CROSSNANO
CROSSBORDER WORKSHOP IN NANOSCIENCE AND NANOTECHNOLOGY

WHEN
23-25 February 2021
9:00 – 18:00

WHERE
On line
Via Microsoft Teams

PhD School in Nanotechnology

UNIVERSITY OF TRIESTE

ORGANIZERS

University of Trieste

Jožef Stefan International Postgraduate School

Jožef Stefan Institute

University of Ljubljana

1st CrossNano Workshop

Crossborder Workshop in Nanotechnology and Nanoscience
February 23–25, 2021
On-line at University of Trieste (PhD School in Nanotechnology)

In cooperation with
Jožef Stefan International Postgraduate School, Ljubljana, Slovenia
Jožef Stefan Institute, Ljubljana, Slovenia
University of Ljubljana (Faculty of Mathematics and Physics, Faculty of Pharmacy, Faculty of Electrical Engineering), Ljubljana, Slovenia

Organizing Committee
Prof. Alberto Morgante (Chair) and Prof. Paola Posocco, *University of Trieste*
Prof. Dragan Mihailović, Prof. Darja Lisjak and Dr Alenka Mertelj,
Jožef Stefan International Postgraduate School, Jožef Stefan Institute, University of Ljubljana

Technical Support: Flaviano Londero, *University of Trieste*

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"FERNANDO TOMMASINI" and "ALESSANDRO DE VITA" AWARD: Alois Bonifacio, Loredana Casalis, Daria Lisjak, Vanni Lughi, Alberto Morgante, Jelena Papan, Paola Posocco
"BEST CAREER" AWARD: Cristina Africh, Tatiana Da Ros, Lucia Pasquato

Edited by: Darja Lisjak, Paola Posocco, Dragan Mihailović and Alberto Morgante

UNIVERSITÀ DEGLI STUDI DI TRIESTE
MEDNARODNA PODIPLOMSKA ŠOLA JOŽEFA STEFANA
JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL
Jožef Stefan Institute Ljubljana, Slovenija
University of Ljubljana

FEBRUARY 23

9:00-9:30 **OPENING**
Alberto Morgante – Coordinator of the PhD School in Nanotechnology, University of Trieste
Giovanni Comelli – Director of the Physics Department of the University of Trieste
Valter Sergo – Deputy Rector of the University of Trieste

CHAIR: ALBERTO MORGANTE

09:30-10:30 **Denis Scaini**
Imperial College London (UK)
Nanoconfined environments: from biological reactions to cellular modulation

10:30-10:50 **BREAK**

CHAIR: GIOVANNI COMELLI

	PhD student	Cycle	Supervisor	Title
10:50-11:10	Matteo Bisetto	35	P. Fornasiero	A study inside the photo-catalytic behavior of well-defined Cu_2O nanoparticles
11:10-11:30	Filippo Costa	35	S. Prato	Imaging and analysis at nanoscale. Merging between SPM and optics
11:30-11:50	Matteo Cretella	35	L. Pasquato	Design, synthesis and use of organic-inorganic nanoparticles protected by fluorinated ligands as nanomaterial for imaging and therapy
11:50-12:10	Federico Loi	35	A. Baraldi	Investigation of structural and chemical properties of mass-selected clusters supported by 2D materials and oxides
12:10-12:30	Anže Mraz		D. Mihailović	Nanoscale charge configuration memory devices and their use in cryocomputing environment

12:30-14:30 **LUNCH**

CHAIR: DARJA LISJAK

	PhD student	Cycle	Supervisor	Title
14:30-14:50	Oana Condurache		A. Benčan	Atomically resolved properties of domain walls in ferroelectric $BiFeO_3$ bulk
14:50-15:10	Silvia Mauri	35	P. Torelli	Investigation of the surface reactivity of catalysts by operando X-ray absorption spectroscopy with synchrotron radiation
15:10-15:30	Edoardo Raciti	35	M. Prato	Light-driven electron transfer processes performed by carbon nitride-based nanocatalysts
15:30-15:50	Aharon Steffè	35	G. Toffoli	Triple-action nanoplatform for theranostic applications in hepatocellular carcinoma (HCC)

15:50-16:10 **BREAK**

CHAIR: ALOIS BONIFACIO

	PhD student	Cycle	Supervisor	Title
16:10-16:30	Živa Marinko		M. Čeh	Anodized titanium foils for a flexible TiO_2 photocatalyst
16:30-16:50	Mina Taleblou	35	S. Piccinin	Controlling the oxidizability of supported Platinum nanoclusters

16:50-17:10	Michele Zanetti	35	M. Lazzarino	Hybrid organic interfaces to investigate the mechanical competence of cardiac myocytes, in order to drive their appropriate development

FEBRUARY 24

CHAIR: LOREDANA CASALIS				
	PhD student	**Cycle**	**Supervisor**	**Title**
09:30-9:50	Marco Beltrami	34	O. Sbaizero	Nanostructuring multilayer ceramic coatings for wood cutting tools
09:50-10:10	Erik Betz-Güttner	34	M. Lazzarino	Terahertz sensing with golay cells microarray device
10:10-10:30	Davide Busatto	34	G. Toffoli	A novel approach for the treatment of pancreatic ductal adenocarcinoma adopting anti-Glypican 1 polymeric nanoparticles loaded with chemotherapeutic agents
10:30-10.50	Martina Conti	34	M. Lazzarino	Nanomechanics structures for the detection and study of cells
10:50-11:10	Ivan Spajić		I. Milošev	Single and multilayer Al_2O_3 and HfO_2 thin films prepared by atomic layer deposition as corrosion protection of medical stainless steel and titanium
11:10-11:30	**BREAK**			
CHAIR: TOMAŽ MERTELJ				
	PhD student	**Cycle**	**Supervisor**	**Title**
11:30-11.50	Mario Daka	34	L. Pasquato	Synthesis, nanocharacterization and applications of nanoparticles and nanomaterials with controlled properties
11:50-12:10	Federica Di Cintio	34	G. Toffoli	Nanoparticles anti-GPC1 loaded with chemotherapy drug in glioblastoma multiforme (GBM) treatment
12:10-12:30	Simone Di Noja	34	M. Prato	Synthesis, properties and applications of nanocarbonaceous systems
12:30-12.50	Patricija Hribar Boštjančič		A. Mertelj	Phase behaviour of alcohol suspensions of magnetic barium hexaferrite nanoplatelets
12:50-14:50	**LUNCH**			
CHAIR: JELENA PAPAN				
	PhD student	**Cycle**	**Supervisor**	**Title**
14:50-15:10	Alessandro Esposito	34	V. Sergo	Design, nanofabrication and characterization of nanostructured metal surfaces as substrates for SERS for bioanalytic analyses and study of their behavior at the nano-biointerface
15:10-15:30	Marcello Ferrara	34	P. Fornasiero	Smart nanostructured electrocatalysts for carbon dioxide reduction
15:30-15:50	Arianna Gazzi	34	M. Prato	Immunocompatibility and biomedical applications of new nanocarbons

15:50-16:10	Matej Šadl		H. Uršič	Aerosol deposition as an enabling technology for flexible energy storage and electrocaloric devices
16:10-16:30	**BREAK**			

CHAIR: SLAVKO KRALJ

	PhD student	**Cycle**	**Supervisor**	**Title**
16:30-16:50	Ahmed Alsadig Ahmed Mohammed	34	L. Casalis	Programmable gold nanoparticles-based probes: A versatile platform toward the development of nanotools for diagnostic applications
16:50-17:10	Monica Mossenta	34	G. Toffoli	Development of a drug delivery therapy strategy through polymeric nanoparticles with an anti-GPC3 antibody coating and chemotherapic loading to treat hepatocellular carcinoma
17:10-17:30	Cristian Soncini	34	M. Pedio	Non equilibrium phenomena: effect on spectroscopies in semiconductors
17:30-17:50	Chiara Stocco	34	Z. M. Arnez	Nanofiber polymeric scaffold for slow and steady release of VEGF and ECs to induce efficient angiogenesis and healing in a mouse model of hind limb ischemia

FEBRUARY 25

CHAIR: NEREA SEBASTIAN UGARTECHE				
	PhD student	**Cycle**	**Supervisor**	**Title**
9:30-9:50	Alice Battistella	33	M. Lazzarino	Atomic Force spectroscopy-based essay to evaluate oocyte post-ovulatory ageing
9:50-10:10	Sebastjan Nemec		S. Kralj	Synthesis of silica coatings with diverse surface morphologies on anisotropic magnetic nanoparticles for magneto-mechanical actuation
10:10-10:30	Leonard Moriau		N. Hodnik	From oxygen reduction reaction and oxygen evolution reaction catalysts to a single multifunctional catalyst for the Regenerative PEM Fuel Cell
10:30-10:50	Lima Maria Augusta Do Rego Barros Fernandes	33	D. Cojoc	Investigating label-free markers at nanoscale for cancer cells using
10:50-11:10	**BREAK**			
CHAIR: ALBERTO MORGANTE				
	PhD student	**Cycle**	**Supervisor**	**Title**
11:10-11:30	Sara Fiori	33	C. Africh	A network of carbon atoms for toxic gases trapping
11:30-11:50	Rok Venturini		D. Mihailović	Research of ultrafast phase switching in 1T-TaS_2 by a picosecond electrical pulse
11:50-12:10	Timur Nurmamytov	33	S. Rubini	Growth of ordered nanowire arrays containing magnetic inserts
12:10-12:30	Beatrice Senigagliesi	33	P. Parisse	Biophysical and biomolecular analysis of EVs and their interaction with target cells
12:30-14:30	**LUNCH**			
CHAIR: VANNI LUGHI				
	PhD student	**Cycle**	**Supervisor**	**Title**
14:30-14:50	Domenico Tierno	33	S. Bonin	Comprehensive characterization and effective combinatorial targeting of high-grade serous ovarian cancer via single-cell analysis
14:50-15:10	Stefano Valente	33	L. Pasquato	Hybrid nanoparticles for theranostics: design, synthesis and characterization
15:10-15:30	**BREAK**			
15:30-15:50	**"FERNANDO TOMMASINI" AWARD** **"ALESSANDRO DE VITA" AWARD** **"BEST CAREER" AWARD**			
15:50-16:10	**CLOSING REMARKS** **Alberto Morgante** – Coordinator of the PhD School in Nanotechnology, University of Trieste **Dragan Mihailović** – Director of the Centre of Excellence in Nanoscience and Nanotechnology (Ljubljana), Institut Jožef Stefan and University of Ljubljana			

Nanoscale charge configuration memory devices and their use in cryocomputing environment

Anže Mraz,[1,4] Rok Venturini,[1,3] Michele Diego,[1] Andrej Kranjec,[1] Damjan Svetin,[1,2] Yaroslav Gerasimenko,[1,2] Vitomir Sever,[1] Ian A. Mihailovic,[1] Jan Ravnik,[1,5] Igor Vaskivskyi,[1,2] Maria D'Antuono,[6] Daniela Stornaiulo,[6] Francesco Tafuri,[6] Dimitrios Kazazis,[5] Yasin Ekinci,[5] Viktor. V. Kabanov[1] and Dragan Mihailovic[1,2]

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Cryocomputing is considered as the next evolution in computing technologies, potentially surpassing classical computers in both performance and efficiency. One of the main factors limiting its progress is the absence of an energy efficient, fast and non-volatile memory device which also operates at low temperatures. Here we present a Charge Configuration Memory (CCM) device which combines all of the above characteristics while also being very simple in design and possible to be scaled down to nanometre dimensions.

We present a CCM device based on a transition metal dichalcogenide 1T-TaS_2 crystal which relies on switching between different topologically protected states to store information. We show basic operational characteristics, scaling laws and reveal microscopic changes in the electronic landscape during device's operation using multi tip scanning tunnelling microscopy (STM) which explain remarkable stability of the device. We explore the possibility of integrating the CCM device into a superconducting single flux quantum (SFQ) logic circuit using a superconducting driver element called a nanocryotron (nTron). We present the time dynamics and current-voltage characteristics of such a hybrid device which show the feasibility of this approach.

The work was supported by ERC ADG Trajectory (GA320602), ERC PoC Umem4QC and the Slovenian Research Agency (young researcher, P10040).

Atomically resolved properties of domain walls in ferroelectric $BiFeO_3$ bulk

Oana Condurache,[1,2] Goran Dražić,[1,2,3] Naonori Sakamoto,[4] Tadej Rojac,[1,2] Brahim Dkhil,[5] Hana Uršič,[1,2] and Andreja Benčan[1,2]

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Ferroelectric materials have a pivotal role in today's modern electronics being active elements in piezoelectric sensors, transducers or actuators. Ferroelectrics are organized into regions in which the polarization vector is oriented in a particular direction, regions called domains. The interphase between two ferroelectric domains is called the domain wall (DW). DWs can have different properties from the domains themselves and their dynamics under electric field give an important extrinsic contribution to the final functional properties (D.A. Ochoa *et al.*, J. Eur. Ceram Soc. 36, 2016). However, the complexity of DWs has only recently been unraveled thanks to the exciting development of high spatial resolution techniques.

In the present work, we investigate DWs in $BiFeO_3$ (BFO) polycrystalline ceramic and in single crystal by atomic-resolution scanning transmission electron microscopy (STEM). A comparison is made between the less frequently observed charged DWs and the more conventional uncharged DWs in terms of morphology and structure. We show that the morphology of both types of DWs in BFO ceramic can be quite complex forming steps and kinks (Figure 1 a), b)). Moreover, we show that charged DWs, even if electrostatically unfavorable, appear to be mechanically more favorable than their uncharged counterparts, since they exhibit lower lattice strain (Figure 1 c), d)) (O. Condurache *et al.*, J. Appl. Phys 129, 2021). Finally, preliminary results on in-situ STEM voltage bias experiments for BFO single crystal are shown, linking their mobility to their morphology and type.

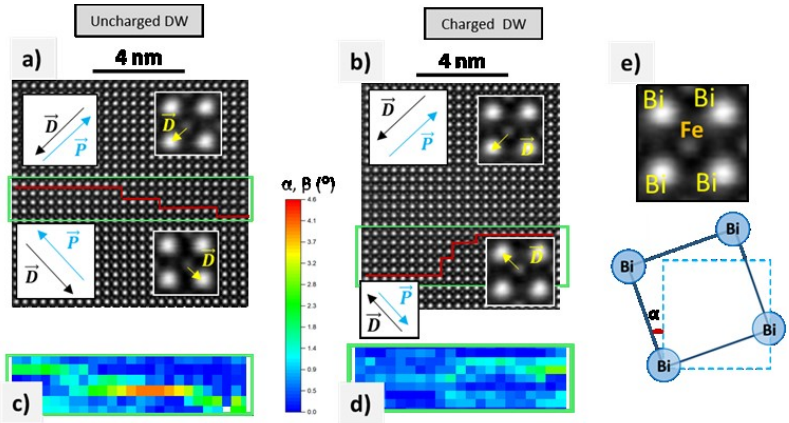

Figure 1: High Angle Annular Dark Field STEM image along $[100]_{pc}$ direction of step-like a) uncharged and b) charged DW in polycrystalline $BiFeO_3$. The middle of the DW is marked with red line. The Fe-displacement vector in respect with the Bi-sublattice on each side of the DW is noted in the insets. c) and d) Unit cell distortion map of the Bi-sublattice (colored map) across the uncharged DW (c)) and charged DW (d)) from the region marked with green in a) and b), respectively. e) One projected perovskite unit cell in the $[100]_{pc}$ showing the central, low-intensity Fe cation surrounded by four, high-intensity Bi cations and schematic representation of the unit-cell distortion angle of the Bi-sublattice.

Anodized titanium foils for a flexible TIO_2 photocatalyst

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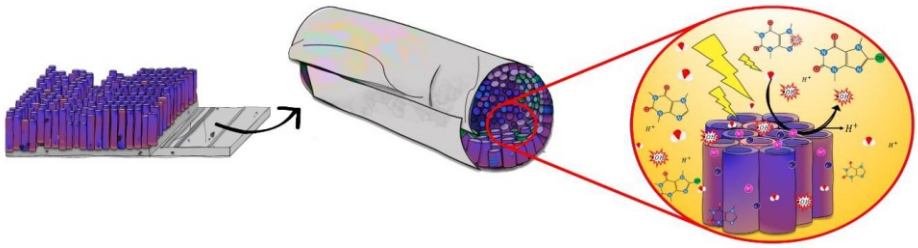

TiO_2 in various morphological forms can degrade organic pollutants in wastewaters and air under UV illumination into an environment more friendly compounds. One of the methods to synthesise TiO_2 in the form of nanotubes is to use anodic oxidation of metal titanium foils. This method yields firmly attached and ordered TiO_2 nanotubes on the titanium substrate, which exhibit a large surface area. The method is relatively simple and can be easily up-scaled. Additionally, TiO_2 nanotubes can be grown on titanium in various shapes and sizes. Given this, we aimed to prepare an efficient and flexible TiO_2 photocatalyst with anodic oxidation of titanium foil.

Our studies used two different titanium foils with different chemical compositions, foil thicknesses, and factory shaping. Some of the foils were electropolished under varying applied voltage, time, and temperature prior to anodic oxidation. After foils were anodised (60 V for 3 hours), subsequent annealing (450oC for 1 hour) transformed initially amorphous TiO_2 nanotubes into polycrystalline TiO2 nanotubes with the anatase structure. The microstructure of titanium foils was investigated with EBSD, FEG-SEM, and stylus profilometry while the morphology of TiO_2 nanotubes was characterised in detail through FEG-SEM, XRD, and optical profilometry. Scotch-tape test was used for the determination of TiO_2 nanotubes adhesion. To determine titanium's chemical composition, an ICP-OES analysis was performed; for electronic states in TiO_2 oxide, an XPS study. Finally, hydroxyl radicals' concentration was measured by EPR spectroscopy and photocatalytic activity with a high-precision UV-Vis-IR spectrophotometer.

Our results confirmed the complexity of TiO_2 nanotube growth vs resulting photocatalytic activity. We concluded that anodic oxidation of untreated titanium foil results in TiO_2 nanotubes with higher specific surface area due to the substrate's starting higher surface roughness. These nanotubes exhibited the best photocatalytic activity. With a series of anodic oxidation experiments on titanium foils with different thicknesses, we found out that titanium foils could be bent without the risk of forming micro-cracks and/or detachment of the TiO_2 nanotubes from the substrate. These findings suggest that TiO_2 nanotubes obtained by anodisation of thin titanium foils are expected to show (1) long-term mechanical stability, and (2) high photocatalytic efficiency in a novel annular-type photocatalytic reactor for the degradation of organic compounds in wastewater and air.

Single and multilayer Al_2O_3 and HfO_2 thin films prepared by atomic layer deposition as corrosion protection of medical stainless steel and titanium

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One of the most commonly used materials for production of biomedical implants are stainless steel- and Ti-based alloys (1). They generally exhibit good corrosion protection properties, but still they are prone to degradation in the specific physiological and biologic conditions in the human body. Therefore, various strategies have been developed to date with aim to protect them and improve their functionality *in vivo* (2). One of the attractive and novel methods that ensure the deposition of ultrathin protective barrier films is atomic layer deposition (ALD) (3). In this work we focused on the deposition of 20 nm and 60 nm Al_2O_3 films on the medical stainless steel (SS316L) and titanium (cp-Ti) to compare the effect of film thicknesses. Furthermore, multi-layered films of 60 nm as the stack of $Al_2O_3/HfO_2/Al_2O_3$ layers were deposited to compare them with the single-layer Al_2O_3 films of the same thickness.

Morphology and composition of the specimens were investigated by FE-SEM/EDS analysis. The 20 nm Al_2O_3 thin films show, due to very small thickness and the presence of pinholes, increased porosity. Thicker films, of 60 nm, achieved a complete coverage of the metal surfaces, but with defects in the form of agglomerates of deposited material, particularly for the multi-layer films due to the presence of hafnia layer.

AFM measurements were performed to measure the film thickness at the cross-section between the film and substrate. Simultaneously, Scanning Kelvin probe force microscopy (SKPFM) measurements of the difference in the Volta potential between bare metal surface and the ALD thin films were carried out. However, due to the very high passivation ability of both substrates, SS316L and cp-Ti, the increase in Volta potential of ALD films was not so high, but noticeable.

Electrochemical measurements, potentiodynamic polarization and electrochemical impedance spectroscopy, were carried out in Hanks' physiological solution at 37 °C simulating human body conditions. Thinner films, 20 nm thick Al_2O_3, initially showed comparable barrier properties as thicker Al_2O_3 films. However, in the course of immersion significant deterioration of barrier properties took place, and even dissolution in the case of cp-Ti substrate. No significant difference in barrier properties were observed for the multi-layer and single-layer films although the top 20 nm of alumina in the multilayer film dissolved under the tested conditions. However, the barrier properties of interlayer hafnia were so stable to resist further dissolution. Overall, ALD films proved to be suitable candidates for biomedical applications since they exhibit high barrier against dissolution under physiological conditions.

Acknowledgment: This project has received funding from the European Union's Horizon H2020 research and innovation programme under the Marie Skłodowska Curie grant agreement No. 764977.

(1) I. Milošev, *Pure and Applied Chemistry* 83 (2011) 309-324. (2) A. Mahajan, S.S. Sidhu, Materials Technology 33 (2018) 93-105. (3) J. S. Daubert, G. T. Hill, H. N. Gotsch, A. P. Gremaud, J. S. Ovental, P. S. Williams, C. J. Oldham, G. N. Parsons, *ACS. Appl. Mater. Interfaces* 9 (2017) 4192-4201.

Phase behaviour of alcohol suspensions of magnetic barium hexaferrite nanoplatelets

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Suspensions of ferrimagnetic barium hexaferrite (BHF) nanoplatelets in 1-butanol are a type of ferrofluid, where above a certain volume concentration the formation of a unique example of a dipolar fluid, i.e. a liquid magnet is observed (1). A combination of interactions in the suspension, including long-range dipolar magnetic and screened anisotropic electrostatic interactions, leads to the generation of the ferromagnetic nematic phase (Figure 1). The BHF nanoplatelets' surface is modified with the surfactant dodecylbenzenesulfonic acid (2) that provides for the colloidal stabilization of the BHF nanoplatelets in alcohols by an electrical double-layer formation. The fraction of dodecylbenzezesulfonic acid also controls the parameters of the electrostatic interactions between the BHF nanoplatelets (3). The suspensions' phase behaviour is studied as a function of dodecybenzenesulfonic-acid concentration, nanoplatelets' size distribution and saturation magnetization. These variables influence the interactions between the nanoplatelets and control the formation of the nematic phase – the liquid magnet.

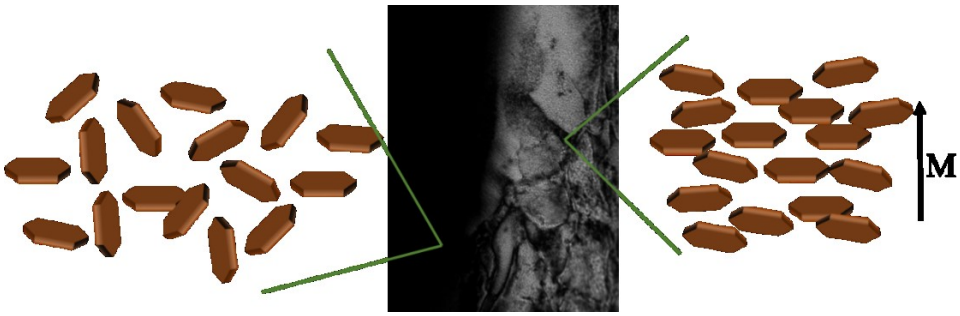

Figure 1: Polarizing optical microscopy image of 1-butanol suspension of the BHF nanoplatelets, distinguishing between the disordered isotropic (the left, black part) and the ordered ferromagnetic nematic phase (the right, grey part).

Acknowledgements: The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P1-0192, P2-0089 and research projects No. PR-08415, J7-8267).

(1) M. Shuai *et al.*, "Spontaneous liquid crystal and ferromagnetic ordering of colloidal magnetic nanoplates," *Nat. Commun.*, vol. 7, p. 10394, 2016. (2) S. Ovtar, D. Lisjak, and M. Drofenik, "Barium hexaferrite suspensions for electrophoretic deposition," *J. Colloid Interface Sci.*, vol. 337, no. 2, pp. 456–463, 2009. (3) P. Hribar Boštjančič, M. Tomšič, A. Jamnik, D. Lisjak, and A. Mertelj, "Electrostatic interactions between barium hexaferrite nanoplatelets in alcohol suspensions," *J. Phys. Chem. C*, vol. 123, no. 37, pp. 23272–23279, 2019.

Aerosol deposition as an enabling technology for flexible energy storage and electrocaloric devices

Matej Sadl,[1,2] Oana Andreea Condurache,[1,2] Andreja Bencan,[1,2] Mirela Dragomir,[1] Uros Prah,[1] Barbara Malic,[1,2] and Hana Ursic[1,2]

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In recent years, the focus of the electronic industry started turning towards flexible electronics, which have the capability of conformable shaping to arbitrary surfaces. The flexible electronic elements can be fabricated on thin foils of polymers or metals, which makes electronics flexible and pliable. Relaxor-ferroelectric (1-*x*)$Pb(Mg_{1/3}Nb_{2/3})O_3$–*x*$PbTiO_3$ (PMN–100*x*PT) materials show excellent electro-mechanical properties, energy storage and energy conversion capabilities, suitable for electric generators, capacitors and electrocaloric cooling refrigerators. The aerosol deposition (AD) method offers a cost-efficient way to deposit dense, micrometer-thick films at room temperature enabling the integration of functional PMN–100*x*PT ceramic layers onto low melting point substrates such as metals and polymers.

In this work, dense 10 µm thick PMN–10PT films were deposited by the AD method on two types of substrates: low-cost stainless steel (Figure 1a) and polymer foil (Figure 1b). The PMN–10PT powders were prepared via mechanochemical activation assisted synthesis, followed by additional thermal treatment and ball milling. Compressive stresses generated in the thick films during the AD process relax after thermal annealing at 400–500 °C. The annealed films attain a relaxor-like polarization vs. electric field hysteresis loops, which makes them promising for energy storage applications. PMN–10PT films on stainless-steel exhibit a recoverable energy density of 9.8 J·cm^{-3} and energy storage efficiency of ~80% at 900 kV·cm^{-1}. The films also exhibit high thermal stability and electrical field cycling stability up to 200 °C and 1.6·10^7 cycles, respectively. Furthermore, the relaxor-like behavior of PMN–10PT makes the films deposited on polymer substrate interesting for flexible electrocaloric devices. A detailed analysis of energy storage and electrocaloric properties of AD-processed PMN–10PT thick films will be presented in this contribution.

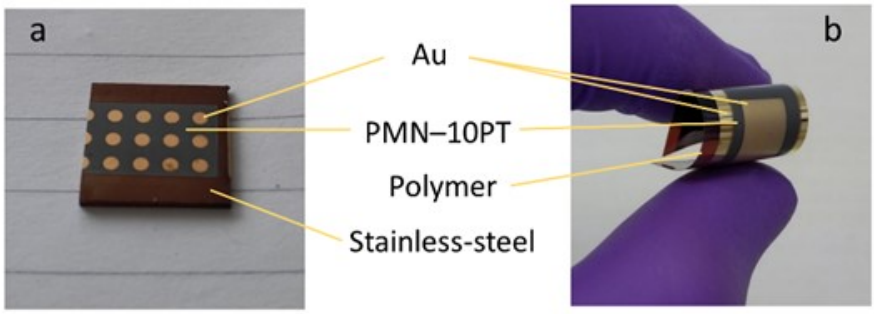

Figure 1: PMN–10PT thick films on (a) stainless-steel and (b) polymer substrates.

Synthesis of silica coatings with diverse surface morphologies on anisotropic magnetic nanoparticles for magneto-mechanical actuation

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Magnetic nanomaterials are extensively studied due to their attractive properties of remote control using external magnetic fields. Among them, anisotropic magnetic nanoparticles, such as nanoplatelets and nanochains, gained great interest due to their distinctive non-spherical shapes (1,2). Indeed, their tunable shapes and sizes allow new functionalities, such as magneto-mechanical actuation (3). This technique is based on the exploitation of mechanical torque generated to targeted soft matter once anisotropic magnetic nanoparticles are exposed to alternate magnetic field at low frequencies. The mechanical destruction is generated by the movement of anisotropic magnetic nanoparticles that are in contact with target soft matter. The exerted forces can lead to the rupture of cellular membranes, stimulate mechanoreceptors or induce structural changes in soft materials. The surface morphology of nanoparticles plays a key role in the contact interactions (adhesion) between nanoparticles and targeted soft matter. However, the role of surface morphology is still poorly understood and requires more investigation due to the challenges related with nanoparticle synthesis. The main reason for lack of data on magneto-mechanical effect is the challenging synthesis of nanoparticles with suitable dimensions and magnetic properties for medical uses as well as due to difficulties with well-defined surface coatings.

Here, we focused on synthetic procedures to produce silica coatings of different thicknesses and surface morphologies on magnetic nanochains and nanoplatelets. Smooth surface silica coatings were synthesized using standard Stöber procedure. To obtain rough mesoporous silica coatings, we utilized our own recently developed procedure based on soft templating (4). We were able to produce diverse silica coatings on nanomaterials with different shapes and dimensions, as shown in Figure 1. We demonstrated protocols for thin and thick smooth coatings as well as silica coatings with tunable roughness.

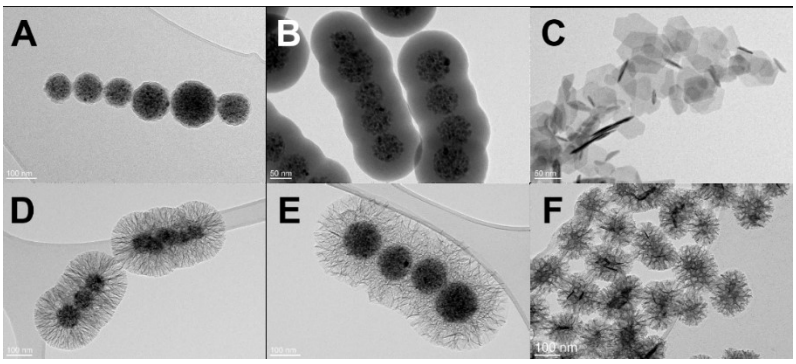

Figure 1. TEM micrographs of silica-coated anisotropic magnetic nanoparticles: nanochains with thin (A) and thick (B) smooth coating, nanochains with thin (D) and thick (E) rough coating, nanoplatelets with smooth coating (C) and nanoplatelets with rough coating (F).

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From oxygen reduction reaction and oxygen evolution reaction catalysts to a single multifunctional catalyst for the Regenerative PEM Fuel Cell

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Global warming is arguably the greatest challenge that we must overcome in the coming years. For this, the reliance on non-renewable fossil fuels needs to disappear. The hydrogen economy is a promising path to do so. Energy surplus from renewable sources can be used to transform water into chemical (H_2 and O_2) in a water electrolyzer (WE) with the help of Ir-based catalysts. Afterwards, this chemical energy can be converted to electricity again in a fuel cell (FC). Pt-based catalysts are the state-of-the-art catalyst in this device. Unfortunately, these metals are scarce, expensive and limiting the commercialization of those devices. Several strategies have been employed to improve the use of precious metals or to decrease their amount, for example by dispersing nanoparticles on high surface area support or by alloying with transition metals (1).

Another strategy is to instead of two separate devices, namely WE and FC, use one that can do both reactions. This makes sense as we neer need both t the same time and we would use less of the precious metals. Therefore, we need to synthesize a bifunctional catalyst that will be active for both oxygen reduction (ORR, in FC) and oxygen evolution (OER, in WE). Therefore, a more compact, lighter and overall cheaper unitized regenerative fuel cell can be made (URFC) (2). However, these kinds of systems are more complex. Nevertheless, using previously developed knowledge from ORR and OER single catalysts can be useful. Hereby, case studies of Pt-alloys for ORR and Ir on $TiON_x$/graphene support for OER are presented before introducing a PtCuIrRu-based multifunctional catalyst for both ORR and OER and also other reactions. Its activity is compared to the state-of-the-art single catalysts in Figure 1.

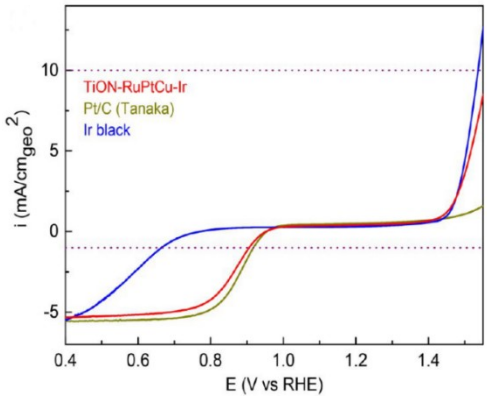

Figure 1: Voltammograms for the ORR and the OER for Pt, Ir and $PtCu_3RuIr$-catalysts, recorded in O_2 saturated 0.1 M $HClO_4$.

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Research of ultrafast phase switching in 1T-TaS_2 by a picosecond electrical pulse

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One of the limitations for high performance computing is in slow and energy inefficient exchange of data between processor and memory (1). Recent discovery of electronic switching between high and low resistance states of the 1T-TaS_2 shows promising features for development of a high-speed and non-volatile memory device (2). Electric pulses at picosecond time scales need to be used to probe intrinsic switching time of such a device, which is challenging due to limitations of signal generators and transmission line dispersion.

We will present electronic circuit with a photoconductive switch on a semiconducting substrate CdMnTe that is designed for excitation and detection of picosecond electrical pulses generated by an ultrafast laser pulse (3, 4). Picosecond pulse is generated by a frequency doubled laser pulse which transiently excites carriers to conducting band in a photoconductive switch. Via Pockels effect of another laser beam we are able to observe propagation of electrical pulse along waveguide. Transmission line architecture allows for efficient propagation of picosecond electric pulse towards the 1T-TaS_2 crystal and measurement of the crystal resistance state. With recent data we are able to confirm switching of 1T-TaS_2 resistance is possible by an electrical pulse that is as short as 2 picoseconds.

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