become a very popular technique for the characterization and study of both dynamic and static magnetic properties of a diversity of ferromagnetic materials. As a consequence, it is widely used in the Spintronics community. In this workshop, the main features of FMR will be presented and the basic measurement setup described. Additionally, the creation of spin currents induced by spin pumping and its detection by interconversion to an electric current (inverse spin Hall effect) will be evidenced by some examples.

Fernando Bartolomé: "Magnetism of a Cr_{10} molecular wheel with S=9 ground-state"

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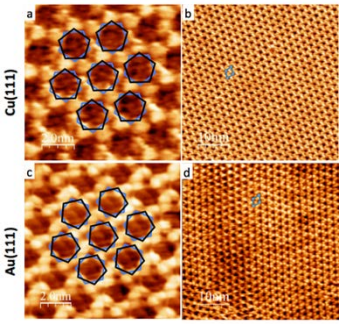

Molecular nanomagnets formed by clusters of ions with large number of unpaired electrons have attracted intense study because molecular aggregates stabilizing high ground spin states may display Single-Molecule Magnetism (SMM). Cyclic complexes are of particular interest because of their planar high symmetry. We have studied wheel molecules of formula $Cr_{10}(OMe)_{20}(O_2CCMe_3)_{10}$ ([Cr_{10}] from now-on), both in bulk and evaporated by direct sublimation in UHV on metallic single-crystal surfaces. [Cr_{10}] molecules self-organize in a quasi-hexagonal 2D network when deposited onto the Cu(111) or Au(111) surfaces up to the monolayer. , as shown in the STM image. The magnetic characterization of monolayer, multilayer and bulk samples of [Cr_{10}] has revealed that this cluster exhibits an unusually high S-ground state, S=9. The magnetic characterization of evaporated [Cr_{10}] was performed by XMCD at the Cr $L_{2,3}$ edges. Monte Carlo simulations considering the Cr(III) as a Heisenberg S=3/2 spin entity are able to describe the M(H) curves qualitatively A static Hamiltonian based on nn interactions leading to a S=9 requires a particular combination of ferro- and antiferromagnetic Cr-Cr interactions, somehow hard to reconcile with the underlying five-fold symmetry of [Cr_{10}]

Juggling with Maths. Beer friendly on-line show

Live streaming of this show at INMA YouTube channel

Juggling with Maths: A Scientific Circus

Two engineers, but also, two circus artists, are here to talk, show and have fun mixing circus, phsysics and mathematics. After years developing their skills, Edu and Ignacio are two amazing jugglers who can take advantage of their engineering background to go into detail of all the science behind of what they do. Did you know that juggling is all about mathematics? Siteswap is a numeric juggling notation used to describe and/or represent juggling patterns. It is an invaluable tool in determining which combinations of throws yield valid juggling patterns. Mixing acts with the explanation of all the beauty of the science behind, we will dive in the circus world! Clubs, balls, mathematics, but also, physics, risk and some nosense... We are waiting for you, the show is about to start!

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