Functional thin films, Nanostructures & 2D materials

Wednesday March 19th

10:30 A.M. - 12:30 A.M.

AMPHITHEATRE LOUIS ARMAND OUEST

Program of the session :

Chairs: David BABONNEAU & Rémi LAZZARI

HOUR	NAME	TITLE
10:30	**Emilie GAUDRY** **IJL - Univ. Nancy**	**Theoretical insights into ultrathin oxide films on metals and alloys: unraveling structures and stabilities**
11:00	Swayam SAHOO INL - ECL	Interface engineering for integration of VO2 on silicon for thermotronics
11:15	Jérémy BARBE IMN - Nantes Université	Sputtered La0.33NbO3 perovskite thin films for high-power Li-ions micro-batteries
11:30	Bertrand VILQUIN INL - Centrale lyon	Structural and electrical properties of ferroelectric HfZrO2-based nano-capacitors for non-volatile memories
11:45	Léa MEYNIER CINam - CNRS	Ferroelectric structure, crystallography and morphology of GeTe thin films grown on Si(111) : the key role of atomic steps
12:00	Qiang YU C2N - Université Paris-Saclay	Electric-field-assisted phase switching in GaAs nanowires
12:15	Chen WEI C2N - CNRS	In-Situ TEM Observation of III-V Nanowire Nucleation on Si

Emilie GAUDRY (Univ. Lorraine - IJL, Nancy)

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Short biography

Émilie Gaudry, Prof at Université de Lorraine, is involved as a Scientific Director at Mines Nancy. She develops research activities at the Jean Lamour Institute, in the field of materials modeling with quantum chemistry and machine learning methods. Initially focused on metallic materials, quasicrystals and associated intermetallic compounds, the scope of her research activities has expanded more recently to metal/oxide interfaces and nano-materials. She is an associate researcher at the Soleil synchrotron where she develops approaches combining surface diffraction experiments and associated modeling. She is Director of the HPC computing center at the University (eXplor), a platform shared between staff from the University and associated EPSTs.

Theoretical insights into ultrathin oxide films on metals and alloys: unraveling structures and stabilities

Thin perovskite films, made of a few-layer thick nano-sheets, have attracted considerable attention due to their extensive structural and electronic variability, linked to the huge number of conceivable unique chemical compositions. The combination of the low dimension with the structural flexibility of this class of crystals opened the door to a rich spectrum of applications in many fields, such as energy transition and catalysis, correlated materials and electronic devices.Decreasing the thickness of two-dimensional (2D) perovskites down to the mono-layer limit is expected to deeply alter their structures and modify the physical and chemical properties. This has recently led to the emergence of novel structures with aperiodic ordering, i.e. dodecagonal oxide quasicrystal interfaces [1,2]. The driving force for these unique structural modifications, resulting from thickness reduction, are far from being fully unveiled [3]. Reduced bonding coordinations, possible strong surface polarizations, support effects and experimental conditions are supposed to play a role, but no clear picture has yet been drawn. In this talk I will show how two-dimensional complex oxide structures can be identified, while also questioning several descriptors that contribute to their stability. This work is a first step towards establishing structure-property relationships for this class of materials, which is crucial not only for advancing fundamental understanding of their unique characteristics but also for optimizing their performance in practical applications.

Keywords

ultrathin oxide films, density functional theory, oxide quasicrystals

Acknowledgement

I would like to express my sincere gratitude to my collaborators in Japan and at IJL, especially Weiliang Ma. I also wish to acknowledge the computational resources (GENCI, TGCC, CINED, IDRIS, EXPLOR) and financial support (ANR NOUS) that made this work possible.

References

[1] C.Ruano Merchan et al., “Two-dimensional Approximant and large hexagonal phase in $SrTiO_3$ films grown on Pt(111)/Al_2O_3(0001)”, Phys. Chem. Chem. Phys., 24 (2022) 7253-7263

[2] Xu Li et al., "Schematic structural analysis of honeycomb structure ultra-thin Ce-Ti-O films on Pt(111) using photoelectron holography and ab initio calculation", J. Phys. Chem C 128 (2024) 20238

[3] T. Dorini et al., “Two-dimensional oxide quasicrystal approximants with tunable electronic and magnetic properties”, Nanoscale 13 (2021) 10771-10779

Wednesday March 19th

4:30 P.M. - 6:30 P.M.

AMPHITHEATRE LOUIS ARMAND OUEST

Program of the session :

Chairs: Guillaume COLAS

HOUR	NAME	TITLE
16:30	**Aimeric OUVRARD** **ISMO - CNRS**	**Charge transfer and atomic interdiffusion in ordered plasmonic nanoparticles in interaction with molecules.**
17:00	Abeer FAHES ICMN - CNRS	Polymer-Integrated AgPt Bimetallic Nanoparticles for Durable Plasmonics
17:15	Christina VILLENEUVE-FAURE Laplace - Univ. Toulouse	A nanoscale investigation of plasma deposited AgNPs-based nanocomposites electrical properties for nanoelectronic applications
17:30	Lionel PATRONE IM2NP - CNRS	Self-assembled monolayer of push-pull chromophores towards the polarization modulation for controlled detection of biomolecules
17:45	Federico ZIZZI CEISAM/IMN - Nantes Univ.	Coupling of Nanomechanics and Photochromism in Azo Soft Materials: From Thin Films to Nanoparticles
18:00	Julien CASTETS ICMCB - Univ. Bordeaux	Fabrication of correlated disordered structures in thin films to tune the visual appearance of surfaces
18:15	Simon DELACROIX LPMC - Ecole Polytechnique	Synthesis of colored glasses by an original sol-gel/laser coupled approach

Aimeric OUVRARD (CNRS - ISMO, Orsay)

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Short biography

Dr. Aimeric Ouvrard is a physicist experimentalist in surface science and non-linear optics and molecular physics at the Institut des Sciences Moléculaires d'Orsay (Univ. Paris Saclay). After a PhD in semiconductor laser physics and molecular spectroscopy for atmospheric physics obtained at University of Montpellier (Fr) in 2005, he did a postdoctorate at Dublin City University for 2 years in the applied field of molecular spectroscopy for pharmaceutical and bioindustrial applications. In 2007, he changed his scientific direction during a second postdoc at Laboratoire de PhotoPhysique Moléculaire (Univ Paris Sud) in non-linear vibrational spectroscopy of supported metal catalysts. In 2009 he enters CNRS at ISMO, to conduct research in non-linear ultrafast spectroscopy of assemblies of molecules and plasmonic nanoparticles. After defending his HDR "Photo-physics of assemblies of nanoparticles and molecules" in 2021, he is now leader of the group "Femtophysics at interfaces" specialized in the development and study of various nanostrutured surfaces of interest for energy harvesting, nanooptics, molecular electronics and heterogeneous catalysis.

Charge transfer and atomic interdiffusion in ordered plasmonic nanoparticles in interaction with molecules.

Understanding the interaction of molecules with nanoparticles is the key to control charge transfers for molecular electronics or energy production. The main difficulty lies in the need to probe at the scale of the individual molecule, otherwise having a system that is poorly dispersed in size to reduce the inhomogeneous broadening of the observables. In this context, we carry out ordered hybrid nano-assemblies where organic molecules functionalize metallic or plasmonic nanoparticles epitaxied on an alumina bilayer on Ni3Al(111). We combine non-linear/linear spectroscopy and microscopy, to reveal structural, chemical and plasmonic properties as well as the impact of charge transfer in those hybrid assemblies [1-5].

The mechanical stress in the bilayer induced by the substrate periodically modulates the surface reactivity, which ensures the ordered growth of Pd metal clusters [1]. The correlation of geometry to the reactivity of long-range, narrow size distributed Pd NPs containing from few atoms to several hundred are revealed using CO molecule as a probe of the surface structure [2]. This nanostructured surface allows producing ordered assemblies of NP weakly coupled with organic molecules (perylene) [4]. By evaporating gold or silver on the Pd core, plasmonic properties arise above two atomic layer thick shell, giving an additional control of photophysical properties. Pd/Ag core/shell NPs show a better long-range ordering and a reduced atomic interdiffusion at the core-shell interface compared to Pd/Au NPs [3] leading to a stronger plasmonic response [5]. When fullerene is evaporated on NPs, we follow in real-time the strong change of optical, vibronic and plasmonic properties. Charge transfer from NP to C60 affects the optical response and the vibronic structure and reduces the plasmonic response. This work paves the way for future assemblies, where charge transfer can be induced and followed in real-time at sub-ps timescale using ultrafast laser.

Keywords

nanoparticles, surface plasmon resonance, molecules, charge transfer, non-linear optics

Acknowledgement

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References

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Functional thin films, Nanostructures & 2D materials

Thursday March 20th

2:00 P.M. - 4:30 P.M.

AMPHITHEATRE GASTON BERGER

Program of the session :

Chairs: Anthony SZYMCZYK

HOUR	NAME	TITLE
14:00	**Matteo GHIDELLI** **LSPM - CNRS**	**Boosting mechanical properties of metallic thin films through advanced nanoengineered design strategies**
14:30	Catherine DE VILLENEUVE PMC - CNRS	Fe-based MOF layers on silicon surfaces
14:45	Kenza JOYEN ICGM - Univ. Montpellier	Molecular sieving membrane for selective hydrogen sensing
15:00	Vincent JOURDAIN LCC - Univ. Montpellier	In situ optical microscopy studies of the catalytic growth and shrinkage of individual carbon nanotubes
15:15	Aude SIMON LCPQ - CNRS	Growth of large carbon molecules and mixed metal-carbon nanoparticles driven by organometallic clusters: interdisciplinary studies
15:30	Alexia BISTINTZANOS INSP - Sorbonne Univ.	pH influence on the structure of metal-organic thin films at the air/water interface
15:45	Ana Karen PIÑON-VASQUEZ MIM2 - Chimie ParisTech	Design and Synthesis of Bioactive Materials Using Two-Photon Polymerization and Thiol-Ene Click Chemistry
16:00	Guillaume COLAS Institut FEMTO-ST - CNRS	Lubrication by self-assembled multilayer enabled through tribochemical transformation into nanometric thick C-based solid material
16:15	Rémi LAZZARI INSP - CNRS	Interface and grain boundary contributions to electron transport in thin films: an application to silver based low e-coatings

Matteo GHIDELLI (CNRS - LSPM, Villetaneuse)

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Short biography

Dr. Matteo Ghidelli is CNRS researcher at LSPM-CNRS heading the group Mechanics of Functional Thin Films composed by 7 faculty and >15 temporary researchers. Dr. Ghidelli completed a joint PhD in 2015 at the Uni. Grenoble Alpes (France) and the Uni. catholique de Louvain (Belgium). After postdoctoral positions at the Uni. Rome Tre and Politecnico di Milano (Italy), he served as Group Leader at Max Planck Institute for Sustainable Materials (Germany), heading the group of “Thin films & Nanostructured Materials” and in 2020, he joined the LSPM. Here, he established a new research activity focused on the synthesis of nanostructured thin films and micro-scale mechanical characterization, especially using in situ SEM techniques. His work emphasizes innovative nanoengineering strategies - such as the synthesis of nanocomposites, nanogranular films, and interface dominated materials - designed to enhance and precisely control mechanical properties and deformation behavior. Dr. Ghidelli is author of 44 papers and he secured >1.5 M€ as third parts funding. In 2022, he obtained the “Habilitation à diriger des recherches (HDR)” and, at the present, he supervises 4 PhD students and 1 postdoc.

Boosting mechanical properties of metallic thin films through advanced nanoengineered design strategies

The current trend toward miniaturization in devices components in key technologies such as microelectronics, energy production, sensors and wear protection requires the development of high-performance thin films with superior mechanical properties combining mutually excluding mechanical properties such as high yield strength and ductility. Achieving such performance, relies on leveraging microstructure-induced mechanical properties, requiring the precise control of film’s microstructure, atomic composition, grain size and thickness based on nanoengineering design concepts. Here, I will present recent results for several class of advanced thin film materials including nanostructured metallic glasses (ZrCu, ZrCuAl)[1, 2] high entropy alloys (CoCuCrFeNi) and nanolaminates (fully amorphous, amorphous/crystalline)[3, 4], highlighting how the control of the microstructure affect the and micro-scale mechanical behavior and enable ultimate mechanical properties. Among the main results, I will show the fabrication of fully amorphous Zr24Cu76/Zr61Cu39 nanolaminates by magnetron sputtering with controlled nanoscale periodicity (Λ, down to 5 nm), local chemistry and glass-glass interfaces [3]. I will show how the shear band instability can be mitigated when $\Lambda \leq 50$ nm, reaching remarkably large elastic/plastic deformation (16%) and yield strength (~2GPa) by micro-pillar compression [3]. Then, I will present the potential of Pulsed Laser Deposition (PLD) as a novel technique to synthetize nanostructured cluster-assembled ZrCu and CoCuCrFeNi films, reaching ultimate yield strength (>3 GPa) and ductility (>6 %) for ZrCu. Finally, I will focus on the synthesis of crystal/glass ultrafine nanolaminates by PLD[4] in which 4 nm Al (crystalline) separate 6 and 9 nm-thick Zr50Cu50 metallic glass nanolayers, showing high yield strength (3.4 GPa) in combination with enhanced elastoplastic deformation (>6%, in compression), while managing to effectively block the percolation of shear bands even at >15% deformation[4]. Overall, I will show how fine microstructural control in metallic thin films is an effective strategy to tailor their deformation behavior and boosting their mechanical properties with potential for industrial applications.

Keywords

Metallic thin films; Mechanical properties; Nanoengineering thin film strategies; In situ SEM micromechanics

Acknowledgement

Special acknowledgments to Andrea Brognara, Francesco Bignoli, and Davide Vacirca for their experimental work as well as to Philippe Djemia, Damien Faurie, James Best and Gerhard Dehm. This work is supported by the ANR-DFG PRCI “Nanostructured Thin Film Metallic GLASSes with superior mechanical/Electrical properties” (EGLASS, ANR-22-CE92-0026-01) and the ANR JCJC project “MICRO-scale mechanical characterization of thin film High Entropy Alloys” (MICRO-HEAs, ANR-21-CE08-0003-01).

References

[1] M. Ghidelli et al., Acta Mater. 213 (2021) 116955.
[2] C. Poltronieri et al., Acta Mater. 258 (2023) 119226.
[3] A. Brognara et al., Small Struct. (2024) 2400011.
[4] F. Bignoli et al., ACS Appl. Mater. Inter. 16(27) (2024) 35686-35696.

Poster Session

FUNCTIONAL THIN FILMS, NANOSTRUCTURES & 2D MATERIALS/ NANOSCALE CHARACTERIZATION

N° POSTER	TITLE	NOM	Prénom
64	OVERCOMING SAMPLE PREPARATION CHALLENGES IN NANOPARTICLE CHARACTERIZATION BY SEM	AMBERT	Stéphane
65	THE HREELM Project – The High Resolution Electron Energy Loss Microscope is coming to probe the surface vibrations at the microscopic scale	AMIAUD	Lionel
66	Development of measuring protocols and data processing methods for reference samples designed to calibrate electrical measurements at nanoscale	CHRETIEN/PIQUEMAL/HOUZE/MORAN-MEZA/HAROURI	Pascal/François/Frédéric/josé/Abdelmounaim
67	AI-Machine Learning models for conductive electrical modes on AFM: maps prediction and material clustering	COQ GERMANICUS	Rosine
68	Unravelling complex mixtures at the nanoscale: the power of coupling field flow fractionation and electron microscopy (FFF-EM)	CROUZIER	Loic
69	Boron Phosphide Nanocrystals from the Viewpoint of Pair Distribution Function Analysis	DOISNEAU	Clara
70	Combined Study of Casimir-Polder Interactions and Patch Potentials on SiNx Nanogratings	FABRE	Nathalie
71	Nano-architecture of mixed organic layers on a silver surface	GUAN	Yimin
72	CARBON NANOTUBE MECHANICAL MASS SENSOR WITH SUB-YOCTOGRAM SENSITIVITY AT ROOM TEMPERATURE	HENN	François
73	Nanoscale characterization of ZnS:Cu Phosphor Powder	HERNANDEZ	Roberto
74	Fluorescence properties of mixed-dimension heterostructures	LE BALLE	Juliette
75	In-rich InGaN/GaN nanowires for red light emitting diodes	TCHOULAYEU POSSIE	Nidel Dilan
76	Design of efficient nanocatalysts for H2 release from boranes and silanes	THIBAULT	Maxime
77	THE HREELM Project – The High Resolution Electron Energy Loss Microscope is coming to probe the surface vibrations at the microscopic scale	AMIAUD	Lionel
78	Enhanced Light Absorption through Nanostructuring of Titanium Nitride (TiN)	BEN MOUSSA	Nizar
79	Study of physical properties of antiphase boundaries in III-V epitaxial layer on silicon with conductive tip atomic force microscopy (C-AFM) and with Kelvin Probe Force Microscopy (KPFM) techniques.	BERNARD	Rozenn
80	Interfacial self-assembly of polydiacetylene and graphene oxide for organic photovoltaics	BISTINTZANOS	Alexia
81	TMD Engineering of 2D-Magnetic Tunnel Junctions – From Barriers to Electrodes	DANIEL	Jane
82	Study and Characterization of TzDA Langmuir Films for Polydiacetylene-Based Sensors	KANDYLI	Maria
83	Charge transfer between plasmonic PdAg nanoparticles and C60 molecules	LI	Xingtong
84	Développement et caractérisation de cristaux magnoniques sur substrats flexibles pour la straintronique	MNASRI	Walid
85	Direct CVD graphene integration for Spintronics	PERRIN	Jérémy
86	Design and Synthesis of Bioactive Materials Using Two-Photon Polymerization and Thiol-Ene Click Chemistry	PINON VASQUEZ	Ana Karen
87	Engineering Spin Wave dispersion and Surface Acoustic Wave-driven FMR in Fe thin films by N-implantation	SHARMA	Anupam