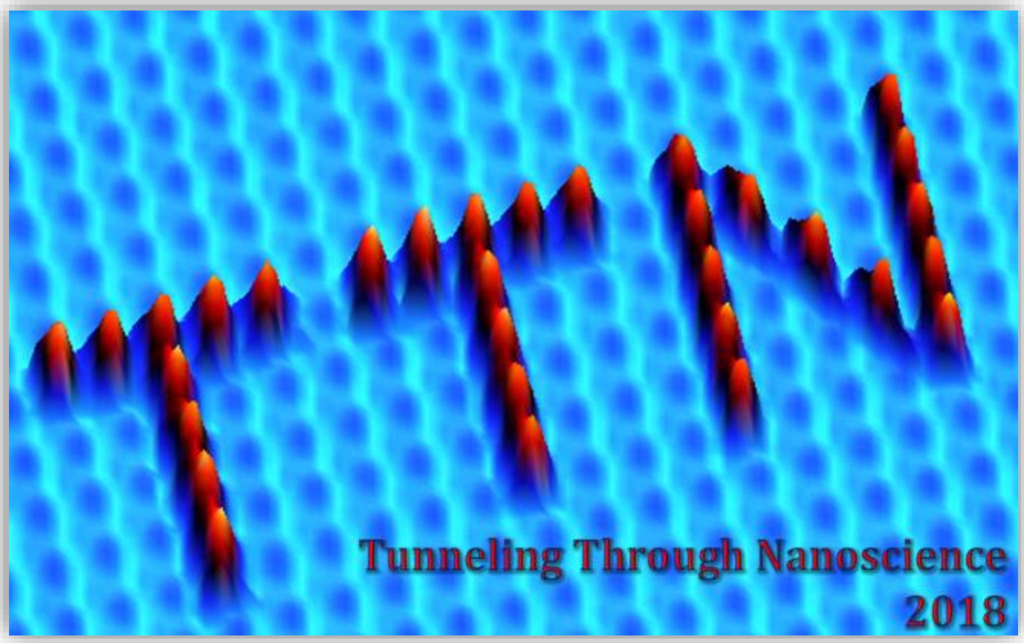
Abstract Book



TTN-2018 International Conference

Ravello, Italy, October 17 - 20, 2018

The Conference will be held at

VILLA RUFOLO

Supported by

This event is organized by

Physics Department of the University of Salerno, in collaboration with the Institute for Superconductors, Innovative Materials and Devices (SPIN) of the Italian National Research Council (CNR), the International Institute for Advanced Scientific Studies "E.R. Caianiello" (IIASS) and supported by University of Salerno.

This event is sponsored by

Conference Chair

Anna Maria Cucolo - University of Salerno, Italy

Organizing Committee

Carmine Attanasio - University of Salerno, Italy
Fabrizio Bobba - University of Salerno, Italy
Antonio Di Bartolomeo - University of Salerno, Italy
Filippo Giubileo - CNR-SPIN Salerno, Italy
Sergio Pagano - University of Salerno, Italy

International Advisory Committee

Jan Aarts - University Leiden, The Netherlands
Fabio Beltram - Scuola Normale Superiore,Italy
Dino Fiorani - ISM-CNR, Italy
Laura Greene - National MagLab, USA
Stefano Sanvito - Trinity College Dublin, Ireland
Alexey Ustinov - Karlsruhe Institute of Technology, Germany
Ruggero Vaglio - University of Naples, Italy

Technical Support Committee

Cinzia Di Giorgio - University of Salerno, Italy
Ofelia Durante - University of Salerno, Italy
Antonia Loffredo - CNR-SPIN Salerno, Italy
Tina Marcella Nappi - IIASS, Italy
Salvatore Abate - CNR-SPIN Salerno, Italy
Bernardo Amoruso - University of Salerno, Italy
Carmen D'Apolito - University of Salerno, Italy
Vincenzo Di Marino - University of Salerno, Italy

Invited Speakers

Aprili M.	*Université Paris-Sud, France*
Arutyunov K.Yu.	*HSE, Russia*
Barbara P.	*Georgetown University, USA*
Birge N.	*Michigan State University, USA*
Boggild P.	*Technical University of Denmark, Denmark*
Casoli F.	*IMEM-CNR, Italy*
Eschrig M.	*Royal Holloway, University of London, UK*
Giannazzo F.	*CNR-IMM, Italy*
Giazotto F.	*CNR-NANO, Italy*
Gobbi M.	*Materials Physics Center, Spain*
Goldobin E.	*University of Tübingen, Germany*
Golubov A.A.	*University of Twente, The Netherlands*
Gomez M.E.	*Universidad del Valle, Colombia*
Hanze M.	*Max Planck Institute, Germany*
Herrera Vasco E.	*Universidad Autonoma de Madrid, Spain*
Heun S.	*Istituto Nanoscienze-CNR, Italy*
Hla S.W.	*Argonne National Laboratory, USA*
Iavarone M.	*Temple University, USA*
Krasheninnikov A.V.	*Aalto University, Finland*
Maggio Aprile I.	*University of Geneva, Switzerland*
Manske D.	*Max Planck Institute, Germany*
Miranda R.	*Universidad Autónoma de Madrid, Spain*
Neu V.	*Leibniz Institute for Solid State and Materials Research, Germany*
Nouchi R.	*Osaka Prefecture University, Japan*
Peddis D.	*ISM-CNR, Italy*
Prieto P.	*Universidad del Valle, Colombia*
Robinson J.	*University of Cambridge, UK*
Ryazanov V.V.	*Moscow Institute of Physics and Technology, Russia*
Schleberger M.	*Universität Duisburg-Essen, Germany*
Silhanek A.V.	*Université de Liège, Belgium*
Truccato M.	*University of Torino, Italy*
Vicent J.L.	*Universidad Complutense de Madrid, Spain*
Volodin A.	*University of Leuven, Belgium*
Wenger C.	*IHP GmbH, Leibniz Institut fuer innovativeMikroelektronik,Germany*
Yakimova R.	*Linkoping University, Sweden*
Zaikin A.D.	*KIT, Germany*
Zasadzinski J.	*Illinois Institute of Technology, USA*

Welcome

to the International Conference "Tunneling Through Nanoscience - TTN2018”. The event, which intends to celebrate 40 years of Prof. Anna Maria Cucolo’s scientific activity, will be held in the magnificent location of “Villa Rufolo” in Ravello (UNESCO World heritage), Italy, from October 17th to October 20th , 2018. The Conference is organized by the Physics Department “*E. R. Caianiello*” of the University of Salerno, the SPIN Institute of the National Research Council (CNR), the International Institute for Advanced Scientific Studies “*E.R. Caianiello*” (IIASS) and sponsored by the Ravello Foundation.

The event aims at joining world recognized experts in the fields of

Scanning Probe Microscopy and Spectroscopy

- Advances in Scanning Probe Microscopy
- Imaging of magnetic structures at the nanoscale
- Scanning probe microscopy and spectroscopy on 2D materials
- Nanoscale mechanical properties explored via local probes
- Scanning probe microscopy applications in electronic devices

Superconductivity and Magnetism

- Tunneling on novel superconductors
- Exotic superconductivity
- Quantum Computing
- Vortex matter in superconducting materials by scanning probe microscopy techniques
- Magnetic tunnel junctions
- Magnetic vortices, skyrmions and three-dimensional nanomagnetism
- Proximity effect and magnetic inclusions in superconductors

Nanostructured Materials and Interfaces

- nanoparticles and nanoclusters
- nanowires
- carbon nanotubes
- graphene
- 2D layered materials
- van der Waals heterojunctions

Venue

The conference will be held in the magnificent location of VILLA RUFOLO, located in Ravello.

The ancient name of **Ravello** was Rebellum. Tradition asserts that the Ravellese were called Rebelli, or rebels, by the other towns of the Amalfitan territory because they refused to acknowledge a certain Doge elected by the Amalfitans in defiance of their Duke Robert Guiscard. There are still many stories to discover along its medieval streets, villas with gardens and ancient stone paths.

Villa Rufolo is a building within the historic center of Ravello and it overlooks the front of the cathedral square. The initial layout dates back to the 13th century, with extensive remodelling in the 19th century by Mr. Francis Neville Reid. He moved to Ravello, very young, for health reasons and remained there until his death at the age of 66. He bought land there, and the half ruined Palazzo of the once famous Rufoli family, and there he henceforth made his home. Around the middle of the 19th century it was sold to the Scotsman Francis Neville Reid who took care of a general restoration, resulting in today's layout.

The villa is entered through an opening in the arched entrance tower, and after a short street a clearing is dominated by the Torre Maggiore: the latter facing the bell tower of the cathedral in Ravello, overlooking the terraces (upper and lower) as well as the Amalfi Coast and the Gulf of Salerno with flower gardens that bloom most of the year.

Villa Rufolo

Entrance Tower of Villa Rufolo

Villa Rufolo has been a source of inspiration for many artists for centuries.

The German opera composer Richard Wagner visited the villa in 1880. He was so overcome by the beauty of the location that he imagined the setting as the garden of Klingsor in the second act of Parsifal. Also Verdi stayed in Villa Rufolo as well as many other great musicians and conductors, such as, Arturo Toscanini, Enrico Caruso, Bernstein, Kempff and Rostropovitch. This musical heritage is still the heart of Ravello'intense cultural life.

This inspired the famous Ravello festival.

The **Ravello Festival** is also popularly known as the "Wagner Festival" and is an annual summer festival of music and arts held in Villa Rufolo's Garden.

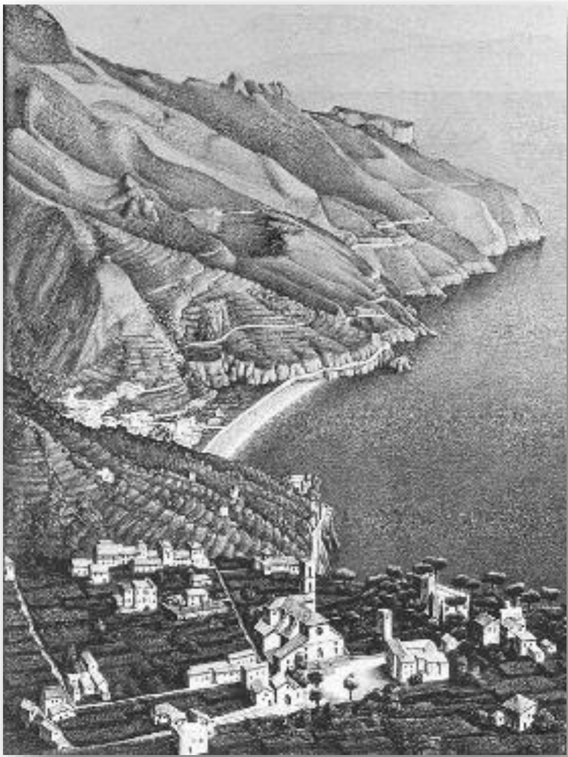
Although the original emphasis during the festival was on Wagner's music, the event has since grown into an almost two-month-long presentation of a wide variety of music featuring large orchestras, chamber groups, jazz, art shows, dance, photographic exhibits, discussion groups and a chance to meet and talk to the featured artists, many of whom are world renown.

Villa Rufolo Garden

Ravello Festival Festival

As regards painting, great men stayed in and drew their inspiration from Ravello, like M.C.Escher

In the spring of 1923 Escher moved to the Amalfi coast in southern Italy, and he was literally struck by the subtle plasticity of the light of the South of Italy and by the mixture of Roman, Greek and Saracen elements present in the architecture of Ravello, Atrani and Amalfi. The orography so moved and animated, so "theatrical", on the other hand, could not have had a different effect on a Dutchman addicted to linear and modest horizons.



Ravello's Farmhouse

Lion of the PIAZZA FONTANA MORESCA in Ravello

*** Bibliography**
Ravello. An (almost) exhaustive handbook for travellers in the town and its surroundings, Ravello Arts Council

Special Event: Concert

The concert season by Ravello Concert Society (RCS) is a traditional and well established event in Ravello which over the years has delighted thousands of visitors with a wide range of performances by soloists and chamber music groups: excellent musicians that offer interesting, engaging music.
The historical location, the Annunziata Historic Building, is located just beyond Villa Rufolo Park and, with its world famous domes, is the landmark of Ravello and its Music Festival. The Annunziata was built in 1281 by the noble family Fusco and later became part of the Rufolo family estate.
Thanks to the support of its audience, RCS became more and more well established and strong in order to guarantee a yearly planning of events as long-lasting as possible totally indipendent of public funding. The music has touched the souls of thousands of listeners and RCS helped artists connect with each other and with international audiences.
During this conference, the RCS will perform on two dates (one in Annunziata Historic Building and another in Ravello Art Center), one of which is partly sponsored by them at a reduced price.

Save the date

19^{th} October *(7:00 p.m.) VENEZIANI-VALLUZZI two-piano duo at* ***Ravello Art Center***

Ravello Art Center

Programme

Wednesday, October 17^{th}

14:30 **WELCOME AND OPENING**

SESSION 1: Josephson junction I CHAIR: Ruggero Vaglio

14:40 –15:00	**M.Aprili**	*Spin-Orbit induced spin locking and φ-Josephson coupling*
15:00 –15:20	**A.V.Silhanek**	*In situ tailoring of single superconducting juctions and nano-SQUIDs via current-induced atom migration*
15:20 –15:40	**F.Giazotto**	*Metallic supercurrent and Josephson field-effect-transistors*
15:40 –16:00	**S. Heun**	*Towards Quantum Hall Effect in a Josephson Junction*
16:00 –16:20	**A.Zaikin**	*How to "Marry" Josephon and Aharonov-Bohm Effects in Andreev Interferometers*
16:20 –16:50		**Coffee Break**

SESSION 2: Josephson junction II CHAIR: Marco Aprili

16:50 –17:10	**N.Birge**	*Phase-Contrallable Josephson Junctions for Cryogenic Memory*
17:10 –17:30	**K.Yu. Arutyunov**	*Quantum Phase Slip as a Dual Process to Josephson Tunneling*
17:30– 17:50	**V.V. Ryazanov**	*Magnetoresistive and Microwave Responses of Hybrid Josephson Structures with Ferromagnetic Layers*
17:50– 18:20	**D.Manske**	*Novel Josephson and proximity effect using triplet superconductors*
19:00		**Welcome Party**

Thursday, October 18th

SESSION 3: Unconventional Structures I CHAIR: Alexey Ustinov

09:30 – 9:50	**J.Robinson**	*Epitaxial Helimagnetic Josephson Devices with Zero-Pi States*
09:50 –10:10	**M.Eschrig**	*Generation of pure spin supercurrents in magnetic heterostructures via non-locally induced Landau Fermi-liquid effects*
10:10 –10:30	**A.A. Golubov**	*Direct Evidence of Proximity Induced Abrikosov Vortex Core in a Nonsuperconducting Metal*
10:30 –10:45	**D.Massarotti**	*Electrodynamics of unconventional magnetic Josephson junctions*
10:45 –11:00	**C.Guarcello**	*Solitonic Josephson Thermal Transport*
11:00– 11:30		**Coffee Break**

SESSION 4: Unconventional Structures II CHAIR: Alexander Golubov

11:30–11:45	**F.Cavaliere**	*Non-monotonic and non-analytic response of quenched gapped quantum systems*
11:45 –12:00	**A.Kalabouknov**	*Interplay between superconductivity and magnetism in the LaAlO3/SrTiO3 nanowires*
12:00 –12:15	**A.Garcia Corral**	*Gate-tunable quantum phase transition of the ground state of a magnetic impurity coupled to a superconductor*
12:15–12:30	**S.V.Bakurskiy**	*Static and dynamic properties of Josephson junctions with thin superconducting layer inside the weak link*
12:30–12:50	**Wenger C.**	*How to handle the variability of tunnel currents in resistive random access memory cells by programming algorithms*
12:50–15:00		**Lunch Break**

SESSION 5: Superconductivity at the Nanoscale CHAIR: Saw-Wai Hla

15:00 –15:20	**A.Ustinov**	*Manipulating atomic-scale tunneling defects in amorphous oxide*
15:20 –15:40	**I.Maggio Aprile**	*A BCS signature revealed by the vortex cores of a high Tc Superconductor*
15:40 –16:00	**J.Zasadzinski**	*Bosonic mode in the scanning tunnelingSpectra of Cuprate and Fe-based Superconductors*
16:00 –16:20	**E.Herrera**	*Electronic and structural properties in the superconducting phase of URu2Si2*
16:20 –16:50		**Coffee Break**

SESSION 5: (continued) CHAIR: Saw-Wai Hla

16:50 –17:10	**M.Iavarone**	*STM studies of FeSe single crystals*
17:10 –17:30	**E.Goldobin**	*Josephson nano-structures fabricated from YBCO film by Focused He Ion beam*
17:30 –17:40	**N.Wasio**	*PanScan Freedom Closed-Cycle UHV LT STM/AFM with R9plus Universal SPM Control System*
17:40		**POSTER SESSION**

Friday, October 19th

SESSION 6: Microscopy and Spectroscopy CHAIR: Maria Iavarone

09:30 – 9:50	**M. Hanze**	*Ultrafast time and frequency domain spectroscopy of magnetic atoms*
09:50–10:10	**F.Casoli**	*Magnetic shape memory free-standing nanodisks: actuation mechanisms and possible applications*
10:10 –10:30	**V.Neu**	*Quantitative MFM- measuring stray field landscapes of magnetic and superconducting samples on the nanometer scale*
10:30 –10:50	**S.W. Hla**	*Novel Scanning Probe Techniques for Quantum Measurements of Nanostructures*
10:50 –11:10	**M.E.Gomez**	*Strain effect on magnetic anisotropy in multiferroic nanostructures*

11:10– 11:40		**Coffee Break**
		SESSION 7: Dynamic phenomena in heterostructures CHAIR: Alejandro Silhanek
11:40–12:00	**D.Peddis**	*Understanding magnetization dynamics of strongly interacting magnetic nanoparticles ensemble*
12:00–12:20	**J.L.Vicent**	*Superconducting Vortex Dynamics on Spin-Ice Nanomagnets*
12:20 –12:40	**R.Miranda**	*Mapping the spin distribution in adsorbed molecules*
12:40 –12:55	**G.Grimaldi**	*Vortex lattice instability at the nanoscale*
12:55–13:10	**P.Gentile**	*Geometrically tunable spintronic platforms: towards curvatronics*
13:10–13:25	**R.Citro**	*Supermagnetoresistance of triplet spin-valves*
13:25–15:00		**Lunch Break**
		SESSION 8: 2D Materials I CHAIR: Rositsa Yakimova
15:00–15:20	**F.Giannazzo**	*Conductive AFM of 2D materials and heterostructures for nanoelectronics*
15:20–15:40	**P.Barbara**	*Nanostructured materials for optoelectronics*
15:40–16:00	**M.Truccato**	*Direct-write X-ray nanopatterning for oxide materials*
16:00–16:20	**A.Volodin**	*Work function of stressed suspended graphene*
16:20–16:50		**Coffee Break**
		SESSION 9: 2D Materials II CHAIR: Marika Schleberger
16:50-17:10	**R.Yakimova**	*Interaction of epitaxial graphene with heavy metals; towards novel sensing platform*
17:10-17:30	**M.Gobbi**	*When 2D materials meet molecules: molecular functions in hybrid van der Waals heterostructures*
17:30		**PRIZES (CHAIR: Fabio Beltram)**
19:00		**CONCERT**
20:45		**SOCIAL DINNER**

Saturday, October 20th

		SESSION 10: Nanomaterials for device applications CHAIR: Paola Barbara
09:30 – 9:50	**A.V.Krasheninnikov**	*Defects and Phase Transformations in Two-Dimensional Transition Metal Dichalcogenides*
09:50 –10:10	**M.Schleberger**	*Defect Engineering of 2D Materials by Particle Irradiation*
10:10 –10:30	**P.Boggild**	*Extreme nanostructuring of graphene*
10:30 –10:50	**R.Nouchi**	*Gate-controlled chemical reactions at surfaces of two-dimensional materials*
10:50 –11:05	**G.Granozzi**	*Highly Efficient MoS2/Ag2S/Ag Photoelectrocatalyst Obtained from a Recycled DVD Surface*
11:05–11:30		**Coffee Break**
		SESSION 11: Electronic properties of nanostructured materials CHAIR: Antonio Di Bartolomeo
11:30–11:45	**D.J.Trainer**	*Electronic properties of one or few-layers MoS2 films*
11:45 –12:00	**A.Longo**	*Tellerium-Poly (methyl methacrylate) nanocomposite materials*
12:00 –12:15	**V.Shevelev**	*Influence of molecular oxygen oh h-BN/metal heterostructures*
12:15–12:30	**B.Liu**	*The effect of Anodic Polarization and N2O oxidization for graphene growth*
12:30-12:45	**Y.Sefir**	*Effect of the structural parameters on the nature of the states of quasiperiodic superlattices*
12:45–13:00	**A.Di Bartolomeo**	*MoS_2 and WSe_2 in field effect transistors*
13:00		**CLOSING**

(green)	Invited (20 min including question time)
(orange)	Oral (15 min including question time)

List of Posters

P01 Asmaa B. Half-metallic completely compensated ferrimagnets in Cr doped BaP

P02 Avallone G. — Compensation Point in Amorphous Gd_xFe_{1-x}-films
P03 Barone C. — Low-temperature response of oxide interfaces to pulsed gate voltage and light illumination
P04 Bokai K. — Interaction of graphene/Co interface with oxygen
P05 Carotenuto G. — Carbon Nanorods Synthesized by Graphite Oxide Thermal Reduction with Microwaves
P06 Cirillo C. — Superconducting critical temperature in NbRe/Co bilayers
P07 Cirillo Cl. — VOC removal from recycled plastics on graphene-based adsorbents
P08 Durante O. — A Nanoscale Signature of Mott Transition in Ca_2RuO_4
P09 Galluzzi A. — Pinning energy and anisotropy properties of a Fe(Se,Te) iron based superconductor
P10 Gentile P. — Spin-selected currents in ferromagnet-superconductor-ferromagnet heterostructures
P11 Iuliano M. — GO/Fe3O4/SO3H Nano-Catalysts for Waste Cellulose Conversion
P12 Kelardeh H.K. — Laser-induced Topological Phase in Graphene
P13 Koplak O. — Magnetic instabilities caused by α-Fe2O3 microbeads on the MgO/CoFeB/Ta/CoFeB/MgO surface
P14 Munoz Noval A. — Interplay between two type II superconductors at the nanoscale
P15 Neilinger P. — Conductivity of strongly disordered ultra-thin MoC superconducting films
P16 Noce C. — Induced electron-hole triplet correlations in ferromagnet-BCS superconductor junctions
P17 Palomba M. — Low density polyethylene coated by graphene nanoplatelets
P18 Ponticorvo E. — Metal-Metal oxide nanostructures as a bifunctional electrocatalysts for simultaneous catalytic oxidation of hydrazine and hydroxylamine
P19 Prieto P. — Heterostructures Based on Epitaxial Oxide Thin Films

Wednesday, October 17th

SESSION 1

Spin-Orbit induced Spin locking and φ-Josephson coupling

Charis Quay[1], Marco Aprili[1], Tom Dvir[2], Hadar Steinberg[2]
Alexandre Assouline[3] and Hervé Aubin[3]
1. Laboratoire de Physique des Solides, CNRS, Univ. Paris-Sud, University Paris-Saclay, 91405 Orsay Cedex, France
2. The Racah Institute of Physics, the Hebrew University of Jerusalem, Israel
3. LPEM, ESPCI Paris, PSL Research University; CNRS; Sorbonne Universités, UPMC University of Paris 6,10 rue Vauquelin, F-75005 Paris, Franc

Ising and Rashba spin-orbit act on the spin degree of freedom of Cooper pairs. In monolayer NbSe2 Ising spin-orbit locks the spins out-of-plane. We have investigated this superconducting state by tunneling spectroscopy. Van der Waals tunnel barriers, fabricated by exfoliation and transfer of layered semiconductors, sustain stable currents with strong suppression of sub-gap tunneling. This allows us to measure the spectra of bulk (20 nm) and ultrathin (3- and 4-layer) NbSe2 devices at 70 mK. The spectra are analyzed using a twoband model incorporating depairing. In the bulk, the smaller gap exhibits strong depairing in in-plane magnetic fields, consistent with high out-of-plane Fermi velocity to be related to 3D character of electron band associated to this gap. In the few-layer devices, the large gap exhibits negligible depairing, consistent with out-of-plane spin locking. In the 3-layer device, the large gap persists beyond the Pauli limit as also expected for Ising superconductors. Rashba spinorbit coupling instead induces an anomalous phase-shift of the superconducting wave-function when associated with an in-plane exchange field. We have observed this anomalous phase shift by Josephson interferometry in hybrid SNS Josephson junctions fabricated with the topological insulator Bi2Se3.

In situ tailoring of single superconducting junctions and nano-SQUIDs via current-induced atom migration

J. Lombardo[1], W. Keijers[2], X.D.A. Baumans1, Ž. L. Jelić[1,3], M.V. Milošević[3], R. B. G. Kramer[4], J. Van de Vondel[2], A. V. Silhanek[1]
1.Experimental Physics of Nanostructured Materials, Q-MAT, CESAM, Université de Liège, B-4000 Sart Tilman, Belgium
2.Laboratory of Solid State Physics and Magnetism, Department of Physics and Astronomy, KU Leuven,Celestijnenlaan 200D, B-3001 Leuven, Belgium
3.Departement Fysica, Universiteit Antwerpen, Groenenborgerlaan 171, B-2020 Antwerpen, Belgium
4.Université Grenoble Alpes, Institut NEEL, F-38000 Grenoble, France CNRS, Institut NEEL, F-38000 Grenoble, France

We demonstrate the in situ engineering of superconducting nanowires via modulation of material properties through high applied current densities [1]. We show that the sequential repetition of such customized electro-annealing in a niobium nanoconstriction can broadly tune the superconducting critical temperature Tc and the normal-state resistance Rn in the targeted area. Once a sizable Rn is reached, clear magneto-resistance oscillations are detected along with a Fraunhofer-like field dependence of the critical current, indicating the formation of a weak link with adjustable characteristics [2]. Applying this method to aluminum nanoconstrictions, it is possible to modify their geometry and consequently their weak links' properties beyond the limit of current lithography techniques [3]. Furthermore, conducting parallel electromigration in aluminium SQUIDs allows us to investigate the evolution of the superconducting properties of the SQUID as function of the cross section of the weak links and eventually access a regime where the SQUID can be operated in the dissipative state. We will also discuss the possibility to change the local oxygen doping in constrictions made of High-Tc materials [4].

[1] V. Zharinov *et al.* Rev. Sci. Instrum. 89, 043904 (2018)
[2] J. Lombardo *et al.* Nanoscale 10, 1987 (2018)
[3] X.D.A. Baumans *et al.* Nat. Commun. 7, 10560 (2016)
[4] X.D.A. Baumans *et al.* Small 13, 1700384 (2017)

Metallic supercurrent and Josephson field-effect transistors

G. De Simoni[1], F. Paolucci[1], P. Solinas[2], E. Strambini[1], F. Giazotto[1]
1.NEST Istituto Nanoscienze-CNR and Scuola Normale Superiore, I-56127 Pisa, Italy
2.SPIN-CNR, Via Dodecaneso 33, 16146 Genova, Italy

In their original formulation of superconductivity, the London brothers predicted more than eighty years ago the exponential suppression of an electrostatic field inside a superconductor over the so-called London penetration depth, λ_L, in analogy to the Meissner-Ochsenfeld effect. Despite a few experiments indicating hints of perturbation induced by electrostatic fields, no clue has been provided so far on the possibility to manipulate conventional superconductors via field-effect. In this talk, I will report the evidence of full field-effect control of the supercurrent in all-metallic transistors made of different BCS superconducting thin films [1]. At low temperature, our field-effect transistors (FETs) show a monotonic decay of the critical current under increasing electrostatic field up to total quenching for gate voltage values as large as ±40V in titanium-based devices. This bipolar field effect persists up to ~ 85% of the critical temperature (~ 0.41K), and in the presence of sizable magnetic fields. A similar behavior, though less pronounced, was observed in aluminum thin film FETs [1]. A phenomenological theory accounts for our observations, and provides a description compatible with an electric field-induced non-local perturbation propagating deeply inside the superconducting film. In our interpretation, this affects the pairing potential, and quenches the supercurrent. Furthermore, I will show the experimental realization of Ti-based Dayem bridge field-effect transistors (DB − FETs) [2] able to control the Josephson critical current (I_C) of the superconducting channel. Our easy fabrication process DB − FETs show symmetric full suppression of I_C for an applied critical gate voltage as low as $V_G^C \sim \pm 8$V at temperatures reaching about the 85% of the record critical temperature

550mK for titanium. Our devices show extremely high values of transconductance (up to 15μA/V) and variations of Josephson kinetic inductance with gate voltage of two orders of magnitude. Besides shedding light on a key issue in physics, our results represent a groundbreaking asset for the realization of an all-metallic superconducting field-effect electronics and leading-edge quantum information architectures based on Josephson FETs.

Towards Quantum Hall Effect in a Josephson Junction

Stefano Guiducci[1], Matteo Carrega[1], Giorgio Biasiol[2], Lucia Sorba[1], Fabio Beltram[1], and Stefan Heun[1]

[1]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Piazza San Silvestro 12, 56127 Pisa, Italy

[2]IOM CNR, Laboratorio TASC, Area Science Park, 34149 Trieste, Italy

Hybrid superconductor/semiconductor devices constitute a powerful platform where intriguing topological properties can be investigated. Here we present fabrication methods and analysis of Josephson junctions formed by a high-mobility InAs quantum-well bridging two Nb superconducting contacts. We demonstrate supercurrent flow with transport measurements, critical temperature of 8.1 K, and critical fields of the order of 3 T. Modulation of supercurrent amplitude can be achieved by acting on two side gates lithographed close to the two-dimensional electron gas. Low-temperature measurements reveal also well-developed quantum Hall plateaus, showing clean quantization of Hall conductance. Here the side gates can be used to manipulate channel width and electron carrier density in the device. These findings demonstrate the potential of these hybrid devices to investigate the coexistence of superconductivity and Quantum Hall effect and constitute the first step in the development of new device architectures hosting topological states of matter.

How to “Marry” Josephson and Aharonov-Bohm Effects in Andreev Interferometers

P.E. Dolgirev, M.S. Kalenkov, A.D. Zaikin*

Skolkovo Institute of Science and Technology, 3 Nobel St., 143026 Moscow, Russia

P.N. Lebedev Physical Institute, 119991 Moscow, Russia

** Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), 76021 Karlsruhe, Germany*

We elucidate a non-trivial interplay between proximity-induced quantum coherence and non-equilibrium effects in multi-terminal hybrid normal-superconducting nanostructures [1]. We demonstrate that applying an external bias voltage one drives the system to a novel
(I_0,ϕ_0)-junction state that emerges from a trade-off between non-equilibrium Josephson and Aharonov-Bohm-like contributions. The relative weight of these contributions depends on the relation between temperature, voltage bias and an effective Thouless energy of our setup. We also analyze the phase-coherent thermopower in such nanostructures which exhibits periodic oscillations as a function of an external magnetic flux Φ originating from the Josephson-like and Aharonov-Bohm-like effects as well as from electron-hole asymmetry [2]. We particularly emphasize the role of the system topology that may have a dramatic impact on the behavior of the system. Our results allow to formulate a clear physical picture explaining a number of existing experimental observations and calling for further experimental analysis of the issue.

[1] P.E. Dolgirev, M.S. Kalenkov, and A.D. Zaikin, Phys. Rev. B 97, 054521 (2018).
[2] M.S. Kalenkov and A.D. Zaikin, Phys. Rev. B 95, 024518 (2017).

SESSION 2

Phase-Controllable Josephson Junctions for Cryogenic Memory

Norman O. Birge
Michigan State University, Dept. of Physics & Astronomy, East Lansing, MI 48824, USA

Large-scale computing facilities and data centers are using electrical power at an ever increasing rate. Projections suggest that a fully superconducting computer would consume considerably less power than conventional semiconductor-based computers, even taking into account the power used in cooling the system to cryogenic temperatures [1]. Building a large-scale memory for such a computer is a challenge. One approach is to use Josephson junctions containing ferromagnetic (F) materials as the basic memory element for such a memory [2,3]. The basic device is a Josephson junction containing two ferromagnetic layers whose magnetization directions can be switched between being parallel or antiparallel to each other, just as in a conventional spin valve. If the thicknesses of the ferromagnetic layers are chosen appropriately, those two magnetic states will result in the junction having a ground-state phase of either 0 or π. We have demonstrated that such a junction can indeed be controllably switched between the 0 phase state and the π phase state, from measurements of two junctions in a SQUID geometry [4]. An alternative approach is to use a junction containing three ferromagnetic layers, which is designed to carry spin-triplet supercurrent. We have recently realized controllable 0 - π switching in such a spin-triplet junction [5]. Spin-triplet junctions may have a technological advantage in that the precise thicknesses of the ferromagnetic layers are less critical than in the spin-valve devices. We will report on our continued progress in optimizing both of these systems.

This research is supported by the Office of the Director of National Intelligence (ODNI), Intelligence Advanced Research Projects Activity (IARPA), via U.S. Army Research Office contract W911NF-14-C-0115.

[1] D.S. Holmes, A.L. Ripple, & M.A. Manheimer, IEEE Trans. Appl. Supercond. 23, 1701610 (2013).
[2] A.Y. Herr & Q.P. Herr, US Patent 8,270,209 (2012).
[3] I. M. Dayton et al., IEEE Magnetics Lett. 9, 3301905 (2018).
[4] E. C. Gingrich, B. M. Niedzielski, J. A. Glick, Y. Wang, D. L. Miller, R. Loloee, W. P. Pratt Jr., and N. O. Birge, Nature Phys. 12, 564 (2016).
[5] J.A. Glick, V. Aguilar, A. Gougam, B.M. Niedzielski, E.C. Gingrich, R. Loloee, W.P. Pratt, Jr., and N.O. Birge, arXiv:1804.00707, to appear in Science Advances (2018).

Quantum Phase Slip as a Dual Process to Josephson Tunneling

Konstantin Yu. Arutyunov[1,2]
[1]*National Research University Higher School of Economics, 101000, Moscow, Russia.*
[2]*P.L. Kapitza Institute for Physical Problems RAS, 119334, Moscow, Russia.*

The subject of quasi-one-dimensional (1D) superconductivity has attracted a significant interest. It has been demonstrated that in sufficiently narrow channels quantum fluctuations of the complex order parameter $\Delta = |\Delta|e^{i\varphi}$ may significantly alter the text-book attributes of superconductivity such as zero resistivity, persistent currents and energy gap in excitation spectra. The particular manifestation of quantum fluctuations corresponding to momentary nulling of the order parameter modulus $|\Delta|$ and 'slippage' of the phase φ by 2π is called *quantum phase slip* (QPS). It has been pointed out that the QPS process, being formally equal to tunneling of magnetic flux through a superconductor, is dual to tunneling of a Cooper pair through an insulating layer of a Josephson junction (JJ). The observation leads to a counterintuitive effect: current-biased narrow superconducting channel governed by quantum fluctuations (QPS junction – QPSJ) demonstrates insulating behavior - Coulomb blockade.

Formation of quantized singularities (*Shapiro steps*) at voltages $V_n=nhf_{AC}/(2e), n=1,2,\ldots$ on V-I dependencies of a JJ irradiated with EM wave with frequency f_{AC} have revolutionized electric metrology enabling building of the quantum voltage standard. The quantum duality between Josephson tunneling and QPS process should enable observation of the *dual Shapiro effect* – formation of quantized singularities at currents $I_n=nf_{ac}(2e)$. Here we experimentally demonstrate the proof-of-principle approach leading to quantum standard of electric current utilizing the QPS effect.

This work contains the results of studies carried out under the project TZ-93 “Quantum solid state systems" within the framework of the Basic Research Program at the National Research University Higher School of Economics (HSE) in 2018 and supported by the Russian Academic Excellence Project 5-100.

Magnetoresistive and Microwave Responses of Hybrid Josephson Structures with Ferromagnetic Layers

V.V. Ryazanov[1,3], I.A. Golovchanskiy[2,3], V.S. Stolyarov[1,3], V.V. Bolginov[1,2], N. N. Abramov[2], V.I. Chichkov[2], A.V. Ustinov[2]

[1] *Institute of Solid State Physics, Chernogolovka, 142432, Russia,*

[2] *National University of Science and Technology MISIS, Moscow 119049, Russia,*

[3] *Moscow Institute of Physics and Technology, State University, Dolgoprudny, 141700, Russia,*

In recent years weak ferromagnetic layers regain strong practical interest due to their integration in various superconductor-ferromagnet-superconductor (SFS) Josephson spintronic elements and ultra-fast electronic devices (see [1]). A detailed analysis of FMR spectra has allowed to estimate characteristic time scale for magnetization dynamics in Pd-Fe based cryogenic memory elements as (3-5) $x10^{-9}$ s. Investigations [3] have shown that the rectangular magnetic Josephson junctions (Nb-PdFe-Nb) can be used as an effective Josephson memory element with the critical current defined by the orientation of magnetic moment at zero magnetic field. We have proposed also a hybrid device based on a long Josephson junction inductively coupled to an external ferromagnetic layer. The Josephson junction in the zero-field-step mode induces a localized AC magnetic field in the ferromagnetic layer and enables to create a synchronized magnetostatic standing wave, which in its turn induces additional dissipation for Josephson soliton propagation in the junction and also enables a phase locking (resonant soliton synchronization) at frequency of natural ferromagnetic resonance. In our recent work we have considered dispersion laws of spin waves that propagate in a ferromagnet/superconductor bilayer, specifically, in a ferromagnetic film coupled inductively to a superconductor. We have shown that in general the coupling enhances substantially the phase velocity of magnons in in-plane spin wave geometries.

[1] Larkin T.I., Bol’ginov V.V., Stolyarov V.S., et al: Appl. Phys. Lett. 100, 222601 (2012).
[2] Golovchanskiy I.A., et. al: Journ. Appl. Phys. 120, 163902 (2016).
[3] Golovchanskiy I.A., et. al: Phys. Rev. B. 94, 214514 (2016).
[4] Golovchanskiy I.A., et. al: Supercond. Sci. Technol. 30, (2017).
[5] Golovchanskiy I.A., et. al: Advanced Functional Materials, 28, 1802375 (2018).

Novel Josephson and Proximity Effect using Triplet Superconductors

Dirk Manske

Max Planck Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany

Josephson junctions with magnetic tunnelling barriers provide an excellent opportunity to observe the interplay of ferromagnetism and superconductivity in a controlled setting. Using various approaches, we predict a universal 0-π transition (sign reversal) of the charge current as the orientation of the barrier magnetic moment is varied [1]. Furthermore, in the theoretical study of Josephson junctions, it is usually assumed that the properties of the tunnelling barrier are fixed. This assumption breaks down when considering tunnelling between two triplet superconductors with misaligned d-vectors in a TFT-junction (triplet–ferromagnet–triplet). Such a situation breaks time-reversal symmetry, which radically alters the behaviour of the junction. A further consequence of the d-vector misalignment is the appearance of a Josephson spin current. Finally, we study the interplay of spin and orbital degrees of freedom in a triplet superconductor-ferromagnet junction [2]. Depending on the number of helical modes, the capacity of carrying spin and charge currents is shown to be directly related to the amplitude and orientation of the ferromagnetic magnetization with respect to the superconducting d-vector [3]. Recent experimental progress allows to fabricate interfaces with the triplet superconductor Sr2RuO4 which opens the route for these devices [4,5].

This work has been done together with Damien Terrade, Mario Cuoco, Paola Gentile, Shabaz Anwar, Yoshi Maeno, and many others.

[1] B. Kastening, D.K. Morr, D. Manske, and K.H. Bennemann, Phys. Rev. Lett. 96, 047009 (2006).
[2] P.M.R. Brydon, C. Iniotakis, D. Manske, and M. Sigrist, Phys. Rev. Lett. 104, 197001 (2010).
[3] P. Gentile *et al*., Phys. Rev. Lett. 111, 097003 (2013).
[4] M. S. Anwar *et al*., Appl. Phys. Express 8, 015502 (2015).
[5] M. Uchida, M. Ide1, H. Watanabe, K. S. Takahashi, Y. Tokura, and M. Kawasaki, APL Materials 5, 106108 (2017).

Thursday, October 18th

SESSION 3

Epitaxial Helimagnetic Josephson Devices with Zero-Pi States

Jason Robinson
Department of Materials Science & Metallurgy, 27 Charles Babbage Road, Cambridge, CB2 1LR, United Kingdom

Superconducting spintronics is a new area of research involving the compatible coexistence of spin-polarization and superconducting phase coherence [1]. This field has the potential to offer exciting opportunities for spintronics and has emerged over the past decade following rapid developments in the understanding of induced unconventional electron pairing at interfaces between superconducting and ferromagnetic materials. It is now established that at a magnetically inhomogeneous superconductor / ferromagnet (S/F) interface, spin-singlet Cooper pairs can convert to a spin-aligned triplet state and so create triplet supercurrents that carry both charge and a net spin [1]. In my group's first triplet experiment we demonstrated pair conversion in polycrystalline Josephson devices using the helimagnetic rare earth metal Ho [2]. In this lecture, I will overview my group's recent research on pair conversion at S/F interfaces (including spin-pumping into Nb [3]) and will focus on new results on all-epitaxial Josephson junctions with Ho in which the spiral pitch is field-history-dependent. These devices offer field-programmable supercurrents with extremely large critical currents which are two-orders of magnitude larger than in equivalent polycrystalline devices. I will also demonstrate the simultaneous existence of zero-Pi states in Ho.

[1] J. Linder and J.W.A. Robinson, Nature Physics 11, 307 (2015).
[2] J.W.A. Robinson, J.D.S. Witt, M.G. Blamire, Science 329, 59 (2010).
[3] K-R Jeon *et al*., Nature Materials 17, 499–503 (2018).

Generation of pure spin supercurrents in magnetic heterostructures via non-locally induced Landau Fermi-liquid effects

Matthias Eschrig and Xavier Montiel
Royal Holloway, University of London, Egham, Surrey, TW20 0EX, UK

We propose a mechanism for the generation of pure superconducting spin-current carried by equal-spin triplet Cooper pairs in a superconductor sandwiched between a ferromagnet and a normal metal with intrinsic spin-orbit coupling. We show that in the presence of Landau Fermi-liquid interactions the superconducting proximity effect can induce non-locally a ferromagnetic exchange field in the normal layer, which disappears above the superconducting transition temperature of the structure. The internal Landau Fermi-liquid exchange field leads to the onset of a spin supercurrent associated with the generation of long-range spin-triplet superconducting correlations in the tri-layer. We demonstrate that the magnitude of the spin supercurrent as well as the induced magnetic order in the normal layer depends critically on the superconducting proximity effect between the superconducting layer and the ferromagnetic and normal layers and the magnitude of the relevant Landau Fermi-liquid interaction parameter. We investigate the effect of spin flip processes on this mechanism. Our results demonstrate the crucial role of Landau Fermi-liquid interaction in combination with spin-orbit coupling for the creation of spin supercurrent in superconducting spintronics and give a possible explanation of a recent experiment utilizing spin-pumping via ferromagnetic resonance [1].

[1] K.-R. Jeon, C. Ciccarelli, A. J. Ferguson, H. Kurebayashi, L. F. Cohen, X. Montiel, M. Eschrig, J. W. A. Robinson, and M. G. Blamire, Nature Materials 17, 499 (2018).

Direct Evidence of Proximity Induced Abrikosov Vortex Core in a Nonsuperconducting Metal

A.A. Golubov[1,2], V. S. Stolyarov [2,3], T. Cren[4], Ch. Brun [4], I. A. Golovchanskiy [2], O. V. Skryabina[3], M. Khapaev[5], M. Yu. Kupriyanov[5], D. Roditchev [4,6]

[1]*Faculty of Science and Technology and MESA+ Institute of Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands*

[2]*Moscow Institute of Physics and Technology, Dolgoprudny, Moscow region, 141700, Russia*

[3] *Institute of Solid State Physics, Russian Academy of Sciences,Chernogolovka, Moscow region, 142432, Russia*

[4] *Institut des Nanosciences de Paris, Université Pierre et Marie Curie-Paris 6 and CNRS-UMR 7588, 4 place Jussieu, 75252 Paris, France*

[5] *Lomonosov Moscow State University, Leninskie Gory, Moscow 119991, Russia*

[6] *Laboratoire de physique et d'étude des matériaux, LPEM-UMR8213/CNRS-ESPCI ParisTech-UPMC, 10 rue Vauquelin, 75005 Paris, France*

We report on the experimental observation and theoretical study of proximity induced Abrikosov vortices on the surface of a 50nm-thick layer of Cu in the hybrid structure Cu/Nb with ultra-low temperature Scanning Tunneling Spectroscopy (STS) [1]. It was shown that in the studied samples the non-superconducting Cu-layer acquires superconducting correlations due to the proximity effect with 100nm-thick superconducting Nb. The presence of the proximity effect at the surface of Cu is evidenced by observation of a proximity gap in the tunneling conductance spectra dI(V)/dV in clear relation to the value of the superconducting gap of bulk Nb. The evolution of the proximity spectra with temperature was also studied in the range (0.3-4.2) K. Upon application of an external magnetic field, spatial variations of the tunneling conductance spectra were observed in the detailed STS maps as round nm-size spots, in the centers of which the proximity gap vanishes. The density of spots rises continuously with magnetic field; it corresponds perfectly to the expected density of Abrikosov vortices in Nb. We identify the observed spots as proximity induced vortices in Cu. Using the quasiclassical Usadel formalism, theoretical approach was developed to calculate selfconsistently the quasiparticle spectra in the vortex core in three dimensions in a superconductor-normal metal bilayer. The results of numerical calculations are in excellent agreement with experimental data and make it possible to determine the size and the shape of the proximity vortex cores, and to evaluate the coherence length in Cu.

Electrodynamics of unconventional magnetic Josephson junctions

D. Massarotti[1,2], R. Caruso[3,2], A. Pal[4], N. Banerjee[4], G. Campagnano[2,3], P. Lucignano[2,3], G. Rotoli[5], D. Stornaiuolo[3,2], G. P. Pepe[3,2], M. G. Blamire[4], and F. Tafuri[3,2]

[1]*Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione, Università Federico II di Napoli, Italy*
[2]*CNR-SPIN UOS Napoli, Italy*
[3]*Dipartimento di Fisica "E. Pancini", Università Federico II di Napoli, Italy*
[4]*Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, UK*
[5]*Dipartimento di Ingegneria Industriale e dell'Informazione, Università degli Studi della Campania Luigi Vanvitelli, Italy*

The continuous progress in material science and nanotechnology has led to the realization of novel types of hybrid Josephson junctions (JJs), which are promoting novel solutions especially in the fields of superconducting electronics and qubits. Among different types of hybrid devices, superconductor-ferromagnet-superconductor (SFS) JJs have emerged, promising advances in the fundamental understanding of the competition between superconducting and magnetic ordering, as well as new devices with additional functionalities based on dissipationless spintronics [1, 2].

We will report on the electrodynamic characterization of spin filter JJs [3], composed by a ferromagnetic-insulator GdN barrier, and of SIFS JJs with a barrier composed by an insulating (I) layer and a ferromagnetic layer [4]. Underdamped behavior, high values of the characteristic voltage, observation of 0-π transitions and the first evidence of macroscopic quantum phenomena [5] through measurements of switching current distributions, make these JJs quite appealing for possible use both in quantum circuits and as cryogenic memories. The low dissipation levels in these junctions and the magnetic properties of the barrier offer new tools for the manipulation of the junction properties. In particular, the capability to control the relevant scaling energy by using magnetic field pulses and microwaves [6], suggests new solutions of tunnel-ferromagnetic JJs in transmon qubits.

[1] A. A. Golubov and M. Yu Kupriyanov Nature Materials 16, 156-157 (2017).
[2] A. K. Feofanov, et al. Nature Physics 6, 593-597 (2010).
[3] K. Senapati, et al. Nature Materials 10, 849-852 (2011).
[4] T. I. Larkin, et al. Applied Physics Letters 100, 222601 (2012).
[5] D. Massarotti, et al. Nature Communications 6, 7376 (2015).
[6] R. Caruso, et al. Journal of Applied Physics 123, 133901 (2018).

Solitonic Josephson Thermal Transport

Claudio Guarcello[1], Paolo Solinas[2], Alessandro Braggio[1], Francesco Giazotto[1]
[1] *NEST, Istituto di Nanoscienze CNR-NANO, Scuola Normale Superiore di Pisa (CNR-NANO) - Piazza San Silvestro 12 Pisa - Italy*
[2] *Istituto SPIN-CNR (SPIN) - via Dodecaneso 33, Genova - Italy*

Although all electric and magnetic features concerning Josephson vortices, i.e., solitons, in long Josephson tunnel junctions were comprehensively hitherto explored, little is known about the coherent thermal transport through a temperature-biased long junction in the presence of solitons. The phase dependent heat current was first studied both theoretically and experimentally in Josephson junctions [1] and superconducting quantum-interference devices (SQUIDs) [2]. This phenomenon is the core of the emerging field of phase-coherent caloritronics, from which fascinating devices, such as heat diodes, thermal transistors, solid-state memories, microwave refrigerators, thermal engines, thermal routers, and heat amplifier, were recently conceived [3]. Here, we report the first endeavor to combine the phase-coherent caloritronics and the physics of solitons in one single solid-state structure. In fact, as a temperature gradient is imposed across the junction, namely, as the electrodes forming the device reside at different temperatures, we demonstrate theoretically that the heat current profile flowing through the system depends on the configurations of solitons along the junction [4-6]. As a result, in correspondence of each soliton the temperature locally significantly modifies. Our results can have immediate impact, and open the avenue to the implementation of a novel generation of solitonic devices for caloritronics, such as a soliton-based thermal router [4], in which the thermal transport can be locally mastered by controlling the soliton eventually set along the system, or a magnetically-controlled Josephson heat oscillator [5].

[1] M. J. Martínez-Pérez and F. Giazotto, Nat. Commun. 5, 3579 (2014).
[2] F. Giazotto and M. J. Martínez-Pérez, Nature 492, 401 (2012).
[3] A. Fornieri and F. Giazotto, Nat. Nanotechnology 12, 944 (2017).
[4] C. Guarcello, P. Solinas, A. Braggio and F. Giazotto, Phys. Rev. Appl. 9, 034014 (2018).
[5] C. Guarcello, P. Solinas, A. Braggio and F. Giazotto, Sci. Rep. 8, 12287 (2018).
[6] C. Guarcello, P. Solinas, A. Braggio and F. Giazotto, Phys. Rev. B 98, 104501 (2018).

SESSION 4

Non-monotonic and non-analytic response of quenched gapped quantum

Systems

S. Porta[1,2], F. M. Gambetta[3], N. T. Ziani[4], D. M. Kennes[5], M. Sassetti[1,2], and F. Cavaliere[1,2,*]
1 Dipartimento di Fisica, Università di Genova, Via Dodecaneso 33, 16146 Genova (Italy)
2 CNR-SPIN, 16146 Genova (Italy)
3 The University of Nottingham, University Park, NG7-2RD Nottingham (UK)
4 Institute for Theoretical Physics and Astrophysics, University of Wuerzburg, 97074 Wuerzburg (Germany)
5 Dahlemn Center for Complex Quantum Systems and Fachbereich Physik, Freie Universitaet Berlin, 14195 Berlin (Germany)
**Dipartimento di Fisica, Università di Genova, Via Dodecaneso 33, 16146 Genova (Italy)*

The properties of a one-dimensional fermionic system undergoing a sudden quantum quench between two different gapped states are analyzed. By means of a generalized Gibbs ensemble analysis or by numerical solutions in the interacting cases, we observe an anomalous, nonmonotonic response of steady-state correlation functions as a function of the strength of the mechanism opening the gap. In addition, a non-analytic response is developed if the quantum quench reverses the sign of the gap. We calculate the full dynamical evolution of correlation functions, displaying a freezing of the propagation of the quench information for large quenches. We argue that this freezing is responsible for the nonmonotonous behavior of observables. In the non-interacting case, this freezing can be traced back to a Klein-Gordon equation in the presence of a source term.

Interplay between superconductivity and magnetism in the $LaAlO_3/SrTiO_3$ nanowires

A. Kalaboukhov, P.P. Aurino, L. Galletti, T. Bauch, F. Lombardi, D. Winkler, D. Golubev*, and T. Claeson
Department of Microtechnology and Nanoscience – MC2, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden
** Low Temperature Laboratory, Department of Applied Physics, Aalto University, FI-00076 Aalto, Finland*

The interface between wide band-gap insulators, $LaAlO_3$ and $SrTiO_3$ (LAO/STO) has received much attention since it possesses very exciting electrical properties such as a quasi-two-dimensional electron gas (q2DEG), two-dimensional superconductivity, ferromagnetic behavior and giant spin-orbit coupling [1]. Coexistence of ferromagnetic ordering and superconductivity is one of the most intriguing aspects for the LAO/STO interface. There are also indications that the superconducting state is inhomogeneous on nanoscale [2]. In order to gain better understanding of the ground state of the LAO/STO interface, we have systematically investigated superconductivity in the nanostructureds with dimensions of 100 – 300 nm [3]. The nanostructures were fabricated using our patterning method based on low-energy Ar+ ion beam irradiation [4]. We realized nano-rings and nano-wires with a lateral width of 100 – 300 nm. Analysis of current-voltage characteristics suggests that our nanostructures behave like clean superconducting filaments without formation of weak links. Moreover, we observed a SQUID-like periodic modulation of the critical current in nano-rings corresponding to the Little-Parks fluxoid quantization. A most remarkable observation is an enhancement of the critical current by a small perpendicular magnetic field. This effect may be explained by the suppression of spin flip scattering on magnetic domains by external magnetic field [5] or by induced unconventional pairing [6]. The nature of magnetic ordering in the LAO/STO interface is still elusive that complicates the interpretation of the superconducting transport properties. We will review some possible experimental configurations that would allow unequivocal determination of the superconducting ground state at the LAO/STO interface.

[1] S. Gariglio, M. Gabay, and J.-M. Triscone, *APL Materials* 4, 060701 (2016).
[2] S. Caprara et al., *Supercond. Sci. Technol.* 28, 014002 (2015).
[3] A. Kalaboukhov et al., *Phys. Rev. B* 96, 184525 (2017).
[4] P.P. Aurino et al., *Appl. Phys. Lett.* 102, 201610 (2013).
[5] T.-C. Wei et al., *Europhys. Lett.*, 75, 943 (2015).
[6] D. Stornaiuolo et al., *Phys. Rev. B* 95, 140502(R) (2017).

Gate-tunable quantum phase transition of the ground state of a magnetic impurity coupled to a superconductor

A. Garcia-Corral, D. M. T. van Zanten, S. Florens, D. M. Basko*, K. J. Franke**,
H. Courtois and C. B. Winkelmann
Université Grenoble Alpes, CNRS, Institut Néel, 25 avenue des Martyrs, 38042 Grenoble, France
**Laboratoire de Physique et Modélisation des Milieux Condensés, Université Grenoble Alpes, CNRS, 25 avenue des Martyrs, 38042 Grenoble, France*
***Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany*

We present the study of the electronic transport properties of a device consisting of a quantum dot (QD) embedded between two metallic leads. Peculiar behaviors observed in the conductance are the signature of the Coulomb blockade and the energy levels quantification in the QD. A gate electrode capacitively coupled to the QD can be used to modify its chemical potential. If the leads are superconducting, a new energy scale emerges in the system: the gap Δ in the superconducting density of states changes drastically the characteristics of the current flowing through the junction.

Depending on the charge state and the discrete levels occupation, the QD may act as a tunable magnetic impurity, controlled by the external gate potential. The competition between magnetism

and superconductivity can generate sub-gap excitations at the superconductor surface (the so-called Yu-Shiba-Rusinov bound states). Furthermore, if the coupling to one of the leads is strong enough, quantum correlation effects give rise to a detectible Kondo resonance, corresponding to the local screening of the magnetic moment in the QD by the conduction electrons of the lead.
In the present experiment, by tuning the gate, we modulate the Kondo temperature TK measured in the normal state, and consequently the energy of the sub-gap bound states for superconducting leads. When the bound state energy becomes zero, a quantum phase transition of the system between a screened and unscreened local spin state is observed. Our results demonstrate the universality of this transition taking place at $\Delta/T_K \approx 2.5$, confirming previous theoretical predictions.

Static and dynamic properties of Josephson junctions with thin superconducting layer inside the weak link

S. V. Bakurskiy, N. V. Klenov, I. I. Soloviev, A. Neilo, N. G. Pugach, M. Yu. Kupriyanov, and A. A. Golubov

Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University 1(2), Leninskie gory, Moscow 119234, Russian Federation

Moscow Institute of Physics and Technology, Dolgoprudny, Moscow Region, 141700, Russian Federation

Faculty of Science and Technology and MESA+ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands

Nowadays the Josephson junctions with magnetic weak links attract special attention due to their possible applications a number of future devices, such as superconducting MRAM, logic, quantum bits and neural networks [1]. The interaction between superconducting and ferromagnetic orders in the proximized area of ferromagnetic SFS junctions provides phenomenon of 0- π oscillation of pairing amplitude in the structure. The effect permits to organize superconducting memory devices in new principals.

The S-IsF-S junction with composite interlayer consists of tunnel barrier I, thin superconducting film s and ferromagnetic layer F combines high performance of the tunnel SIS junctions and special properties of magnetic SFS devices. We developed a microscopic theory of the electron transport in these devices in the frame of the Usadel equations.

We have found that 0- π transition in SIsFS junction can be hidden during the measurement of critical current, due to formation of multiple branches in the current-phase relation (CPR) shape [2]. We demonstrate that the effect is the direct consequence of the significant second harmonic in CPR of the ferromagnetic sFS part of the SIsFS device. Furthermore, we find that decrease of the thickness of the intermediate s-layer leads to the significant deviation of pair potential Δ at 0 and π -phase. It modifies the critical current of tunnel SIs junction and provides possibility for macroscopic distinguish the phase shift.

We also study dynamic properties of the SIsFS junction in the frame of the modified RSJ model taking into account nonequilibrium processes in s-layer [3]. We find that appearance of the voltage on tunnel layer doesn't influence on the current properties of sFS-junction, but sFS-junction in resistive state acts as internal pumping for SIs- weak link.

This work was supported in part by the Projects RFBR-18-32-00672 mol_a and 17-12-01079 from Russian Science Foundation.

[1] I. I. Soloviev, N. V. Klenov, S. V. Bakurskiy, M. Yu Kupriyanov, A. L. Gudkov, and A. S. Sidorenko. Beyond Moore's technologies: operation principles of a superconductor alternative. Beilstein Journal of Nanotechnology, 8:2689–2710, 2017.

[2] S. V. Bakurskiy, V. I. Filippov, V. I. Ruzhickiy, N. V. Klenov, I. I. Soloviev, M. Yu Kupriyanov, and A. A. Golubov. Current-phase relations in SIsFS junctions in the vicinity of 0-π transition. Physical Review B - Condensed Matter and Materials Physics, 95(9):094522–1–094522–11, 2017

[3] J. Keller, and D. A. Ryndyk, Phys. Rev. B 71, 054507, 2005

How to handle the variability of tunnel currents in resistive random access memory cells by programming algorithms

Christian Wenger[1,2], Mamathamba Kalishettyhalli Mahadevaiah[1], Eduardo Perez[1], C. Zambelli[3], P. Olivo[3], M. Ziegler[4], H. Kohlestedt[4]

1 IHP, 15236 Frankfurt / Oder, Germany

2 Brandenburg Medical School Theodor Fontane, 16816 Neuruppin, Germany

3 Universitá degli Studi di Ferrara, 44122 Ferrara, Italy

4 Kiel University, 24143 Kiel, Germany

Recent advances in the performance of resistive random access memory (RRAM) have led to a significant interest in CMOS technologies. Although RRAM based memory arrays demonstrated excellent performance parameters, the variability is still a critical issue. While the intracell variability can be optimized for particular memory cells, the intercell variability must be minimized by using specific programming algorithms. In addition, major concerns are cycling variability, and resistance distributions degradation. Controlling these phenomena requires employing program-verify schemes. In this talk, an optimized scheme to minimize resistance dispersion and to achieve reliable multi-bit operation is evaluated. However, statistical variations can be tolerated in computing applications like neuromorphic networks. The synaptic behaviour of RRAM devices can be evaluated by applying successive algorithms consisting of set or reset pulses. These algorithms can be used to study the synaptic functionality of RRAM arrays.

SESSION 5

Manipulating atomic-scale tunneling defects in amorphous oxides

Jürgen Lisenfeld[1], Alexander Bilmes[1], Georg Weiss[1], and Alexey Ustinov[1,2]
[1] *Karlsruhe Institute of Technology, Physikalisches Institut, Karlsruhe, Germany*
[2] *Russian Quantum Center and National University of Science and Technology MISIS, Moscow, Russia*

In structurally disordered solids, atoms or groups of atoms are able to quantum mechanically tunnel between two nearly equivalent sites. These atomic tunneling systems have been previously identified as the cause of various low-temperature anomalies of bulk glasses and as a source of decoherence of superconducting quantum circuits where they are sparsely present in the disordered oxide barriers. A tiny mechanical deformation of the oxide barrier changes the energies of the atomic tunneling systems. We have measured these changes by tracing changes in the microwave spectra of superconducting qubits induced by coherent interactions with microscopic two-level tunneling systems. The observed hyperbolic dependence of the energy splitting of individual atomic tunneling states on external strain [1], for the first time, confirmed the central hypothesis of the two-level tunneling model for disordered solids [2]. Tuning the properties of individual defects by applying mechanical strain allowed us to detect their mutual interactions [3] and study their spectral properties [4]. We also probed the interaction between individual two-level defects and quasiparticles in a superconductor and observed an increase of defect decoherence rates with quasiparticle density [5]. More recent results include detection of individual defects in microwave response of superconducting thin-film resonators [6] and tuning their properties by applying dc electric fields.

[1] G. J. Grabovskij, T. Peichel, J. Lisenfeld, G. Weiss, A. V. Ustinov, Science 338, 232 (2012).
[2] P. W. Anderson, B. I. Halperin, C. Varma, Phil. Mag. 25, 1 (1972); W. A. Phillips, J. Low Temp. Phys. 7, 351 (1972).
[3] J. Lisenfeld, G. J. Grabovskij, C. Mueller, J. H. Cole, G. Weiss, A. V. Ustinov, Nature Commun. 6, 6182 (2015).
[4] J. Lisenfeld, A. Bilmes, S. Matityahu, S. Zanker, M. Marthaler, M. Schechter, G. Schön, A. Shnirman, G. Weiss, A. V. Ustinov, Sci. Rep. 6, 23786 (2016).
[5] A. Bilmes, S. Zanker, A. Heimes, M. Marthaler, G. Schön, G. Weiss, A. V. Ustinov, and J. Lisenfeld, Phys. Rev. B 96, 064504 (2017).
[6] J. D. Brehm, A. Bilmes, G. Weiss, A. V. Ustinov, and J. Lisenfeld, Appl. Phys. Lett. 111, 112601 (2017).

A BCS signature revealed by the vortex cores of a high T_c Superconductor

Ivan Maggio-Aprile[1], Christophe Berthod[1], Jens Bruer[1], Andreas Erb[2], and Christoph Renner[1]
[1]*Université de Genève-DQMP, 24 quai Ernest Ansermet, Geneva, Switzerland*

[2] *Walther Meissner Institut für Tieftemperaturforschung, Garching, Germany*

Most of the observations made by scanning tunnelling spectroscopy (STS) in the vortex cores of high-temperature cuprate superconductors have revealed unusual features. Among these, the detection of a robust pair of electron-hole symmetric states at finite subgap energy in $YBa_2Cu_3O_{7-\delta}$ (Y123) [1] was in total contradiction with the zero-bias anomaly expected for a d-wave vortex core.

In recent STS experiments on Y123, we found that these subgap states are not a specific signature of the vortices, but belong to an electronic background uniformly measured across the surface, whether a magnetic field is applied or not [2]. This finding led us to consider a model where the total tunnelling current is the combination of two additive channels: one associated with the quasiparticle excitations of a clean *d*-wave superconductor; the other and dominant one corresponding to a non-superconducting background where the subgap peaks belong. We can eliminate this unknown contribution by subtracting a spectrum measured away from the vortex cores from all the tunnelling spectra in the map. The remaining signal can be modelled in the Bogoliubov-de Gennes framework, by computing the spatial dependence of the LDOS in the presence of vortices and performing the same subtraction. We find a remarkable correspondence between the model and the data, demonstrating that the vortex cores in HTS cuprates present the expected BCS quasiparticle LDOS [3]. The model provides further insight into the vortex-core structure, which is different for each vortex due to an irregular lattice and depends on the Fermi surface topology more than on the gap symmetry.

[1] I. Maggio-Aprile *et al.*, Phys. Rev. Lett. 75, 2754 (1995)
[2] J. Bruer *et al.*, Nat. Commun. 7, 11139 (2016)
[3] C. Berthod *et al.*, Phys. Rev. Lett. 119, 237001 (2017)

Bosonic Mode in the Scanning Tunneling Spectra of Cuprate and Fe-based Superconductors

John Zasadzinski
Physics Department, Illinois Institute of Technology
Materials Science Division, Argonne National Laboratory

Scanning tunneling spectroscopy (STS) of the high Tc cuprate, $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi2212) near optimal doping consistently reveals an above-gap dip feature, which displays the characteristic signatures of a strong coupling effect similar to the phonon structures found in conventional superconductors. This bosonic mode feature has a characteristic energy $\Omega \sim$ 35 meV-40 meV near optimal doping and is observed with an enhanced strength in SIS break junctions and intrinsic Josephson junctions (IJJ). The doping dependence of this bosonic mode leads to $\Omega \sim 4.9\ k_BT_C$ remarkably close to the resonance spin excitation measured in neutron scattering, strongly suggesting that spin fluctuations serve as the pairing glue. Similar bosonic mode features are found in the STS spectra of other high Tc cuprates, as well as in Fe-based superconductors and is invariably linked to the resonance spin excitation. This suggests that the dynamics of the pairing interaction in these two classes of unconventional superconductors are quite similar. We discuss the observation of the bosonic mode in single Cu-O layer superconductors which have a wide variation in optimal doped Tc from 94K in Hg1202 down to 5K in Bi2201.

Electronic and structural properties in the superconducting phase of URu_2Si_2

Herrera Edwin[1,2]

[1]*Laboratorio de Bajas Temperaturas, Departamento de Física de la Materia Condensada, Instituto Nicolás Cabrera. Condensed Matter Physics Center and and Instituto Nicolás Cabrera. Universidad Autónoma de Madrid, E-28049 Madrid, Spain*

[2]*Facultad de Ingeniería y Ciencias Básicas, Universidad Central, Bogotá 110311, Colombia*

We report high resolution atomic size Scanning Tunneling Microscopy/Spectroscopy (STM/S) measurements on single crystals of URu_2Si_2. After cleaving the sample in-situ perpendicular to the c-axis of the tetragonal crystal structure at liquid helium temperature, we observe atomically flat terraces which we identify as U or Si terminated. We find a one dimensional (1D) spatial modulation with a wavelength of 6.5 ± 0.5 nm oriented with a small angle to an in-plane atomic axis. The modulation corresponds to tiny changes in the STM topography of at most a few pm at each period. The 1D modulation provides a microscopic feature that can related the numerous observations showing in-plane symmetry breaking in the hidden order phase of URu_2Si_2. We also discuss quasiparticle interference patterns and their relationship to the bandstructure.

STM studies of FeSe single crystals

Maria Iavarone

Department of Physics, Temple University, Philadelphia, Pennsylvania 19122, USA

In spite of its simple crystal structure, the electronic properties of the iron-based superconductor FeSe (Tc ~ 9 K) are rich and attractive. Superconductivity in FeSe takes place in a so-called nematic phase that is associated with orbital ordering. Another interesting aspect is that Fermi wave length is as long as the coherence length therefore, placing FeSe most likely in the BCS-BEC crossover regime. These features should result in non-trivial electronic states around the local defects such as vortices and impurities. We have performed low temperature STM/STS experiments on FeSe to investigate its

electronic structures. Multiband superconductivity aspects, symmetry of the order parameter, role of disorder, vortex matter and chemical substitution effects on the band structure of this system will be discussed.

Funding Acknowledgement: This work was supported by U.S. Department of Energy under Grant No. DE-SC0004556.

Josephson nano-structures fabricated from YBCO film by Focused He Ion beam

E. Goldobin, B. Müller, M. Karrer, D. Kölle, R.Kleiner
Physikalische Institut—Experimentalphysik II, University of Tübingen,
Auf der Morgenstelle 14, 72076, Tübingen, Germany

We have fabricated Josephson devices by ``writing'' them into YBCO film by using Focused He Ion Beam (He-FIB). The He-FIB with a diameter smaller than 1nm destroys the crystal structure of YBCO crystal, making it ``more insulating'' in the irradiated area. Thus, by moving the He-FIB across the YBCO strip, one can produce Josephson barrier for optimal irradiation dose or insulating barrier for high dose. The Josephson junctions with such a FIB induced barrier exhibit RSJ-like current-voltage characteristic and Fraunhofer-like dependence of the critical current on applied magnetic field $I_c(H)$. Critical current densities j_c reach 100kA/cm^2. The high-dose barrier shows insulating behavior, with $R(T)$ rapidly growing as the temperature decreases from 80K down to 4.2K. These He-FIB induced insulating walls can be used for nano-structuring without using lithography. For example, we demonstrate fabrication of constriction-type Josephson junctions of the size ~10nm created by insulating walls made by high-dose He-FIB.
The use of He-FIB opens many new possibilities that still have to be explored in details. For example, one can do nano-structuring on the scale down to 10nm using insulating walls; one can "write" Josephson nano-junctions anywhere on the chip in different orientations and with different j_c; one can "write" tiny insulating dots that can be used for pinning of Abrikosov vortices, etc.

PanScan Freedom Closed-Cycle UHV LT STM/AFM with R9*plus* Universal SPM Control System

Natalie A. Wasio
RHK Technology, Inc., 1050 E. Maple Rd., Troy, MI 48083 USA

RHK Technology is the world leader in cryogen-free low-temperature SPM and universal SPM controllers. The award winning PanScan Freedom is the world's first cryogen-free UHV LT SPM system with proven performance and exceptional results in a surprisingly compact package. In addition to offering STM and STS capabilities, the PanScan Freedom also offers qPlus® AFM capability for non-contact AFM experiments. The model PanScan Freedom TESLA is available for magnetic applications, which enables cryogen-free low-temperature SPM measurements in magnetic fields up to 5T. The revolutionary R9*plus* SPM Controller is engineered for the most advanced applications yet easily operated by new users. In addition to powering RHK microscopes, R9*plus* is a universal control system capable of powering home-built SPMs and any commercial SPM, opening up new potential for aging microscope platforms. Along with the PanScan and R9*plus* product lines, RHK's Beetle SPM's offer superb mechanical and thermal stability for variable and high temperature STM and beam-deflection AFM experiments. RHK's unique combination of hardware, electronics, software, in-house expertise, ongoing service, and nearly four decades of worldwide experience assures that researchers receive outstanding products and support crucial to achieving their research objectives.

Friday, October 19th

SESSION 6

Ultrafast time and frequency domain spectroscopy of magnetic atoms

Max Hänze,[1,2] Gregory McMurtrie,[1,2] Luigi Malavolti,[1,2] Björn Schlie,[1,2] Mohamad Abdo,[1,2] and Sebastian Loth[1,2]

1-Universität Stuttgart, Institute for Functional Matter and Quantum Technologies. Stuttgart, Germany

2-Max Planck Institute for Solid State Research, Stuttgart, Germany

Spin and charge dynamics are particularly pronounced in nanoscale materials where they give rise to exciting effects such as quantum interference or quantum critical behavior. Accessing these dynamics on their intrinsic length and time scales is an important step towards a microscopic understanding of quantum physics on the atomic scale.

Applying pulses [1] or continuous wave signals [2] to individual atoms has proven a powerful technique for the characterization of fast magnetic surface dynamics using scanning tunneling microscopy. We show that the dynamics of individual atoms can be observed, in both the time domain, using pump probe spectroscopy, and in the frequency domain, using broadband noise detection. The two techniques address different excitation regimes of the atom's quantum states. While pump-probe measurements rely on large driving fields, noise detection non-invasively reveals picosecond-scale fluctuations, enabling the investigation of few-atom spin systems yet considered static.

These experiments shed light onto the impact of spins on surfaces and highlight pathways to design and control magnetism at the single atom level.

[1] S. Loth, M. Etzkorn, C. P. Lutz, D. M. Eigler, A. J. Heinrich, Science 329 1628 (2010)
[2] S. Baumann, W. Paul, T. Choi, C. P. Lutz, A. Ardavan, A. J. Heinrich, Science 350 6259 (2015)

Magnetic shape memory free-standing nanodisks: actuation mechanisms and possible applications

F. Albertini[1], S. Fabbrici[1], F. Casoli[1], M. Campanini[2,1]L. Nasi[1], P. Ranzieri[1], R. Cabassi[1], C. Magén[3], F. Celegato[4], G. Barrera[4], P. Tiberto[4]

1 IMEM-CNR, 43124, Parco Area delle Scienze 37/a, Parma, Italy

2 Empa, 8600, Überlandstrasse 129, Dübendorf, Switzerland
3 Instituto de Nanociencia de Aragón, 50018, Campus Río Ebro, Zaragoza, Spain
4 INRIM, 10135, Strada delle Cacce 91, Torino, Italy

Magnetic shape memory materials display multifunctional properties (e.g. magnetomechanical, magnetocaloric, magnetoreisistive…) arising from the presence of a martensitic transformation and magnetic states [1]. Low-dimensional materials, mainly thin films, have recently attracted much interest for their great potential in novel applications (e.g. microactuators, energy harvesters, solid-state microrefrigerators) [2]. We have shown that in epitaxial thin films the magnetic and structural properties can be optimized at the different length-scales by an appropriate choice of substrates/underlayers, thickness and growth parameters, including temperature and stress applied during growth [3].
In the present talk we will focus on patterned structures and free-standing nanodisks.
Patterned thin films were obtained by polystyrene-nanosphere lithography of epitaxial NiMnGa-based thin films grown by sputtering r.f. on MgO substrates with a Cr underlayer. Free-standing nanodisks (d=160, 650 nm) were subsequently obtained by removing the Cr underlayer by a selective chemical etching. A multiscale structural and magnetic study was performed by means of electron microscopy (HREM, STEM-HAADF, electron diffraction, Lorentz microscopy), X-ray diffraction, AFM/MFM, and SQUID magnetometry.
Patterned thin films maintain the same macroscopic martensitic and magnetic properties of continuous thin films (e.g. martensitic transformation temperature, crystalline structures, magnetization loops). On the other hand, their microstructural and magnetic configurations are influenced by lateral confinement and release from substrate.
Remarkably, the combined application of temperature and field to free-standing nanodisks gives rise to substantial microstructural changes, enabling different actuation modes. Areal variation of the order of some percent, and tunable in intensity and sign by the application of T and magnetic fields have been obtained
These features, arising from the combination of ferromagnetic and martensitic properties, pave the way to the realization of ferromagnetic shape memory nanoactuators. Possible new–concept biomedical applications will also be discussed.

[1] M. Acet, et al., Handbook of Magnetic Materials vol. 19, Elsevier, Amsterdam, 2001
[2] A. Backen et al., Adv. Eng. Mat. 14,(2012) 696
[3] P. Ranzieri et al., Acta Mater. 61 (2013) 263,P. Ranzieri et al., Adv. Mater. 32, (2015) 4760

Quantitative MFM – measuring stray field landscapes of magnetic and superconducting samples on the nanometer scale

Volker Neu
Institute for Metallic Materials, IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany

Magnetic force microscopy (MFM) has established its place as an extremely valuable method for the investigation of magnetic microstructures on the nanometer scale. Its rather simple principle of sensing the sample's stray field above its surface makes it a robust but yet sensitive and highly resolving method with little demand on sample surface preparation. Beyond being a purely qualitative imaging technique, quantitative MFM has the capability to locally measure the stray fields and eventually provide quantitative input data for a reconstruction of the underlying magnetization structure. This requires a full calibration of the imaging properties of the MFM tip and the most general approach is through the determination of the so-called tip transfer function (TTF) in Fourier space [1-3]. A calibrated tip transforms MFM signals into true stray field values on the nanometer scale, which for certain applications is already the desired quantity. Furthermore, the field profile is corrected for the tip broadening and thus allows a true size determination of isolated magnetic objects. Reconstructing the magnetization structure from the stray field landscape will need additional knowledge on the sample. Here, micromagnetic simulations can help by providing valid initial magnetization models.
We will present examples of qMFM studies, which demonstrate the large benefit of treating MFM data quantitatively. (i) Magnetic nanowires typically possess a homogeneous ground state with magnetization the along the wire axis. Nevertheless, a vortex state can form at the wire's end, which is barely measurable by global magnetometry, but can be clearly identified by high-resolution qMFM. (ii) Magnetic thin films with small perpendicular anisotropy can develop so-called stripe domains, which are characterized by a periodic modulation of the z-moment on top of an overall magnetization in the plane. A quantitative MFM analysis determines the amplitude of the perpendicular magnetization component, and together with micromagnetic simulations, can probe the 3-dimensional magnetization structure of these domains. (iii) Flux lines in type-II superconductors emanate a stray field profile which width depends on the magnetic penetration depth λ. Quantitative measurements of λ as a function of temperature $\lambda(T)$ provide experimental input for determining the symmetry of the order parameter.

[1] Hug *et al.* JAP 83 (1998)
[2] Vock *et al.* APL 105 (2014)
[3] Panchal *et al.* Sci. Rep. 7 (2017).

Novel Scanning Probe Techniques for Quantum Measurements of Nanostructures

Saw-Wai Hla
Argonne National Laboratory and Ohio University

In this talk, novel instrumentation techniques recently developed in Argonne National Laboratory to investigate quantum properties of individual nanoparticles, single molecules, and single atoms on surfaces as well as new quantum phenomena discovered by using these techniques will be presented [1-6]. At the first part, the latest results of our synchrotron X-rays scanning tunneling microscope (SX-STM) will be shown [1-3]. To date, synchrotron measurements vital for the characterization of materials at the nanoscale are performed by using conventional detectors. The spatial resolution of most synchrotron measurements is poor because they depend on the X-ray beam size. SX-STM enables to probe local X-ray induced currents at the atomic scale independent of the X-ray beam size and thus it has a tremendous advantage over the conventional synchrotron measurements. As the demonstrations of this nascent technique, the detection of element specific X-ray excited electrons from a single Co nanocluster, local X-ray Magnetic Circular Dichroism measured on Co and Fe thin films, and X-ray absorption spectroscopy of individual nanoparticles will be presented. At the second part, operation of molecular machines using STM manipulation schemes will be presented. Unlike biological counterparts, the synthetic molecular machines may tolerate a more diverse range of conditions, and thus be advantageous for the complex functions with low power consumption suitable to operate in solid state devices. Fundamental operations of some synthetic molecular machines are investigated at one molecular machine-at-a-time in an atomically clean environment. These investigations reveal how charge and energy transfer are taken place within single molecular machines as well as among the molecular machines in the molecular networks. Moreover by introducing dipole active components in the rotor arms of the molecular motors, communication among the molecules can be introduced via dipolar interaction. In addition to single molecule operations, synchronization of molecular motors can be achieved depending on the symmetry of the molecular assemblies on surfaces and the strength of applied electric field energy.

[1] Y. Li, A. Ngo, A. DiLullo, K.Z. Latt, H. Kersell, B. Fisher, P. Zapol, S.E. Ulloa, and S.-W. Hla. *Anomalous Kondo resonance mediated by semiconducting graphene nanoribbons in a molecular heterostructure. Nature Communications* 8, 946 (2017)

[2] Y. Zhang, H. Kersell, R. Stefak, J. Echeverria, V. Iancu, U.G.E. Perera. Y. Li, A. Deshpande, K.-F. Braun, G. Rapenne, C. Joachim, and S.-W. Hla. *Simultaneous and coordinated rotational switching of all molecular rotors in a network. Nature Nanotechnology* 11, 706-711 (2016).

[3] U.G.E. Perera. F. Ample, H. Kersell, Y. Zhang, G. Vives, J. Echeverria, M. Grisolia, G. Rapenne, C. Joachim, and S.-W. Hla. *Controlled clockwise and anticlockwise rotational switching of a molecular motor*. *Nature Nanotechnology* 8, 46-51 (2013).

[4] H. Kersell, N. Shirato, M. Cummings, H. Chang, D. Miller, D. Rosenmann, S.-W. Hla, and V. Rose. *Detecting element specific electrons from a single cobalt nanocluster with synchrotron X-ray scanning tunneling microscopy. Appl. Phys. Lett.* 111, 103102 (2017).

[5] N. Shirato, M. Cummings, H. Kersell, Y. Li, B. Stripe, D. Rosenmann, S.-W. Hla, and V. Rose.

Elemental fingerprinting of materials with sensitivity at the atomic limit. *Nano Lett.* 14, 6499-6504 (2014).
[6] V. Rose, K. Wang, T.U. Chien, J. Hiller, D. Rosenmann, J.W. Freeland, C. Preissner and S.-W. Hla. *Synchrotron x-ray scanning tunneling microscopy: Fingerprinting near to far field transitions on Cu(111) induced by synchrotron radiation*. *Adv. Funct. Mater.* 23, 2646-2652 (2013).

Strain effect on magnetic anisotropy in multiferroic nanostructures

M. E. Gomez[1,2], J. E. Ordoñez,[1] L.Marín,[2] L. A. Rodríguez,[1,3] P. Algarabel[4], P. Prieto
1Department of Physics, Universidad del Valle, Cali, Colombia
2Center of Excellence on Novel Materials, CENM, Universidad del Valle, Cali, Colombia. [3] Instituto de Nanociencia Aragón INA Spain

In multiferroic heterostructures magneto electric coupling between a ferroelectric and a ferromagnetic material has been extensively studied during the last decade and various interaction mechanisms have been identified as promising routes towards exclusively electric-field controlled magnetism. In this work, we report the magnetic anisotropy in strain-coupled systems. We have systematically growth ferromagnetic (FM) $La_{2/3}Sr_{1/3}MnO_3$ (t_{LSMO}=100 nm) / ferroelectric (FE) $BaTiO_3$ (t_{BTO}=100 nm), (LSMO/BTO), bilayers on (001) oriented $SrTiO_3$ (STO), $(LaAlO_3)_{0.3}(Sr_2TaAlO_6)_{0.7}$ (LSAT), and $LaAlO_3$ (LAO) substrates as a possible route to design artificially heterostructures with possible magnetoelectric coupling. We have structurally analyzed samples via X-ray reciprocal space map, strain mapping using geometry phase analysis (GPA) of high angle annular dark-field (HAADF) images from scanning transmission electron microscopy, and high resolution electron microscopy. Results reveal that LSMO grew epitaxially strained whereas the BTO film grew relaxing its single-crystal structure through dislocations formed in the LSMO-BTO interface. Samples also exhibited ferromagnetic order with magnetization between 280-320 emu/cm^3 at 300 K, making possible multiferroic behaviour at room temperature. We realized magnetization hysteresis loops at 300 K, with the magnetic field (H_{app} = 5 kOe) applied along different in-plane crystallographic directions for magnetic anisotropy analysis. Magnetic polar results show that bilayer grown on STO substrate exhibits a change in the magnetic anisotropy from biaxial magnetic ordering (observed in the LSMO/STO single-layer) to uniaxial magnetic ordering, probably due to strain induced by the BTO layer on the top of LSMO layer. This effect is not observed in the bilayers grown on LSAT and LAO substrates. This result revealed that the superficial strain effect induced a uniaxial anisotropy when LSMO films is grown under tensile strain.

Acknowledgments: We thank *Instituto de Nanociencias de Aragon (INA)* and collaborators José Ángel Pardo, Luis Morellon, Cesar Magen, Ricardo Ibarra for supporting growth and measurements of samples. This work has been supported by Center of Excellence on Nobel Materials–CENM, Research Projects*: CI7917-CC 10510 contract 0002-2013 COLCIENCIAS and CI 7978* UNIVALLE.

SESSION 7

Understanding magnetization dynamics of strongly interacting magnetic nanoparticles ensemble

D. Peddis*, D. Fiorani*,
**ISM-CNR, Area della Ricerca Roma 1, Via Salaria km 29.300, Monterotondo Scalo (RM), Italy*

In a magnetic nanoparticles (MNPs) ensemble the thermal evolution of the dynamics depends on the nature and strength of the inter-particle interactions. In sufficiently concentrated nanoparticle systems, strong dipolar interaction combined with random orientation of anisotropy axes determine a competition between different moment alignments leading to a collective freezing of particle moments in a disordered magnetic state, known as superspin glass (SSG), below a characteristic glass temperature (T_g). The SSG exhibits slow dynamics qualitatively indistinguishable from that observed in atomic spin glasses (SG), characterized by aging, memory and rejuvenation phenomena. In this talk, the equilibrium and non-equilibrium dynamics of a dense ensemble of $MnFe_2O_4$ nanoparticles, that can be considered as model system, will be discussed. Nanoparticles have been synthesized by coprecipitation of Fe^{3+} and Mn^{2+} from water-in-toluene reverse micelle system and subsequent thermal treatment at 320°C. Mean crystallite size obtained by XRD analysis is ~2 nm, whereas by powder specific area (278 m^2/g) is ~ 4 nm, suggesting the presence of some aggregated crystallites. Zero Field Cooled (ZFC) and Field Cooled (FC) magnetization curves show the typical SSG behavior, i.e. a sharp maximum at T_g (65 K). The transition temperature detected by Mössbauer spectroscopy (T_M) is pretty close to T_{max} ($T_M/T_{max} \sim 1.4$), despite the significantly different time scales, as expected for a collective magnetic state. This landscape is confirmed by AC susceptibility measurements showing a frequency dependence described by a power law with the same exponent as for SG (~8.6). Non-equilibrium dynamics of the system has been investigated by memory experiments using different protocols (TRM; ZFC, IRM), showing for the first time the validity of the principle of superpositon for a SSG system. Monte Carlo simulations reproduce well the experimental findings[1–3].

[1] D. Fiorani, D. Peddis, Understanding dynamics of interacting magnetic nanoparticles: from the weak interaction regime to the collective superspin glass state, J. Phys. Conf. Ser. 521 (2014) 12006.
[2] D. Peddis, P.E. Jonsson, G. Varvaro, S. Laureti, Magnetic Interactions: A Tool to Modify the Magnetic Properties of Materials Based on Nanoparticles, in: C. Binns (Ed.), Nanomagnetism Fundam. Appl., Elsevier B.V, Oxford, UK, 2014: pp. 129–189.

[3]D. Peddis, M. Vasilakaki, K.N. Trohidou, D. Fiorani, Dynamics in Superspin Glass Systems, IEEE Trans. Magn. 50 (2014) 6–9.

Superconducting Vortex Dynamics on Spin-Ice Nanomagnets

V. Rollano [1], A. Muñoz-Noval [2], A. Gomez [1, 3], E. M. Gonzalez [1, 2], F. Valdes-Bango [4], L. M. Alvarez-Prado [4], M. Velez [4], J. I. Martin [4], M. R. Osorio [1], D. Granados [1], J. L. Vicent [1,2]

1. IMDEA-Nanociencia, Cantoblanco, 28049 Madrid, Spain.

2. Departamento Física de Materiales, Facultad CC. Físicas, Universidad Complutense, 28040 Madrid, Spain

3. Centro de Astrobiología (CSIC-INTA), Torrejón de Ardoz, 28850 Madrid, Spain.

4. Departamento de Física, Universidad de Oviedo, 33007 Oviedo, Spain

Superconducting vortices are robust topological defects which allow studying a lot of distinct topics. In this talk we will focus on the interplay between superconducting vortices and magnetic topological defects. The hybrid samples are honeycomb arrays of Co nanomagnets embedded in Nb superconducting films grown on Si substrates. They are fabricated using standard sputtering, electron beam lithography and etching techniques. The connected Co nanobars show magnetic frustration, so the magnetic moments interact through competing exchange interactions that cannot be satisfied at once. We have obtained, due to the topology of the honeycomb structure, artificial spin ice arrays, since Co nanomagnets are geometrically frustrated and they have to obey the so-called Pauling rules (in-out ice rules) (1). Remarkably, in each vertex of the honeycomb nanostructure two well defined charged magnetic Néel walls develop. They are linked to -1/2 magnetic semi-vortices induced by the honeycomb topology. On the other hand, magnetic periodic pinning potentials induce distinctive features in the superconducting vortex dynamics (2). We have experimentally identified the honeycomb vertex +1/-1 magnetic charges as the magnetic pinning potentials which yield matching effects between the magnetic charge unit cell and the superconducting vortex lattice; that is, when the superconducting vortex lattice matches the +1 or -1 magnetic charge unit cell minima appear in the magnetoresistance, since the superconducting vortex lattice motion slows down at commensurability conditions. Once, we have single out the origin of the magnetic/superconducting interaction we focus on the magnetic characteristic of the honeycomb vertex. These vertices contain two charged magnetic Néel walls. Consequently, asymmetric magnetic pinning potentials are present. In this situation, the superconducting vortex lattice dynamics probes the asymmetric magnetic pinning potentials. Therefore, a ratchet effect develops (3). That is; an alternating force applied on the superconducting vortex lattice yields a net motion of the vortex lattice. In summary, an input alternating current (ac) generates an output dc voltage and a rectification effect is obtained.

We thank Spanish MINECO grant FIS2016-76058, 'Severo Ochoa' Program for Centers of Excellence in R&D (SEV-2016-0686), CAM grant S2013/MIT-2850 and EU COST (NANOCOHYBRI) CA16218.

[1] A. Pushp *et al.* Nat. Phys. 9, 505 (2013).
[2] M. Velez *et al.* J. Magn. Magn. Mat. 320, 2547 (2008) and references therein.
[3] J. E. Villegas *et al.* Science 320, 1188 (2003).

Mapping the spin distribution in adsorbed molecules

Rodolfo Miranda[1,2]
[1] *IMDEA Nanociencia, Cantoblanco, 20760 Madrid, Spain*
[2] *Departamento de Física de la Materia Condensada, Instituto Nicolás Cabrera e IFIMAC, Universidad Autónoma de Madrid, Cantoblanco, 28760 Madrid, Spain.*

Creating an ordered 2D array of objects with protected magnetic moments deposited at surfaces, individually addressable and with potentially controlled interactions between their spins is highly desirable for different quantum technologies. Being able to visualize the distribution in space of the spins is a requirement to advance our knowledge and control of these systems. Below a certain temperature, a magnetic moment located at the surface can be screened by the electron sea of the substrate giving rise to a many body state known as Kondo resonance.

We present some selected examples to illustrate how by recording the spatial distribution of the sharp Kondo resonance at the Fermi level with Scanning Tunneling Spectroscopy at low temperatures one can visualize experimentally the spin distribution:

i) Spin distributed in a molecular orbital: isolated molecules of TCNQ/graphene/Ru(0001)[1]
ii) Spin localized in a bond: isolated molecules of F4-TCNQ/graphene/Ru(00101)[2]
iii) The turning on (and off) of localized magnetic moments by controlled, reversible reaction of an acceptor molecule (i.e. TCNQ) and a radical covalently bonded to graphene epitaxially grown on Ru(0001)[3,4]
iv) The controllable fabrication of a superconducting tip for the STM allows to explore the ultimate limit of resolution of the Kondo resonance in TCNQ molecules adsorbed on Pb-intercalated graphene grown on Ir(111), a substrate with a giant spin-orbit coupling.

[1] M. Garnica et al, Nature Physics 9, 368 (2013)
[2] M. Garnica et al, Surface Sci. 630, 356 (2014)
[3] J.J. Navarro et al, Nano Letters 16, 355 (2016)
[4] J.J Navarro et al, Chem. Comm. 53, 10418 (2017)

Vortex lattice instability at the nanoscale

G. Grimaldi[1], A. Leo[2], N. Martucciello[1], J.C. Villégier[3], E. Enrico[4], E. Monticone[4], A. Galluzzi[2,1], M. Polichetti[2,1], S. Pace[2,1], A. Nigro[2,1]
[1]*CNR-SPIN Salerno, via Giovanni Paolo II, 132, I-84084 Fisciano (SA), Italy*
[2]*Dipartimento di Fisica 'E. R. Caianiello' Università di Salerno, via Giovanni Paolo II 132, I-84084 Fisciano (SA), Italy*
[3]*CEA Grenoble, Grenoble F-38054, France*
[4]*I.N.RI.M. Istituto Nazionale di Ricerca Metrologica, Divisione Nanoscienze e materiali, Strada delle Cacce 91, Torino I-10135, Italy*

Vortex matter becomes unstable under extremely high driving forces. In superconducting materials, this instability can be observed in the current-voltage characteristics as an abrupt voltage jump to the normal state. Although a well established theory is able to predict such an instability in a defect-free conventional superconductor, real superconductors should be modeled in the presence of different pinning landscapes. We present an experimental study on submicron bridges of NbN and NbTiN ultra-thin films with a thickness of few nanometers. The films are patterned starting from microbridges, obtained by UV lithography, down to nanoscale restrictions of the width and length obtained by Electron Beam Lithography. The nanoscale geometry effect on vortex instability is investigated not only by more narrow width bridges, but also by changing the direction of the applied external field on these ultra-thin films. Indeed, measurements of critical currents as well as instability currents are performed in high-resolution magnetic field systems. The magnetic field is applied parallel and perpendicular to the c-axis samples. Both orientations show the vortex lattice instability, regardless of the superconducting material, and this becomes relevant for practical applications involving nanostructures.

Geometrically tunable spintronic platforms: towards curvatronics

Zu-Jian Ying[1,2], Paola Gentile[1,2], Carmine Ortix[3,4], Mario Cuoco[1, 2]
1CNR-SPIN, I-84084 Fisciano (Salerno), Italy
2Dipartimento di Fisica "E. R. Caianiello", Università di Salerno, Fisciano (Salerno), Italy
3Institute for Theoretical Solid State Physics, IFW-Dresden, Helmholtzstr. 20, D-01069 Dresden, Germany
4 Institute for Theoretical Physics, Center for Extreme Matter and Emergent Phenomena, Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands

Low-dimensional semiconducting nanomaterials have proven to be an ideal playground for the generation and manipulation of topological quantum states, which are at present at the centre of an intensive investigation. Apart from the conventional geometries, the most recent advances in nanotechnology have demonstrated the possibility to create flexible semiconductor nanomaterials which are bent into curved, deformable objects ranging from semiconductor nanotubes, to

nanohelices, etc. Motivated by the excitement in both topological states of matter and novel shape deformed nanostructures, we have explored the impact that nanoscale geometry [1] has on electronic, topological and superconducting properties of low-dimensional materials, showing the possibility to exploit the interplay between geometry, Rashba spin-obit coupling (RSOC) and superconductivity as a tool for the realization of novel platforms for spintronics and superconducting spintronics. By considering the paradigmatic example of quantum wires with RSOC, which are periodically corrugated at the nanometer scale [2], we show that geometric effects in low-dimensional nanomaterials can lead to metal-insulator transition and promote the generation of topological states of matter. Relevantly, such a system, under the application of a rotating magnetic field, can realize the Thouless topological pumping protocol in an entirely novel fashion [3]. We also show that, in shape deformed nanostructures, geometric curvature effectively acts like a spin-torque, twisting the electron spin, thus driving non-trivial spin textures, which in turn affect the electron spin interference in closed loop configurations [4].
We finally show that in the presence of superconductivity, the interplay between RSOC and shape deformations can lead to novel paths for an all-geometric manipulation of the superconducting state, both for spin-singlet and spin-triplet quantum configurations [5], as well as of the supercurrent in weak links between Rashba coupled superconducting nanowires with geometric misalignment [6].
[Acknowledgements: EU-FET OPEN project “CNTQC”, grant agreement N. 618083 (http://www.nano2qc.eu/)]

[1] P. Gentile, M. Cuoco, C. Ortix, SPIN, Vol. 3, No. 2, 1340002 (2013).
[2] P. Gentile, M. Cuoco, C. Ortix, Phys. Rev. Lett. 115, 256801 (2015).
[3] S. Pandey, N. Scopigno, P. Gentile, M. Cuoco, C. Ortix, Phys. Rev. B 97, 241103(R) (2018).
[4] Z.-J. Ying, P. Gentile, C. Ortix, M. Cuoco, Phys. Rev. B 94, 081406(R) (2016).
[5] Z.-J. Ying, M. Cuoco, C. Ortix, P. Gentile, Phys. Rev. B 96, 100506(R) (2017).
[6] Z.-J. Ying , M. Cuoco, P. Gentile, C. Ortix, 2017 16th International Superconductive Electronics Conference (ISEC), IEEE Xplore (2018).

Supermagnetoresistance of triplet spin-valves

Roberta Citro[1,2] and Francesco Romeo[1]
[1]*Dipartimento di Fisica, Università degli Studi di Salerno, Via Giovanni Paolo II, 132 -84084 Fisciano (Sa), Italy*
[2]*Spin-CNR, Research Unit of Salerno, Via Giovanni Paolo II, 132-84084 Fisciano (Sa), Italy*

We discuss the magnetoresistance of a spin valve with a triplet superconductor spacer between two ferromagnets with noncollinear magnetizations. We show that the magnetoresistance of the triplet spin valve depends on the relative orientations of the vector characterizing the superconducting order parameter and the magnetization directions. For devices with a long superconductor, a spin polarized current sustained by Cooper pairs is observed. In this regime, a supermagnetoresistance effect emerges for the chiral symmetry of the order parameter [1], differently from a conventional spin-valve with an s-wave superconductor spacer [2]. These findings open new perspectives in designing spintronics devices based on the interplay of ferromagnetic and triplet correlations.

[1] F. Romeo and R. Citro, Phys. Rev. Lett. 111, 226801 (2013).
[2] F. Romeo and R. Citro, Phys. Rev. B 84, 024531 (2011).

SESSION 8

Conductive AFM of 2D materials and heterostructures for nanoelectronics

F. Giannazzo[1], G. Greco[1], F. Roccaforte[1], R. Yakimova[2], C. Mahata[3], M. Lanza[3]
[1] CNR-IMM, Strada VIII, 5, 95121 Catania, Italy
[2]IFM, Linköping University, Linköping, Sweden
[3] Institute of Functional Nano & Soft Materials, Soochow University, Collaborative Innovation Center of the Ministry of Education 199 Ren-Ai Road, Bld. 909, Office 3215, Suzhou, 215123, China

Two-dimensional materials (2DMs) are currently the object of wide interests both from a basic and a technological standpoint. In electronics, they have been considered, to date, to replace one or more components of currently employed device structures (like the FET), as well as to demonstrate novel device concepts, based on the stacking of different 2DMs or on their integration with 3D semiconductors [1]. Progresses in devices technology have been fostered by the advances in large-area growth of 2DMs by semiconductor-industry-compatible approaches, like chemical vapour deposition (CVD), molecular beam epitaxy (MBE) or atomic layer deposition (ALD).

As a matter of fact, 2DMs electronic properties are strongly dependent on the growth methods, on the substrates where they are grown, as well as on post-growth processes required to integrate these materials for devices fabrication. As an example, peculiar nano- or micro-scale defects/inhomogeneities (e.g. grain boundaries, thickness fluctuations, wrinkles,..) are related to the morphology and structural/chemical properties of the substrate and to the specific nucleation/growth mechanisms. Clearly, these local electrical and structural inhomogeneities are reflected in the final behaviour of electronic devices.

In this context, nanoscale resolution electrical characterization of 2DMs by scanning probe methods is essential to get a complete understanding of their macroscopic electrical behaviour on a large area. In particular, conductive atomic force microscopy (CAFM) is the method of choice to investigate the mechanisms of current injection between contacts and 2DMs and/or the lateral homogeneity of 2DMs conductivity [2], as this technique allows performing high resolution current mapping and local current-voltage analyses at the nanoscale.

This presentation will provide an overview of CAFM applications to 2DMs for next generation micro- and nano- electronic devices, by discussing a number of relevant case studies:

(i) the lateral homogeneity of current transport in graphene grown by CVD or by thermal decomposition of SiC;

(ii) the Schottky barrier homogeneity of MoS_2;

(iii) the vertical current injection through 2D/3D or 2D/2D materials heterojunctions

(iv) the conduction mechanisms, lateral homogeneity and reliability of h-BN obtained by exfoliation from bulk crystals or by CVD on metals.

The results of the nanoscale electrical characterization will be correlated to device level measurements, thus providing an insight in the phenomena limiting the performances of 2DMs-based devices.

[1] F. Giannazzo, G. Greco, F. Roccaforte and S. S. Sonde, Crystals 8, 70 (2018).
[2] F. Giannazzo, G. Fisichella, G. Greco, P. Fiorenza, F. Roccaforte, in “Conductive Atomic Force Microscopy: Applications in Nanomaterials” (Ed: M. Lanza), WILEY-VCH Verlag, Weinheim 2017, Ch. 7, pp. 163– 186. ISBN: 978-3-527-34091-0.

Nanostructured materials for optoelectronics

Paola Barbara
Department of Physics, Georgetown University (USA)

Atomically thin materials like graphene and transition metal dichalcogenides have emerged as a versatile platform to study physics in reduced dimensions and for applications in ultra-thin electronics on flexible substrates. They are particularly suitable for optoelectronics, due to their direct bandgap (for monolayer semiconducting TMDs) and their considerable light absorption. For a gapless material like graphene, light absorption occurs in a wide energy range, including ultraviolet, visible, telecom and terahertz radiation, a region of the electromagnetic spectrum where highly sensitive detection is notoriously difficult. Light absorption in graphene causes a large increase in electron temperature, making it an ideal material for hot-electron bolometers. Nanostructuring graphene into quantum dots introduces an energy gap due to quantum confinement, while still preserving broadband detection and yielding extraordinary performance. I will review our recent work on the realization of these highly-sensitive detectors and their applications.

Direct-write X-ray nanopatterning for oxide materials

M. Truccato[1,2], L. Mino[3], V. Bonino[1,2], F. Picollo[1,2], M. Fretto[4], A. Agostino[3], C. Prestipino[5],
1. Department of Physics, University of Torino, via Giuria 1, 10125, Torino, Italy
2. I.N.F.N., Sezione di Torino, via Giuria 1, 10125 Torino Italy
3. Department of Chemistry, University of Torino, via Giuria 7, 10125, Torino, Italy
4. INRiM, Strada delle Cacce 91, 10135, Torino, Italy
5. Institut Sciences Chimiques de Rennes, UMR-CNRS 6226, Campus de Beaulieu, Université de Rennes 1, 35042, Rennes, Cedex, France

The recent development at synchrotrons of nanofocused hard X-ray beams with high power densities has paved the way to the exploitation of radiation-induced damage in order to locally modify the electronic properties with a spatial resolution in the nanometer domain.
In the case of the high-temperature superconducting oxides $Bi_2Sr_2CaCu_2O_{8+\delta}$ (Bi-2212) and $YBa_2Cu_3O_{7-\delta}$ (Y-123), whose properties highly depend on the non-stoichiometric oxygen content δ, the photon damage has been studied and exploited to fabricate devices based on the intrinsic Josephson junctions of Bi-2212 single crystals. This result has been achieved by means of a beam at 17.5 keV about 50 × 50 nm^2 in size and with a photon flux of the order of 10^{10}-10^{11} photons per second, in an experimental setup that also allows device on-line monitoring during fabrication [1, 2]. This has been the first example of direct-writing X-ray nanopatterning (XNP) of an electronic device. Although the microscopic mechanism for the material damage is not fully understood yet, we have detected an increase of the c-axis length that is compatible with some oxygen loss from the crystal, which, under some special circumstances, could be ascribed to photogenerated electrons knocking on the Bi-2212 interstitial oxygen atoms and modifying their amount δ. Moreover, nano-XRD maps have revealed the formation of mosaic domains whose misalignment increases with increasing the irradiation dose.
Finally, XNP has been recently demonstrated also in a more conventional transition metal oxide like TiO_2. We have been able to directly write conducting channels between two Au electrodes on top of TiO_2 rutile single crystals with a nanobeam at 17.4 keV, modifying the device resistance by 4 orders of magnitude. All of these findings represent a potential breakthrough for the whole class of functional oxides, enabling the fabrication of novel devices via XNP, which could be advantageous in terms of device heat dissipation and of its native 3D structure.

[1] M. Truccato et al., Nano Lett., 2016, 16, 1669
[2] L. Mino, et al., Scientific Reports, 2017, 7(1), 9066

Work function of stressed suspended graphene

A. Volodin[1], C. Van Haesendonck[1], O. Leenaerts[2], B. Partoens[2], F. M. Peeters[2]

1 KU Leuven, Afdeling Vaste-stoffysica en Magnetisme, Celestijnenlaan 200D, BE-3001 Leuven, Belgium
2 Universiteit Antwerpen, Departement Fysica, Groenenborgerlaan 171, BE-2020 Antwerpen, Belgium

The influence of mechanical strains on the electronic properties of graphene may turn out to be crucial in achieving the ultimate goal to build all-graphene circuits. Appropriately designed strain patterns should then provide the backbone of such circuits. Mapping of the work function (WF) distribution in such graphene structures is essential for fully understanding the relation between mechanical strains in graphene and its electronic properties.
We report on WF measurements on graphene, which is exfoliated over a predefined array of wells in silicon oxide, by Kelvin probe force microscopy operating in vacuum [1]. The obtained graphene sealed microchambers are able to support large pressure differences, providing controllable stretching of the nearly impermeable graphene membranes. Measuring in vacuum practically excludes the impact of uncontrolled ambient humidity and provides much more accurate values of the contact potential. Our measurements allow detecting variations of the WF induced by the mechanical stresses in the suspended graphene where the WF varies linearly with the strain and changes by 62 ± 2 meV for 1 percent of strain. Our related ab initio calculations result in a WF variation larger by a factor of 1.4 than the experimental value. The limited discrepancy between theory and experiment can be accounted for by a charge transfer from the unstrained to the strained graphene regions.

[1] A. Volodin, C. Van Haesendonck, O. Leenaerts, B. Partoens, and F. M. Peeters, Appl. Phys. Lett. 110, 193101 (2017)

SESSION 9

Interaction of epitaxial graphene with heavy metals: towards novel sensing platform

Rositsa Yakimova, Ivan Shtepliuk, Maria Francesca Santangelo, Mikhail Vagin, Tihomir Iakimov and Jens Eriksson
Department of Physics, Chemistry and Biology, Linköping University, SE-58183, Linköping, Sweden

Here we examine the possibility of using graphene as a sensing platform for rapid detection of Cd, Hg and Pb.

Based on DFT simulations and advanced electrochemical measurements, we provide comprehensive insights into the detection mechanisms of heavy metals by epitaxial graphene on SiC.

We fabricated two different sensors for direct measurements of the metal concentrations in aqueous solutions and employed two different sensing concepts:

(i) 3-electrode electrochemical cell, exploits graphene as working electrode. According to voltammetry and chronoamperometry measurements, the graphene electrode exhibits enhanced adsorption capacity to Lead compared to other heavy metal species. This is confirmed by the appearance of sharp redox peak for Pb ions with detection limit of 2 mg/L, which is significantly lower than the WHO permissible limit of 10 mg/L for Pb in drinking water. It was found that the initial kinetics of the Pb species is governed by the three-dimensional diffusion-controlled instantaneous nucleation mechanism with low diffusion coefficient, while the mercury and cadmium deposition can be described by a model involving progressive nucleation with quite high diffusion and low energy barriers.

(ii) Lateral graphene resistance enabling real-time monitoring of the changes in graphene conductivity after interaction with metals. Real-time response of the epitaxial graphene sensor to liquid-phase solutions containing Pb2+ ions was tested. It was revealed that the current across the graphene resistor supported by SiC substrate increases rapidly even with small concentration of the target metal ions. The response/recovery speed of the heavy metals sensor was very fast, within 10/60 seconds.

The calculated adsorption energy of Pb2+ ion is 7.5 eV, which is significantly larger than that of neutral Pb atom (0.3 eV). Thus, we suggest that the sensing mechanism of epitaxial graphene is governed by the physisorption of neutral Pb atoms in the case of graphene electrode and chemisorption of divalent Pb ions in the case of graphene resistor. We report on the direct connection of calculated parameters (binding energy, charge transfer, Fermi level, and work function) to the sensitivity of the graphene-based devices and discuss the implications for heavy metal sensing.

Our results clearly pointed to the viability of epi-graphene on SiC for developing a novel sensing platform.

When 2D materials meet molecules: molecular functions in hybrid van der Waals heterostructures

Marco Gobbi[1,2], Emanuele Orgiu[2,3], Paolo Samorì[2]

1 Centro de Fisica de Materiales (CSIC-UPV/EHU), Paseo Lardizabal, 5 – E-20018 San Sebastián, Spain

2 University of Strasbourg, CNRS, ISIS, 8 allée Gaspard Monge, F-67000 Strasbourg, France

3 Institut National de la Recherche Scientifique (INRS), 1650 Boulevard Lionel-Boulet, J3X 1S2 Varennes, Canada

Van der Waals heterostructures, composed of vertically stacked inorganic 2D materials, represent an ideal platform to demonstrate novel device architectures and to fabricate on-demand materials.[1] The incorporation of molecules within these systems holds an immense potential, since an almost infinite variety of molecules can be designed and synthesized with predictable functionalities.[2]

Here, we show how molecular design can be exploited to modify intrinsic properties and confer new capabilities to 2D materials.

In a first work, we show that programmable 1D periodic potentials take place at the interface between ordered molecular layers and graphene, which might introduce anisotropy in the graphene band structure. The amplitude and sign of the potentials can be modified without altering their periodicity by employing different molecules. [3]

In a second work, we demonstrate how the photo-responsive nature of molecular switches can be conferred to the charge transport properties of 2D materials. In particular, photochromic molecules self-assembled on graphene and MoS2 generate atomically precise superlattices in which a light-induced structural reorganization enables control over the local charge carrier density.[4] Accordingly, novel device functionalities are demonstrated, including the photo-modulation of the threshold voltage in MoS2 and the use of spatially confined light irradiation to define reversible lateral heterojunctions.

These experiments provide a glimpse of the potential of combining 2D materials with molecular monolayers to build up novel multifunctional materials with unique properties.

[1] A. K. Geim, & I. V. Grigorieva, Nature 499, 419–425 (2013)
[2] M. Gobbi, E.Orgiu, P. Samorì, Adv. Mater. 30, 1706103 (2018)
[3] M. Gobbi et al. Nat. Commun. 8, 14767 (2017)
[4] M. Gobbi et al. Nat. Commun. 9, 2661 (2018)

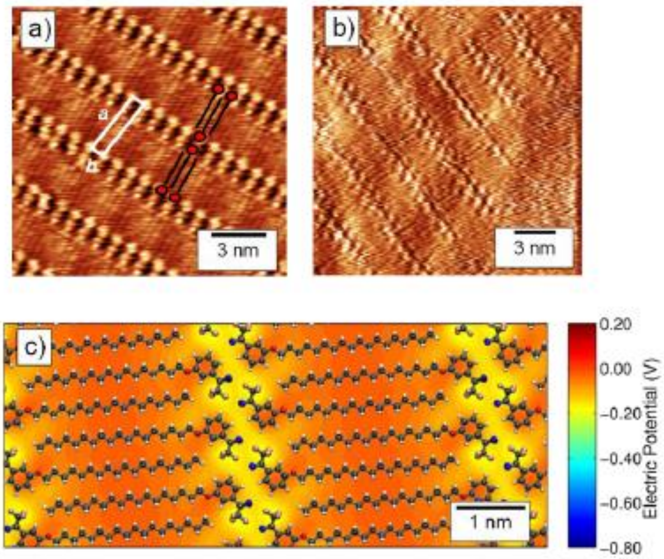


Fig. 1. (a, b) Scanning tunnelling microscopy image of ordered molecular monolayers on highly oriented pyrolytic graphite (a) and CVD graphene (b). (c) Electrostatic potential introduced onto the graphene by the ordered molecular monolayer, as calculated on the basis of the nanoscale assembly and of the doping introduced at the device level.

Saturday, October 20th

SESSION 10

Defects and Phase Transformations in Two-Dimensional Transition Metal Dichalcogenides

Arkady V. Krasheninnikov[1,2]
1 Helmholtz Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Germany
2 Department of Applied Physics, Aalto University School of Science, Finland

Following isolation of a single sheet of graphene, many other 2D systems such as hexagonal BN, transition metal dichalcogenides (TMDs) and silica bilayers were manufactured. All these systems contain defects and impurities, which may govern the electronic and optical properties of these materials. Moreover, defects can appear during the characterization of the materials in transmission electron microscope. All of these calls upon the studies on defect properties and mechanisms of their formation. In my talk, I will present the results [1] of our recent first-principles theoretical studies of defects (native and irradiation-induced) in inorganic 2D systems obtained in close collaboration with several experimental STM and TEM groups. I will further discuss defect- and impurity-mediated engineering of the electronic structure of inorganic 2D materials.

[1] https://users.aalto.fi/~ark/publist.html

Defect Engineering of 2D Materials by Particle Irradiation

R. Kozubek, L. Madauß, P. Ernst, and M. Schleberger
Fakultät für Physik and Cenide, Universität Duisburg-Essen, 47057 Duisburg, Germany

The exciting and often unusual properties of 2D materials are interesting from a basic research point of view but are also at the heart of many future applications. An important issue in this context are defects which will always be present in all 2D materials at finite temperatures and may affect the material properties in various ways. Because defects may be beneficial for certain applications or may even be a prerequisite for a given function, e.g.,
chemically active sites for catalysis [1] or well-defined pores for membrane-based applications [2], the development of efficient strategies for defect engineering has become indispensable [3]. A standard tool in materials science to artificially introduce defects into solids in a controllable way is the use of ion beams. In particular the use of swift heavy and highly charged ions offers both new challenges as well as opportunities (see e.g. [4-6]) some of which shall be discussed in this talk.

[1] G. Li et al., J. Am. Chem. Soc. 138 (2016) 16632
[2] O'Hern et al., ACS Nano 6 (2016) 10130

[3] Z. Li et al., Applied Physics Reviews, 4 (2017) 011103
[4] J. Hopster et al., 2D Materials 1 (2014) 1011011
[5] L. Madauß et al., 2D Materials, 4 (2017) 015034
[6] L. Madauß et al., Nanoscale 9 (2017) 10487
[7] R. Kozubek et al., ACS Applied Nano Materials (2018), doi.org/10.1021/acsanm.8b00903

Extreme nanostructuring of graphene

P. Bøggild, J. Caridad, B. S. Jessen, L. Camilli, G. Calogero, David M.A. Mackenzie, L. Gammelgaard, J. D. Thomsen, T. J. Booth, M. Brandbyge, A. P. Jauho, T. Booth
CNG – Center for Nanostructured Graphene, Technical University of Denmark

Unlike 3D materials, graphene uniquely allows the “bulk” of the crystal to be patterned by lithography. This is a huge opportunity to create circuits that use quantization of energy, charge and current by shaping the graphene at the nanoscale. Unfortunately, the transport properties of graphene are highly sensitive to the disorder, which is invariably the consequence of top-down fabrication. This has prevented and delayed the emergence of band-gap engineering of 2D materials for almost a decade. In this presentation I will show our recent progress in overcoming the challenge of nanostructuring graphene, without ruining the quality of the edges which the transport properties depend on.

Careful tuning of etching processes lead to strongly diminished edge roughness, which for the first time allowed us to observe the appearance of additional edge states in the quantum Hall effect of graphene nanoconstrictions, and the suppression of the quantized Landau levels[1], as well as ultra-dense (10 nm neck width) lattices with well-preserved mobility and a bandgap. High quality edges also opens for the possibility of creating stable, reversible molecular switches based on polar molecules attached to the edge of encapsulated graphene. I will discuss how nanolithography may eventually compete with self-assembly processes, such as our recent demonstration of graphene superlattices by in-plane synthesis of graphene-BCN superlattices[2]. Finally, I will discuss the possibility of realizing in-plane 2D scanning microscopes inside graphene, using focused beams of relativistic dirac fermions [3] to image nanoscale objects.

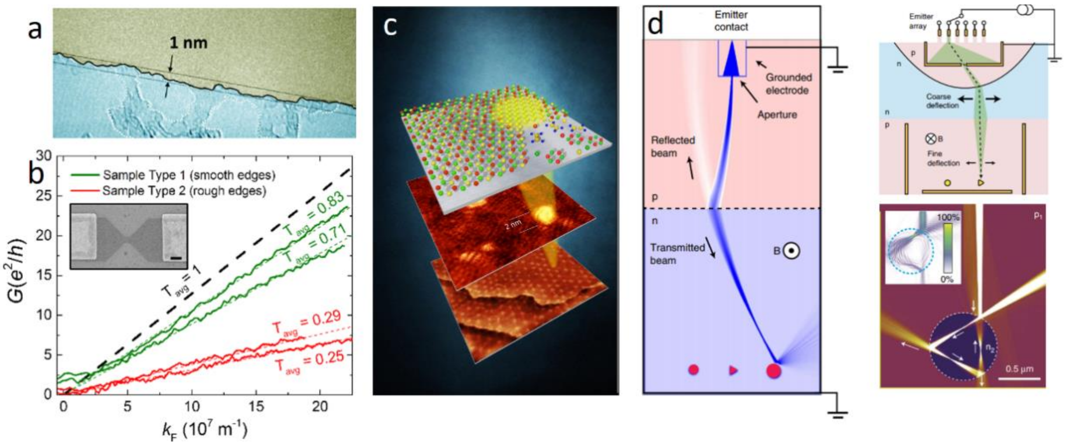


Figure 1. (a) graphene edge with 1 nm disorder, (b) increased transmission for low edge disorder[1], (c) 2 nm graphene-dots in a boron-nitrogen-carbon matrix[2], (d) Dirac fermion microscope concept with monte carlo and tight-binding simulations of image formation [3].

[1] Caridad et al, Nat. Comm., 9, 659 (2018)
[2] Camilli et al, Nat. Comm., 8, 47 (2017)
[3] Boggild et al, Nat. Comm, 8, 15783 (2017)

Gate-controlled chemical reactions at surfaces of two-dimensional materials

Ryo Nouchi[1,2]
[1]*Department of Physics and Electronics, Osaka Prefecture University, Sakai 599-8570, Japan*
[2]*PRESTO, Japan Science and Technology Agency, Kawaguchi 332-0012, Japan*

Two-dimensional (2D) materials that can be obtained by exfoliation of layered crystals are very sensitive to surface phenomena owing to their ultimate thinness. Their ultrathin body enables us to control the whole body by means of a field-effect-transistor (FET) configuration because the gate electric field is not completely screened. Thus, it is expected that surface phenomena are controllable by means of FETs with a channel of 2D materials. I will talk on such gate-controlled surface phenomena, especially on gate-controlled chemical reactions at 2D materials surfaces.

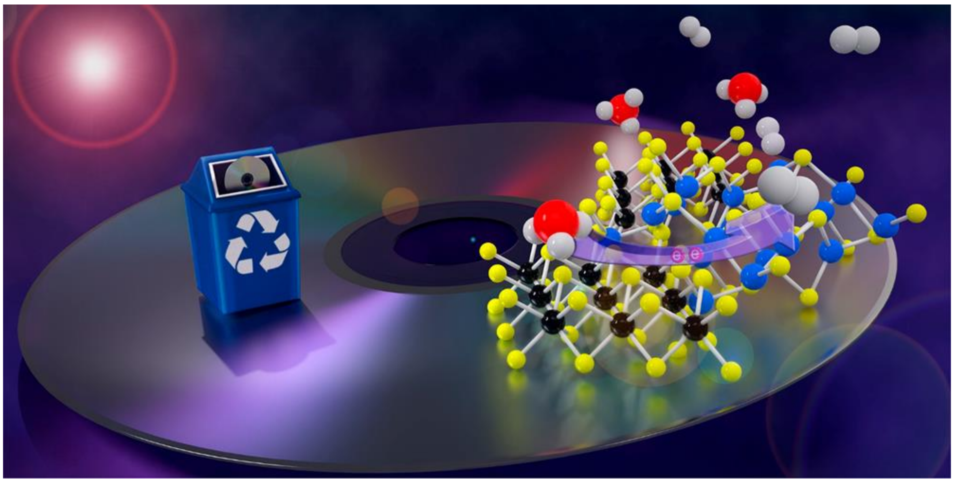
FET-related parameters such as the drain voltage and the gate voltage are shown to control surface chemical reactions. The drain voltage should raise the temperature of the 2D channel through Joule heat generation. The gate voltage can tune the charge carrier density/type in the 2D channel, and control surface adsorption phenomena by the gate electric field. If reactants come from the surrounding environment (e.g., oxygen molecules in oxidation reactions), the adsorption of the reactants onto 2D channels can be a rate-limiting process. In this case, we can control the whole reaction by controlling the adsorption process.

In this talk, such controllability of FET-related parameters will be discussed based on various surface reactions of mechanically exfoliated graphene flakes and catalytic reactions at surfaces of transition-metal oxide nanosheets.

Highly Efficient $MoS_2/Ag_2S/Ag$ Photoelectrocatalyst Obtained from a Recycled DVD Surface

Tomasz Kosmala, Dario Mosconi, Giuseppe Giallongo, Gian Andrea Rizzi and Gaetano Granozzi
Department of Chemical Sciences and INSTM Unit, University of Padova, Via F. Marzolo 1, 35131, Padova, Italy

The fabrication of efficient, stable, and cheap electrodes for electrochemical and photoelectrochemical production of H_2 is nowadays a very challenging and widespread research topic. Alternatives to platinum group metals (PGMs) are currently highly investigated since they have been put in the list of critical raw materials. Both Ag_2S and MoS_2 have been studied for quite a long time as efficient and convenient electrocatalysts for hydrogen evolution reaction (HER). Therefore, many efforts have been devoted primarily to the preparation of exfoliated MoS_2 materials (hereafter, 2D-MoS_2) to exploit their HER catalytic activity. However, if we want exploit the Sun energy to increment the efficiency of the HER process, the photoelectrocatalytic (PEC) approach must be pursued and in this case designing a composite catalyst is the principal issue.
An efficient photoelectrocatalyst for hydrogen evolution reaction (HER) was prepared by electrochemical deposition of MoS_2 on the Ag nanostructured surface of a commercial writable digital versatile disc (DVD). The deposition was performed by reduction of MoS_4^{2-} ions and the concomitant production of HS^- ions led to the formation of Ag_2S nanoparticles. The result was a composite material $MoS_2/Ag_2S/Ag$ characterized by the formation of uniformly distributed n−p nanojunctions that make the performances of this easy to prepare and cheap electrocatalyst comparable or better than those of similar MoS_2 based systems. This study suggests a viable opportunity to turn an abundant waste into an added-value material.



Acknowledgments: we thankfully acknowledge the support from the Italian Ministry of Foreign Affairs and International Cooperation (MAECI) for funding through cooperation project “GINSENG” (PGR00953) between Italy and China

SESSION 11

Electronic properties of one or few-layers MoS_2 films

Daniel J. Trainer[1], Yuan Zhang[2], Aleksei V. Putilov[1], Cinzia Di Giorgio[1], Marian Precner[2], Tomas Polaković[2], Qiao Qiao[3], Yimei Zhu[3], Xiaoxing Xi[1] , Fabrizio Bobba[1,5], Goran Karapetrov[2] , Saw Hla[2], Maria Iavarone[1]

1. Physics Department, Temple University, Philadelphia, PA, United States.

2. Center for Nanoscale Materials, Argonne National Laboratory, Lemont, IL, United States.

3. Physics Department, Drexel University, Philadelphia, PA.

4. Department of Condensed Matter Physics and Materials Science, Brookhaven National Laboratory, Upton, NY, United States

5. Physics Department, Salerno University, Salerno, Italy.

Atomically thin materials such as single layer Molybdenum Disulfide (MoS2) have emerged as promising candidates for next generation flexible 2D electronics.
We report on structural and electronic properties of defects in chemical vapor-deposited monolayer and few-layer MoS2 films. Scanning tunneling microscopy, Kelvin probe force microscopy, and transmission electron microscopy were used to obtain quantitative measurements of the local density of states, work function and nature and mobility of defects. These defects include point defects such as S and Mo vacancies as well as extended defects such as film edges and grain boundaries.
Furthermore, few studies to date have investigated the electronic properties of these materials as a function of applied strain. In this work we use low temperature scanning tunneling microscopy and spectroscopy (STM/STS) to elucidate the effect of strain on the quasiparticle band-gap of monolayer MoS2.

Funding Acknowledgement: Use of the Center for Nanoscale Materials, an Office of Science user facility, was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No.DE-AC02-06CH11357.
This work was supported as part of the CCDM, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science under Award #DE-SC0012575

Tellurium-Poly(methyl methacrylate) nanocomposite materials

A. Longo[1], M. Palomba[1], U. Coscia[2,3], G. Ambrosone[2,4], G. Carotenuto[1]
[1] *Institute for Polymers, Composites and Biomaterials, National Research Council, Piazzale E. Fermi 1, 80055 Portici (Na), Italy.*
[2] *Department of Physics 'Ettore Pancini', University of Naples 'Federico II', via Cintia, 80126 Napoli, Italy.*
[3] *CNISM, Naples Unit, via Cintia, 80126 Napoli, Italy.*
[4] *Superconducting and Other Innovative Materials and Devices Institute, National Research Council via Cintia, 80126 Napoli, Italy.*

Fine powders composed of tellurium grains of average size less than 10 nm were produced by dry vibration milling combined with liquid-phase sedimentation techniques, starting from polycrystalline powders with average grain diameter of ca. 30 µm. A novel nanocomposite material was obtained by binding the nanosized tellurium grains with poly(methyl methacrylate) (PMMA), using a solvent mediated method. The morphological, structural and electrical properties of Te/PMMA nanocomposite films were investigated. The Raman spectroscopy points out that the prepared material was composed of Te and TeO2 crystalline phases. Infrared spectroscopy analysis indicates that the milled powder contained an increased amount of tellurium oxide as compared to the "as received" powder. The electrical properties of the films were studied in dark condition and under white light illumination turning on and off the light cyclically. Te/PMMA nanocomposite films show a linear behavior of the photocurrent under white light illumination varying the optical power density of about three order of magnitude (2-1,608 mW/cm2). The observed photoconductivity properties [1-3] make the fabricated Te/PMMA material exploitable for plastic electronic applications [4].

[1] K. Oishi, K. Okamoto, and J. Sunada, Thin Solid Films, 148, 29 (1987)
[2] J. Sunada, K. Okamoto, K. Oishi, and S. Shimazu, Appl. Surf. Sci., 33/34, 434 (1988)
[3] J. Sunada, Y. Hashimoto, K. Oishi, and K. Fukuchi, Phys Lett A, 151, 447 (1990)
[4] E. Reichmanis, H. Katz, C. Kloc, and A. Maliakal, Bell Labs Technical Journal, 87, 10 (2005)

Influence of molecular oxygen on h-BN/metal heterostructures

Shevelev Victor, Bokai Kirill, Fedorov Alexander*, Vilkov Oleg and Usachov Dmitry

St. Petersburg State University, 7/9 Universitetskaya nab., St. Petersburg, 199034, Russia
**IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany*

Two-dimensional (2D) materials remain in the focus of intensive research directed towards their applications in future spintronics. It was shown theoretically that in order to inject highly spin-polarized current from ferromagnetic metal into graphene implementation of an insulating tunnel barrier is needed [1]. Nowadays, the most promising insulating layer for this purpose is an ultrathin hexagonal boron nitride (h-BN).

To date, the most notable heterostructure where the tunnel spin injection into graphene was directly demonstrated is based on the h-BN/Co interface [2]. Production of such heterostructures involves transfer of CVD-grown graphene on top of h-BN/Co system. During this process and further using the system inevitably gets in contact with molecular oxygen, so it is important to know how O2 molecules affect the h-BN/Co interface. Currently, interaction of molecular oxygen with h-BN/Co system remains completely unexplored.

Thus, in this work we demonstrate a comprehensive study of molecular oxygen reaction with h-BN on Co and Au surfaces, which possess different chemical activity and interaction with h-BN. For this purpose, two samples of h-BN were synthesized on Co(0001) substrate. Afterwards, Au intercalation was carried out under one of them. Both samples were annealed in oxygen atmosphere at temperature of 300C; after each stage of annealing XPS and NEXAFS spectra were measured. Data analysis shows that h-BN reacts with oxygen on both surfaces, but in different ways. Comparison of experimental data with DFT calculations allows us to propose following mechanism of h-BN oxidation on cobalt. Oxygen molecules penetrate between h-BN and Co, where they dissociate and active O atoms are further incorporated into h-BN lattice with substitution of N atoms.

In the case of h-BN/Au oxidation occurs much more slowly. Presence of Au monolayer under h-BN leads to significant decreasing of oxygen dissociation rate that results in low reactivity. Prolonged annealing leads to etching of h-BN. NEXAFS map at the edge of Co absorption shows forming of islands of cobalt oxide on the whole area in the field of view. We suppose that different mechanism of h-BN oxidation takes place; O atoms do not substitute N atoms inside h-BN lattice. We believe that in the case of h-BN/Au reaction proceeds mainly along the borders of h-BN layer. We suppose that at the areas of surface, where h-BN was etched, Au atoms form clusters and open the path to Co surface for oxygen.

This work was supported by Saint Petersburg State University Grant 11.65.42.2018 and RFBR Grant No. 17-02-00427 A.

[1] A. Fert *et. al.*, Conditions for efficient spin injection from a ferromagnetic metal into a semiconductor, *Phys. Rev. B*, 2001, 64, 184420.

[2] M. V. Kamalakar *et. al.*, Inversion of Spin Signal and Spin Filtering in Ferromagnet|Hexagonal Boron Nitride-Graphene van der Waals Heterostructures, *Scientific Reports*, 2016, 6, 1

The effect of Anodic Polarization and N_2O oxidization for graphene growth

Bo Liu[1], En-Yan Zheng[2], Chih-Hsien Hsu[1], Hanyuan Liang[1], Chienfeng Su[1], Asim Senapati[1], Chin An Huang[2*], Chao-Sung Lai[1,3,4,5*]

1.Department of Electronic Engineering, Chang Gung University, Guishan Dist., 33302, Taoyuan, Taiwan

2 Department of Mechanical Engineering, Chang Gung University, Taoyuan 33302, Taoyuan, Taiwan

3 Biosensor Group, Biomedical Engineering Research Center, Chang Gung University, Guishan Dist., 33302, Taoyuan, Taiwan

4 Department of Nephrology, Chang Gung Memorial Hospital, Guishan Dist., 33305, Linkou, Taiwan

5 Department of Materials Engineering, Ming Chi University of Technology, Taishan Dist., 24301, New Taipei City, Taiwan

The discovery of graphene open a new era of two-dimensional material. As the key member of two-dimensional family, graphene rises much attention due to its unique lattice and band structure, outstanding physical, chemical, and mechanical properties. While the nature of zero bandgap of graphene seems block its way toward next-generation nano-electronics[1]. But its week surface van der Waals interaction underwrite graphene as a unique role in the electronic devices. Recently, we report a graphen-based memristor, in which the on-off ratio is above 10^6 by taking the advantages of its unique lattice structure of graphene[2].

Another unique properties of graphene is the grain size tunable. Comparing to traditional material, such as Si, the grain size of graphene can be controlled during CVD process. The CVD growth graphene owns much more scalability and compatibility with conventional semiconductor fabrication process than the exfoliated one. While for the CVD growth graphene, the defects, disorder at grain boundaries regions will degrade the performance of graphene, causing a short range scattering[3]. So it is necessary to control the CVD growth conditions and control the graphene grain size properties.

In this study, we applied an anodic polarization techniques to polish and flatten the Cu surface and a N_2O gas flow before graphene growth to suppress the nucleation density of graphene sites. We note that the N_2O gas is semiconductor fabrication compatible, which served as an inert gas of metal post annealing.

[1] Liu, B.; Chiu, I.; Lai, C. Improvements on Thermal Stability of Graphene and Top Gate Graphene Transistors by Ar Annealing. Vaccum 2017, 137, 8–13.

[2] Liu, B.; Liu, Z.; Chiu, I.; Di, M.; Wu, Y.; Wang, J.; Hou, T.; Lai, C. Programmable Synaptic Metaplasticity and below Femtojoule Spiking Energy Realized in Graphene-Based Neuromorphic Memristor. ACS Appl. Mater. Interfaces 2018, 10 (24), 20237–20243.

[3] Liu, B.; Yang, C.; Liu, Z.; Lai, C. N-Doped Graphene with Low Intrinsic Defect Densities via a Solid Source Doping Technique. nanomaterials 2017, 7 (10), 302.

Effect of the structural parameters on the nature of the states of quasiperiodic superlattices

Y. Sefir , Z. Aziz , Z.F. Meghoufel, S. Terkhi, A. Zitouni, and S.Bentata
Laboratoire de Technologie et des Propriétés du solide, Université Abdelhamid Ibn Badis, BP 227,27000 Mostaganem, Algérie

We numerically studied the effect of the structural parameters on the nature of the states of quasiperiodic superlattices of Fibonacci by the formalism of the matrix transfer. We are interested in $GaAs/Al_xGa_{1-x}As$ superlattices, where *x* aluminium molar fraction. Periodicity introduced induced into the spectrum of the transmission a fragmentation of the principal minibande in several subminibandes separated by bandgaps from different widths. Each subminibande contains singular localised states. It is a direct consequence of the destructive interferences of the electronic waves on the walls of the barriers because the aperiodicity to introduce cheeks the role of a defect destroying the periodicity of the system.

Keywords: Formalism of the matrix transfer- $GaAs/Al_xGa_{1-x}As$ superlattices- Aluminium molar fraction *x*- Singular localised states.

[1].Z.Aziz, S. Bentata, R. Djelti and Y. Sefir, *Solid state Communication* 150, 865-869 (2010).
[2].Z.Aziz, Y. Sefir, R.Djelti, B. Bouadjemi and S. Bentata, *IEEE Conference Proceeding, Electronics, Communications and Photonics Conference* (SIECPC) (2013).
[3].Yamina sefir, Zoubir Aziz, Redouan Djelti, Bouabdellah Bouadjemi, Samir Bentata ,Superlattices and Microstructures,S0749-6036(13)00244-9(2013).

MoS_2 and WSe_2 in field effect transistors

A. Di Bartolomeo[1,2], F. Giubileo[2], A. Grillo[1,2], L. Iemmo[1,2], G. Luongo[1,2], F. Urban[1,2]
[1]*Physics Department, University of Salerno, Salerno, Italy*
[2]*CNR-SPIN, CNR, Salerno, Italy*

Transition-metal dichalcogenides, such as MoS_2 or WSe_2, have recently become very popularfornext-generation electronic devices and sensors as alternative or complement to graphene. Such materials offer remarkable properties, which include layer-dependent bandgap, intrinsic n- or p-type conduction, strong light interaction, good mechanical strength, etc. Monolayer MoS_2 and WSe_2 have direct bandgap and enable field-effect transistor with high On/Off current ratio and strong photoresponse. A drawback is the low carrier mobility, in the order of few tens $cm^2V^{-1}s^{-1}$ on substrate, and the sensitivity to oxygen, water or other adsorbates, which make unprotected devices rather unstable. Here, we discuss the current-voltage (I-V) characteristics at high drain bias of monolayer MoS_2 transistors with Schottky contacts [1]. We show that oxidized Titanium contacts, due to a long air exposure, form rectifying junctions on MoS_2 and cause asymmetric output characteristics, which we explain in terms of two slightly asymmetric back-to-back Schottky barriers. We show that, the highest current arises from image-force barrier lowering at the electrically forced junction, while the reverse current is due to Schottky-barrier limited injection at the grounded junction. We demonstrate that features commonly observed in MoS_2 transistors, such as persistent photoconductivity and hysteresis in the transfer characteristic, are peculiarities of the MoS_2 channel rather than effects of the contacts. We use transistors with ohmic contacts, at low drain bias, to deeply investigate the photoconductive and photogating effects [2]. We point out that the photoconductivity can persist with a decay time longer than 10^4 s, due to photo-charge trapping in extrinsic and intrinsic defects, which are also the cause of hysteresis. We highlight the important role of intrinsic donor-like defects.Finally, we demonstrate n-type conduction in WSe_2 transistors that, combined with the low workfunction of WSe_2, we exploit for field emission applications [4]. We show that the field emission current from a WSe_2 flake can be modulated by a back gate, thus enabling a new field emission transistor.

[1] A. Di Bartolomeo et al., Advanced Functional Materials 28 (2018), 1800657
[2] A. Di Bartolomeo et al., Nanotechnology 28 (2017), 214002
[3] A. Di Bartolomeo et al., 2D Materials 5 (2018), 015014
[4] F. Urban et al., Nanomaterials 8 (2018), 151

Poster session

P01 Half-metallic completely compensated ferrimagnets in Cr doped BaP

Bouabca Asmaa[1], Rozale Habib[1], Sayede Adlane[2], X.Twang[3]
[1]*Condensed Matter and sustainable development Laboratory (LMCDD), University of Sidi Bel-Abbes, Sidi Bel-Abbes 22000, Algeria*
[2]*UCCS, CNRS-UMR 8181, Université d'Artois, Faculté des Sciences Jean Perrin, Rue Jean Souvraz, SP 18, 62307 Lens Cedex, France*
[3] *School ofPhysics and Electronic Engineering, Chongqing Normal University, Chongqing 400044, PR China*

On the basis of ab-initio calculations we have investigated the electronic and magnetic properties of $Cr_{1-x}Ba_xP$ alloy, our calculations suggest that as we dope BaP with Cr atoms and move towards $Cr_{1-x}Ba_xP$ where x=0, 0.125, 0.25, 0.50, and 0.75 all alloy are HM-FM. Interestingly $Cr_{0.25}Ba_{0.75}P$ is a HM-AFM otherwise 'fully compensated ferrimagnet', this alloy should be of special interest for applications since it creates no external stray field and thus exhibit minimal energy losses. In addition, the robustness of half-metallicity with respect to the variation of lattice constants of $Cr_{1-x}Ba_xP$ is also discussed; moreover ferrimagnetism co-exists with the half-metallicity, resulting in the desired fully compensated half-metallic ferrimagnetism, for a wide range of lattice constants. Furthermore we found that this new HMFCF is stable according to its small formation energy.

P02 Compensation Point in Amorphous Gd_xFe_{1-x}-films

G. Avallone[1], A. Ferrentino[1,2], V.Granata[1], J. Aarts[2], C. Cirillo[1], and C. Attanasio[1]

[1]*Dipartimento di Fisica "E.R. Caianiello"and CNR-SPIN Salerno, Università degli Studi di Salerno, Fisciano (Sa) I-84084, Italy*
[2]*Huygens-Kammerlingh Onnes Laboratory, Leiden University, the Netherlands*

Amorphous ferrimagnetic thin films composed of rare-earth and transition metals are well known for their useful technological applications [1-4]. Among these materials, Gd_xFe_{1-x}, has significant properties and advantages, such as a large magnetization density, as well as the possibility to tune the compensation temperature, T_{comp}, the coercive field, H_c, and the saturation magnetization, M_{sat}, by changing both the composition, x, and the thickness, t [5-7]. Thanks to these properties, Gd_xFe_{1-x} is often used in domain wall junctions or magneto-optical memories [1, 3, 4]. Recently, new insights into the all-optical magnetization switching (AOS) phenomenon in Gd_xFe_{1-x} were provided [8].

Therefore, coupling Gd_xFe_{1-x} to a conventional superconductor in a layered structure could give the possibility to modify the superconducting state through the AOS effect, if T_{comp} is of the order of few Kelvin.

Thin films of amorphous Gd_xFe_{1-x} were deposited by co-sputtering technique using a DC magnetron sputtering system. In order to tune the value of T_{comp} of Gd_xFe_{1-x}, several samples with different t and x were fabricated by changing the deposition parameters. Since it is very important to control accurately the Gd_xFe_{1-x} composition, electron diffraction spectroscopy was used to determine the value of x and to calibrate the fabrication process. Moreover, X-ray diffraction measurements were performed to check the absence of crystallinity of the alloy. The magnetic behavior as a function of the temperature was studied by using a SQUID magnetometer from room temperature down to 2 K. Samples with x ≈ 28% and t = 35 nm have a value of T_{comp} that fits our purpose. Indeed, the magnetization as a function of temperature approaches to zero for temperatures below 10 K, while the H_c temperature dependence shows a peak in the same temperature range. Finally, $Gd_{28}Fe_{72}$/Nb bilayers were successfully deposited and a preliminary superconducting characterization was performed.

[1] N. Imamura, C. Ota, Jpn. J. Appl. Phys. 19, L731 (1980).
[2] K. Aoshima, et al., J. Disp. Technol. 11, 129 (2015).
[3]S. Mangin, et al., Phys. Rev. B 58, 2748 (1998).
[4] N. Nishimura, et al., J. Appl. Phys. 91, 5246 (2002).
[5] M. Urner-Wille, K. Witter, J. Magn. Magn. Mater. 13, 77 (1979).
[6] Z. Shen, et al., In Proceedings of the Fifth International Symposium on Optical Storage, Shanghai, China, 22–26 May 2000.
[7] S. Sugano, N. Kojima, Magneto-Optics; Springer: Tokyo, Japan (2011).
[8] L. Le Guyader, et al. Phys. Rev. B 93, 134402 (2016).

P03 Low-temperature response of oxide interfaces to pulsed gate voltage and light illumination

C. Barone[1], C. Mauro[1,2], A. Safeen[3], A. Sambri[3], E. Di Gennaro[3], U. Scotti di Uccio[3], F. Miletto Granozio[3], S. Pagano[1]

[1] Dipartimento di Fisica "E.R. Caianiello" and CNR-SPIN Salerno, Università di Salerno, I-84084 Fisciano, Salerno, Italy

[2] Dipartimento di Ingegneria, Università del Sannio, I-82100 Benevento, Italy

[3] Dipartimento Scienze Fisiche and CNR-SPIN, Università di Napoli "Federico II", Compl. Univ. di Monte S. Angelo, Via Cintia, I-80126 Napoli, Italy

Two-dimensional electron gases (2DEGs) at oxide interfaces show a large variety of functional properties of major physical interest, including a high low-temperature mobility, superconductivity, a large Rashba spin-orbit coupling, an exceptionally large spin-to-charge conversion efficiency and a yet controversial magnetic response. Furthermore, such properties are tunable under external control parameters, as widely investigated in the case of field effect. Here, it is studied the peculiar low-temperature electric transport behavior of the 2DEG formed at the LGO/STO oxide interface, under the combined application of field effect and light. For the first time, it is shown that, by suitably applying a gate voltage pulse, a metastable insulating conducting state can be induced in the sample, and that such state can be erased by light. A wide temperature range has been investigated, making possible, therefore, a comparison of the experimental observations in different temperature regions. The results are interpreted in terms of electrostatic interaction between two sets of mobile and localized carriers, where external perturbations may dynamically transfer electrons between one set and another.

P04 Interaction of graphene/Co interface with oxygen

Kirill Bokai, Viktor Shevelev, Dmitry Marchenko*, Alexander Fedorov**, Dmitry Usachov
St. Petersburg State University, 7/9 Universitetskaya nab., St. Petersburg, 199034, Russia
** Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany*
*** IFW Dresden, P.O. Box 270116, 01171 Dresden, Germany*

Numerous graphene synthesis methods have been developed during the past decade to provide high-quality graphene layers. Among them, chemical vapor deposition (CVD) on catalytically active metals holds great promises for a large-scale graphene synthesis. Despite extensive efforts to increase the quality of graphene layers, formation of defects is unavoidable and leads to the degradation of the graphene properties [1]. This motivates further efforts to tune the CVD process for increasing the size of grains. Despite significant progress, more work is required to control the microstructure of CVD-grown graphene. Efficient visualization of grain boundaries will significantly facilitate studies in this direction. Typical techniques to image the structure of graphene grain boundaries are either quite complicated or have very limited capabilities [2]. Recently a promising method based on graphene treatment in oxygen plasma was suggested [3]. However, plasma is very reactive; it oxidizes graphene and generates plenty of redundant defects. Thus, we were aimed to develop a simple method for visualization of grain boundaries and other defects in graphene based on its reaction with molecular oxygen at elevated temperatures.

For this we performed a systematic spectroscopic (X-ray photoelectron spectroscopy) and microscopic investigation of interaction of molecular oxygen with polycrystalline and oriented graphene, synthesized on Co substrate. We have found that in the case of polycrystalline graphene intercalation occurs even at room temperature. At elevated temperatures polycrystalline graphene can be completely intercalated with oxygen while oriented graphene — only partially. This is accompanied by a gradual destruction of graphene layers due to etching, which mainly takes place at the grain boundaries and defects. Also, intercalation leads to charge doping of graphene and its work function changes notably. This fact and controllable etching has allowed to effectively visualize grain boundaries and defects using photoemission and scanning electron microscopy (PEEM and SEM).

These results benefit deep understanding of the oxygen interaction with graphene/Co interface at different pressures and temperatures. This gives a platform for efficient visualization and characterization of defects in graphene.

This work was supported by DFG-SPbU (Grant No. 11.65.42.2017) and RFBR (Grant No. 17-02-00427).

[1] A.W. Tsen et al., *Tailoring electrical transport across grain boundaries in polycrystalline graphene*. Science 336, 1143 (2012).
[2] K. Kim et al., *Grain boundary mapping in polycrystalline graphene*, ACS Nano 5, 2142 (2011).
[3] Jong-Young Lee et al., *Direct observation of grain boundaries in chemical vapor deposited graphene*. Carbon 115, 147 (2017).

P05 Carbon Nanorods Synthesized by Graphite Oxide Thermal Reduction with Microwaves

G. Carotenuto[1], A. Longo[1], M. Palomba[1], G. Ambrosone[2,3], U. Coscia[2,4]
1 Institute for Polymers, Composites and Biomaterials - National Research Council (IPCB-CNR). UOS Napoli/Portici, Piazzale E. Fermi, 1-80055 Portici (NA), Italy.
2 Department of Physics 'Ettore Pancini', University of Naples 'Federico II', via Cintia, 80126 Napoli, Italy.
3 SPIN, National Research Council via Cintia, 80126 Napoli, Italy.
4 CNISM, Naples Unit, via Cintia, 80126 Napoli, Italy.

Recently, carbon nano-rods (CNRs) have been investigated for potential applications as support for catalytic metal nanoparticles, in gas storage, electrochemical energy storage, etc. [1]. The CNRs consist of stacked graphene sheets with aspect ratios ranging from 3 to 5 and their functional properties arise from quantum-confinement and surface effects [1]. These materials have been produced by different techniques, like for example arc discharge, plasma torch, CVD, nanocasting, etc. [1]. In this work, CNRs have been obtained as byproduct of the graphene synthesis made by thermal reduction of graphite oxide (GO), using microwave heating [2]. In particular, water solutions of GO have been synthetized according to the Hummers method and dried to give GO paper. This solid material has been dissolved in N-methyl-2-pyrrolydone (NMP) by a prolonged ultrasound treatment and the achieved GO/NMP solution has been heated to the solvent boiling point (202°C) in a microwave oven. In a few minutes the solution turned into a black graphene/NMP suspension and by a filtering procedure a graphite/NMP gel and a reddish CNRs/NMP solution have been obtained. The CNRs have been recovered by solvent removal and purified by washing with ethanol. The purified product has been morphologically characterized by transmission electron microscopy (TEM). According to the TEM micrographs shown in Figure 1, CNRs have length of several hundred nanometers (300-600 nm) and height less than 100 nm. The excitation-emission properties of these nanostructures were investigated by florescence spectroscopy.

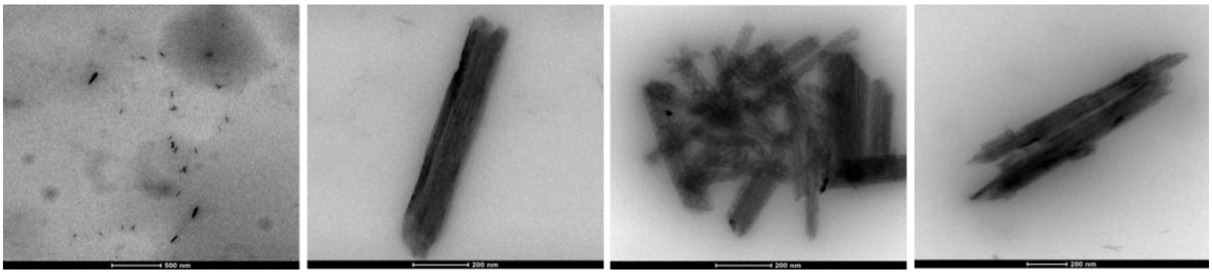


Fig. 1 – CNRs resulting from the thermal reduction of GO/NMP solution by microwave.

[1] P. Pachfule, D. Shinde, M. Majumder, Q. Xu, “Fabrication of carbon nanorods and graphene nanoribbons from a metal-organic framework”, Nature Chemistry, Vol. 8 (2016)718-724.

[2] A. Longo, G. Carotenuto, “Graphene oxide reduction by microwave heating”, AIP Conference Proceedings 1736, 020164 (2016).

P06 Superconducting critical temperature in NbRe/Co bilayers

C. Cirillo[1], M. Caputo[1], G. Divitini[2], J. W.A. Robinson[2], and C. Attanasio[1]
[1]*CNR-SPIN Salerno and Dipartimento di Fisica “E.R. Caianiello”, Università degli Studi di Salerno, Italy*
[2]*Department of Materials Science and Metallurgy, University of Cambridge, United Kindom*

It is now generally accepted that the combined presence of Spin Orbit Coupling (SOC) and magnetic field can give rise to unconventional superconducting pairing. In particular, there are theoretical evidences that SOC can act as a generator of long-ranged spin triplet pairs in superconductor/ferromagnetic (S/F) hybrids [1,2]. In the literature the physics arising either when the SOC and the exchange field coexist in the F layer [1,2], or in presence of interfacial SOC [2-4] are usually explored.
In this work we present instead results obtained on NbRe/Co bilayers, where NbRe ($Nb_{0.18}Re_{0.82}$) is a non-centrosymmetric superconductor with a significant SOC [5,6]. Preliminary TEM investigation

of single NbRe films confirmed the homogeneous distribution of the atomic concentration ratio between Re and Nb through the film, as well as a sharp interface with the silicon substrate. M(H) measurements performed on NbRe/Co bilayers reveal a well-established magnetic properties and a magnetically dead layer of about 1.5 nm. Finally, we studied the behavior of the superconducting critical temperature (T_c) as a function of the thickness of the Co layer (d_{Co}), which reveals a very slow decay if compared to the well-known $T_c(d_F)$ dependence obtained in the case of conventional Nb/Co control samples.

[1] I.V. Tokatly and F.S. Bergeret, Phys. Rev. Lett. 110, 117003 (2013)
[2] H.T. Simensen and J. Linder, Phys. Rev. B 97, 054518 (2018)
[3] N. Baneriee, J.A. Ouassou, Y. Zhu, N.A. Stelmashenko, J. Linder, and M.G. Blamire, arxiv:1709.03504v2
[4] N. Satchell and N.O. Birge, arxiv: 1803.01965v2
[5] C. Cirillo, R. Fittipaldi, M. Smidman, G. Carapella, C. Attanasio, A. Vecchione, R.P. Singh, M.R. Lees, G. Balakrishnan, and M. Cuoco, Phys. Rev. B 91, 134508 (2015)
[6] C. Cirillo, G. Carapella, M. Salvato, R. Arpaia, M. Caputo, and C. Attanasio, Phys. Rev. B 94, 104512 (2016)

P07 VOC removal from recycled plastics on graphene-based adsorbents

Maria Sarno, Claudia Cirillo
Department of Industrial Engineering and Centre NANO_MATES University of Salerno
Via Giovanni Paolo II,132 - 84084 Fisciano (SA), Italy

During the processing of recycled plastics, undesired odour emissions, such as volatile organic compounds (VOCs), can occur. This restricts the indoor applications of recyclates. For this reason, it is necessary to reduce the VOCs emissions during processing of recycled plastics. VOCs consist in a wide range of carbon-based substances which quickly evaporate at low temperatures [1].
Most effective methods for VOCs removal consists in adsorption on porous solids. Amongst adsorbent materials, graphene and graphene-based materials possess excellent adsorption properties especially thanks to their extremely high specific surface area which can even reach 2000 m^2/g, making these materials the best alternative to activated carbons [2].
On the other hand, catalytic oxidation is a very efficient and economic method to completely remove the VOCs adsorbed, by oxidizing them into CO_2, water and other less odorous compounds. Catalysts used for the oxidation of VOCs can be classified into three major groups: (i) noble metals catalysts [3]; (ii) non-metal oxide catalysts [4] and (iii) mixed-metal catalysts [5]. Metal oxide based catalysts are cheaper and more resistant to poisoning, but they are less durable and less efficient compared to supported noble-metal catalysts in the

oxidation of VOCs [6].
Typically, the catalyst is deposited on a suitable support. Moreover, in the case of noble metals, because of they are highly expensive, a combination with a more economic support, such as a graphene-based material, may achieve both reduced costs and high dispersion of the catalyst, i.e. higher catalytic activity.
In this work, to exploit the advantages of metals and metal oxides, we report the removal of VOCs emitted from recycled plastics by means of the adsorption on graphene, prepared by the liquid phase exfoliation of graphite in Nmethylpyrrolidone [7], and oxidation of the adsorbed substances by metal/metals oxide nanohybrid catalysts loaded into the adsorbent.
Our results, allowing the adsorption and conversion/removal of molecules responsible for bad smells in the processing of recycled plastics, showed that the approach is an innovative alternative to the traditional VOCs treatment techniques.

[1] Kamal et al., Atmospheric Environ. 2016, 140, 117-134.
[2] Son et al., J. Hazard. Mater. 2016, 301, 27−34.
[3] Tsou et al., 2005, Appl. Catal. B Environ. 57, 117−123
[4] Garcia et al., 2010, Appl. Catal. A Gen. 386, 16−27.
[5] Garcia et al., 2006. Appl. Catal. B Environ. 62, 66−76.
[6] Bastos et al., 2009. Appl. Catal. B Environ. 93, 30−37.
[7] Guadagno et al., 2015, RSC Adv.,5, 27874−27886.

P08 A Nanoscale Signature of Mott Transition in Ca_2RuO_4

Ofelia Durante[1], Cinzia Di Giorgio[1,2], Domenico D’Agostino[1], Rosalba Fittipaldi[2], Veronica Granata[1,2], Antonio Vecchione[2], Anna Maria Cucolo[1,2], and Fabrizio Bobba[1,2]

1. *Dipartimento di Fisica “E.R. Caianiello”, Università degli studi di Salerno, Fisciano (Sa), Italy*
2. *CNR- SPIN , Fisciano (SA), Italy*

Recently, the Mott insulator Ca_2RuO_4 (CRO) has been shown to undergo a metal to insulator transition (MIT) driven by both temperature and electric field. When driven by the temperature, the metallization of CRO takes place above 357 K, whereas a certain electric field threshold has been shown to be responsible for room temperature insulator-metal switching [1]. In both cases, the MIT is accompanied by a structural transition: the c-axis unit cell elongates from 11.9Å – insulating state - to 12.3Å – metallic state.

Here, we want to investigate the relation between electric field, current flow and structural deformation in CRO crystals, at the nanoscale, by using atomic force microscopy (AFM) and its derived techniques, such as Conductive-AFM (C-AFM). In particular, we acquire AFM force-distance curve and current at the same time, while locally applying a DC voltage. During a force-distance curve, the AFM probe moves toward sample surface until the reciprocal interaction sets in. At this point, the AFM probe pushes against the surface up to a force setpoint (of the order of nN), while simultaneously measuring the current. By keeping the probe in contact with the surface, changes in cantilever deflection (due to possible topographic deformation) and current can be monitored for a fixed time. We check the surface topography, by AFM imaging, after each force-distance curve, acquired at several different DC biases. We found that morphological deformations occur when current flows into the sample. Finally, by measuring the height of the deformation by AFM, we can estimate the number of atomic cells involved in the process and the portion of the crystal affected by the electric field.

[1]Fumihiko Nakamura, Mariko Sakaki, Yuya Yamanaka, Sho Tamaru, Takashi Suzuki & Yoshiteru Maeno, "*Electric-field-induced metal maintained by current of the Mott insulator* Ca_2RuO_4*",* Scientific Reports 3, 2536 (2013)

P09 Pinning energy and anisotropy properties of a Fe(Se,Te) iron based superconductor

A. Galluzzi[1,2], K. Buchkov[3], E. Nazarova[3], V, Tomov[3], G. Grimaldi[2], A. Leo[1,2], S. Pace[1,2] and M. Polichetti[1,2]

1.Department of Physics "E.R. Caianiello", University of Salerno, via Giovanni Paolo II, 132, Fisciano (SALERNO), I-84084, Italy

2.CNR-SPIN Salerno, via Giovanni Paolo II, 132, Fisciano (SALERNO), I-84084, Italy

3Georgy Nadjakov, Institute of Solid State Physics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria

The measurements of DC magnetization M as a function of magnetic field (H) and time (t) have been performed in order to study the superconducting and pinning properties of a Fe(Se,Te) iron based superconductor fabricated by means of the Bridgman technique and showing the presence of twin boundaries responsible of the appearance of a second magnetization peak effect. In particular it has been evidenced that the crossover from a weak pinning regime to a strong pinning regime causes the trigger of this peak phenomenon. By performing the superconducting hysteresis loops M(H) at different temperatures in the case of perpendicular field, the critical current density Jc(H) has been extracted in the framework of the Bean critical state model. The Jc(H) curves have shown the presence of the second magnetization peak effect that causes an anomalous increase in the field dependence of the critical current density. Moreover, in order to obtain the anisotropy of the sample, we have also performed M(H) measurements in parallel field at the same previous temperatures. Analogously we have extracted the Jc(H) curves and compared with the perpendicular field ones. In particular, performing the ratio between perpendicular and parallel critical current density values , we have collected the sample anisotropy values and compared with the literature ones. The information regarding the pinning energy U have been extracted by means of the relaxation of the irreversible magnetization M(t). In particular, performing relaxation measurements at different temperatures and magnetic fields, the temperature dependence of the pinning energy U(T) at different magnetic fields has been obtained. The presence of a maximum in the U(T) curves suggests a pinning crossover at a given field and temperature Hcr(T). The Hcr(T) values have been linked with the end of the Jc(H) growth that corresponds to the disappearance of the peak effect phenomenon.

P10 Spin-selected currents in ferromagnet-superconductor-ferromagnet heterostructures

Alfonso Romano, Marilena Catapano, Paola Gentile and Canio Noce
CNR-SPIN, I-84084 Fisciano (Salerno), Italy
Dipartimento di Fisica "E. R. Caianiello", Università degli Studi di Salerno, I-84084 Fisciano (Salerno), Italy

Heterostructures made of ferromagnetic (FM) and superconducting (SC) alternating layers exhibit a variety of peculiar phenomena occurring at the nanoscale range of layer thicknesses [1]. Thanks to the great progress in the preparation of high-quality hybrid FM/SC systems achieved in the last years, their properties have been deeply investigated in view of the design of new devices susceptible of relevant applications in the field of electronics and spintronics. The interest in the above-mentioned systems is however not limited to this context. Under specific conditions, their behavior may provide relevant information on the type of ferromagnetism characterizing the FM layer [2] as well as on the symmetry of the order parameter in the superconductor, allowing to distinguish among different superconducting pairing states [2]. Interference effects at the interfaces of FM/SC/FM double-barrier junctions are expected to lead to even richer physics. Transport properties of FM/SC/FM junctions have been so far investigated by assuming for the FM layers Stoner-like models where the bands associated with the two possible electron spin orientations have the same dispersion and are rigidly shifted in energy by the exchange interaction [3]. Given the complexity of the forms in which the phenomenon of ferromagnetism manifests itself in metals, we have analyzed the above systems referring to scenarios different from the Stoner one. Among them, we consider a form of itinerant ferromagnetism driven by a gain in kinetic energy stemming from a spin-dependent band-width renormalization [4]. The analysis is performed considering a suitable generalization of the Bogoliubov-de Gennes equations, where a possible spin-dependence of the electronic masses is explicitly taken into account. We show that appreciable differences between the effects induced by the two mechanisms responsible for the metallic ferromagnetism emerge in particular in the case of intermediate and high values of the magnetization, in the proximity regime as well as in the tunnelling one. They concern the behavior at low and zero bias of the reflection and transmission probability coefficients, which gives rise in the case of mass spin-asymmetry and non-orthogonal injection to an inversion of the magnitude of the spin-resolved contributions to the conductance. Such an inversion is not observed when standard Stoner ferromagnets are considered. This result may be relevant in connection with the design of electronic devices where the control of the spin of the carriers is required.

[1] A. I. Buzdin, Rev. Mod. Phys. 77, 935 (2005); F. S. Bergeret, A. F. Volkov, and K. B. Efetov, Rev. Mod. Phys. 77, 1321 (2005); J. Linder and J. W. A. Robinson, Nature Phys. 11, 307 (2015)
[2] G. Annunziata, M. Cuoco, C. Noce, A. Romano, and P. Gentile, Phys. Rev. B 80, 012503 (2009); G. Annunziata, M. Cuoco, P. Gentile, A. Romano, and C. Noce, Phys. Rev. B 83, 094507 (2011).
[3] Z. C. Dong, R. Shen, Z. M. Zheng, D. Y. Xing, and Z. D. Wang, Phys. Rev. B 67, 134515 (2003).
[4] J. E. Hirsch, Phys. Rev. B 59, 6256 (1999); M. Cuoco, P. Gentile, and C. Noce, Phys. Rev. Lett. 91, 197003 (2003).

P11 GO/Fe_3O_4/SO_3H Nano-Catalysts for Waste Cellulose Conversion

M. Sarno, M. Iuliano
Department of Industrial Engineering, University of Salerno, Via Giovanni Paolo II, 132, 84084, Fisciano (SA), Italy.
NANO_MATES, Research Centre for Nanomaterials and Nanotechnology at the University of Salerno, University of Salerno, Via Giovanni Paolo II, 132, 84084, Fisciano (SA), Italy.

The progressive depletion and price fluctuation of fossil resources are promoting a shift from fossil to renewable materials in the feedstock for the production of energy, fuels, and chemicals. Nowadays, only about 5% of all the produced chemicals derived from renewable resources. On the other hand, lignocellulose and cellulosic biomass, hitherto underutilized, can be converted into value-added chemicals by acid hydrothermal treatment. This route represents a sustainable solution to increasing demand of these chemicals, allowing the security of supply, and bringing economic advantage, in particular when cheap raw materials, agricultural waste, or residue are employed as substrates. Hydrolysis of cellulose is a way to successfully abstract simple and defined chemical building blocks. Various methods, including mineral acid-catalyzed hydrolysis, and hydrolysis in supercritical water, have been reported to promote the hydrolysis of cellulose. However, some distinct drawbacks are present in these traditional methods such as the corrosion of reactors and harsh reaction conditions, which limits the practical utility. The use of heterogeneous catalysts may overcome the above-mentioned drawbacks. Recently, hydrolysis of cellulose over heterogeneous catalysts has been widely investigated [1-3]. Although heterogeneous catalysts are often recycled more easily than their homogeneous counterparts, the tedious recovery procedure via filtration or centrifugation and the inevitable loss of solid catalysts in the separation process still limited their application, particularly

for the small nanosized particles. Magnetic nanoparticles (MNPs) based catalysts have recently been receiving growing attention, as they can be readily separated from the reaction mixture by a permanent magnet.
Here, we report the potential use GO/Fe_3O_4/SO_3H Nano-Catalysts to convert waste cellulose in value-added chemicals.
GO/Fe_3O_4/SO_3H nanoparticles have been synthesized in a single step, and for hydrolysis in a new experimental apparatus, consisting in an autoclave, which permits to work in an inert atmosphere and to easily carry out spillages during the hydrolysis to monitor the process. The effects, reaction time, concentration and temperature on the hydrolysis were investigated.

[1] R. Rinaldi, R. Palkovits, F. Schüth, *Angew. Chem. Int. Ed.* 47 (2008) 8047–8050.
[2] I.-J. Kuo, N. Suzuki, Y. Yamauchi, K.C-W. Wu, *RSC Adv.* 3 (2013) 2028–2034.
[3] R.R. Singhania, A.K. Patel, R.K. Sukumaran, C. Larroche, A. Pandey, *Bioresour. Technol.* 127 (2013) 500–507.

P12 Laser-induced Topological Phase in Graphene

Hamed Koochaki Kelardeh, Vadym Aplakov, Mark Stockman
Center for Nano-Optics (CeNO), Georgia State University, USA

Strong circularly polarized field of an ultrashort optical pulse compels motion of graphene electrons in the momentum space in closed trajectories. When such a trajectory passes close to a Dirac point (where the valence and conduction bands of graphene touch), the electron has a high probability of excitation to the conduction band. Applying a pulse with two optical periods, one forces an electron to pass twice in the vicinity of the Dirac point. These events interfere quantum mechanically forming fringes in the reciprocal space. Rotating around the Dirac point, an electron acquires an additional phase, the so-called Berry phase.
In our previous study (PRB 93, 155434), we have proposed a self-referenced interferometry in the reciprocal space of graphene. However, because the Berry phase is $\pm\pi$, the corresponding self-referenced interference term carries a double phase, $\pm 2\pi$, which is equivalent to zero and not observable directly, albeit one can see an indirect effect of the Berry phase momentum distribution of electrons as bifurcations of fringes at the interferogram which are characteristic of vertices (e.g., Fig.2 the above-mentioned paper).
Here we propose an approach to directly observe the Berry phase without the involvement of the magnetic field. The idea is to use a superlattice superimposed on graphene to cause electron diffraction (Bragg reflection from the superlattice) in the reciprocal space. That causes the self-referenced phase to be different from $\pm 2\pi$ and, therefore, to be observable directly by the reciprocal space interferometry. Such an interferogram can be read out using attosecond pulses produced by

high harmonic generation. This allows studying attosecond dynamics of electrons related to the topological properties of the system.

P13 Magnetic instabilities caused by α-Fe2O3 microbeads on the MgO/CoFeB/Ta/CoFeB/MgO surface

O. Koplak[1], A. Bezverhnii[1], R. Morgunov[1,2]
1.Institute of Problems of Chemical Physics, Chernogolovka, Moscow, Russia
2.Baltic Federal University, Kaliningrad, Russia

The GMR heterostuctures were proposed and applied for measurements of concentration of magnetically labelled cells [1, 2]. Magnetic nanoparticles are bound to studied molecules in a biological system and they affect GMR platform magnetization by scattering local magnetic field. Magnetization affects electrical conductivity of sensors and generates correspondent response of electronics. The recording of kinetics of protein–magnetic tag complexes fixed on the sensor surface becomes possible by GMR sensor resistivity. The MgO/CoFeB/Ta/CoFeB/MgO GMR platforms manifesting perpendicular magnetic anisotropy [3, 4] were used in our experiments. The α-Fe2O3 microbeads of ~ 1 µm size containing nanoparticles of 50 nm radius were deposited on the surface of the platforms (Fig. 1a, b). Sensor surface was scanning by magnetic force microscope allows us to distinguish the role of nucleation of phase reversal, statistical distribution of particles and their effect on magnetic properties of the sensor.

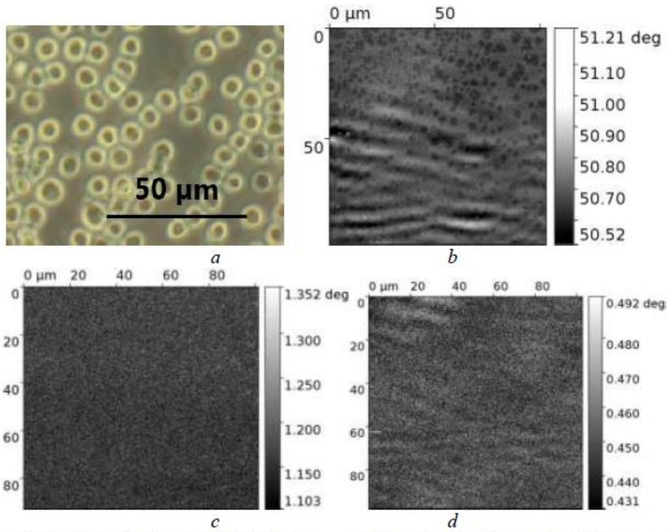


Fig.1. Optical (a) and MFM (b) images of the microbeads on the GMR sensor and MFM images before before MNPs deposition (c), after their removal by ultrasonic cleaning (d).

The optical images as well as AFM and MFM scans of the GMR sensor allowed one to distinguish separated microbeads (Fig. 1a, b). No magnetic inhomogeneity was found before micro deposition in any parts of platforms (Fig. 1c). After MNPs deposition well distinguished wave-like inhomogeneity was found (Fig.1b). Large scale ~ 4-5 µm period of the wave-like magnetic instabilities of the ferromagnetic films induced by ferromagnetic microbead deposition were observed on the surface of the platform.

Ultrasonic cleaning of the sensors removes large scale magnetic inhomogeneity as well as MFM images of the microbeads (Fig.1d). Multiple repetition of deposition-cleaning procedures evidently showed good reproducibility of the wave-like magnetic instabilities. Stray fields of the NPs are able to generate local obstacles and change magnetization processes in CoFeB thin film. Magnetic scattering fields of the ferromagnetic microbeads captured in cells shift critical switching magnetic field controlled by competition between magnetic anisotropy, interlayer exchange coupling and Zeeman energy in synthetic ferrimagnet with perpendicular anisotropy. Authors are thankful to Prof. S.Mangin and Dr.Y.Lu for spin valve platforms put at our disposal and fruitful discussion and to L.Litvinova, O. Haziahmatova, for help with microbead deposition on the surface of the GMR sensor.

[1] C. Jiang, et al., J. Mater. Chem. C 5, 252-263 (2017).
[2] G. Li, et al., Sensors and Actuators A Phys. 126(1), 98–106 (2006).
[3] R. Morgunov, et al., Physical Review B 96, 054421 (2017).
[4] O. Koplak, et al., Journal of Magnetism and Magnetic Materials 433, 91-97(2017).

P14 Interplay between two type II superconductors at the nanoscale

V. Rollano[1,2], J. del Valle[3], A. Gomez[1,4], J. L. Prieto[5], E. Navarro[2], E.M. Gonzalez[1,2], I. K. Schuller[3], J.L. Vicent[1,2] , A. Muñoz-Noval[2]

1 IMDEA-Nanociencia, Cantoblanco, 28049 Madrid, Spain

2 Departamento Física de Materiales, Facultad CC. Físicas, Universidad Complutense, 28040 Madrid, Spain

3 Department of Physics, Center of Advance Nanoscience, University of California, San Diego, 9500 Gilman Drive, La Jolla, California 92093, USA.

4 Centro de Astrobiología (CSIC-INTA), Torrejón de Ardoz, 28850 Madrid, Spain.

5 ISOM-ETSIT, Universidad Politécnica de Madrid – 28040 Madrid, Spain

In the present work, we have fabricated a superconducting nano composite made up of two type II superconductors in order to study the interplay and competition between superconducting characteristic lengths and the dimensions of the superconducting elements.

The hybrid sample comprises an array of Niobium (Nb) nanotriangles embedded in a Vanadium (V) thin film. First, the array of Nb nanotriangles is defined on a Si substrate by electron beam lithography and grown by magnetron sputtering. Then, the V thin film is deposited by magnetron sputtering on top of the Nb array. Conventional lithography and etching techniques are used to define a cross-shaped bridge which allows carrying out transport measurements.

A study of superconducting vortex dynamics is performed below the superconducting temperature of both materials (4.84 K for Nb nanotriangles and 4.6 K for the V thin film) by means of magneto-transport measurements. In the mixed state, we have measured and analyzed the superconducting critical magnetic field, (I,V) curves, magnetoresistance and ratchet effect. These experimental data show the crucial role played by the interplay between both superconductors. The most interesting results are that we observe matching effect in the magnetoresistance curves but we do not observe Little-Parks oscillations and a well-defined vortex liquid phase.

P15 Conductivity of strongly disordered ultra-thin MoC superconducting films

P. Neilinger[1], M. Žemlička[1,2], M. Šindler[3], C. Kadlec[4], P. Szabó[5], P. Samuely[5], D. Manca[1] and M. Grajcar[1,6]

[1]Department of Experimental Physics, Comenius University, SK-84248 Bratislava, Slovakia,
2Institute of Science and Technology Austria, 3400 Klosterneuburg, Austria
[3]Institute of Physics, Czech Academy of Sciences, Cukrovarnická 10, 16253 Prague 6, Czech Republic
[4]Institute of Physics, Czech Academy of Sciences, Na Slovance 2, 18221 Prague 8, Czech Republic
[5]Centre of Low Temperature Physics, Institute of Experimental Physics, Slovak Academy of Sciences, SK-04001 Košice, Slovakia
[6]Institute of Physics, Slovak Academy of Sciences, Dúbravská cesta, Bratislava, Slovakia

Disordered superconductors are currently a subject of intense research, motivated by the appeal of dealing with the most fundamental issues of condensed matter physics, as well as by the high promise for their applications. Molybdenum carbide (MoC) is a highly disordered superconductor, in which the disorder rate can be conveniently tuned by the carbon content and/or by the film thickness, which accordingly leads to the suppression of the superconducting critical temperature and an increase of the sheet resistance. Above a critical sheet resistance, the films undergo a quantum phase transition to isolating state – Superconducting Insulator Transition [1][2]. We present an optimized deposition process of ultra thin MoC films for sample preparation with enhanced sheet resistance and high critical temperature T_c, characterized by transport measurement in the temperature range from 10K to 400mK. The critical temperature rise from 3.7K for film thickness $t \approx 3$ nm and sheet resistance $R_s \approx 900\Omega$ and saturates to 8.5K at $t \approx 30$nm ($R_s \approx 65\Omega$). The structure, stoichiometry and surface roughness of the prepared samples were analyzed by means of XRD, EDX and STM, determining that our samples are in cubic crystallographic δ-phase and have a surface with atomically smooth regions. Further, the equilibrium transmission measurements of the films were performed in a standard time-domain THz spectroscopy setup based on a femtosecond laser oscillator. We show, that the modified Mattis-Bardeen theory with introduced finite quasiparticle lifetime [3], τ, offers a good description of the experimentally observed complex conductivity. Furthermore, a comparison to the the Dynes phenomenological parameter Γ, obtained from STM below T_c, is given.

[1] S. J. Lee and J. B. Ketterson, Phys. Rev. Lett. 64, 3078 (1990)
[2] P. Szabó, Physical Review B 93, 014505 (2016)
[3] M. Zemlicka, Phys. Rev. B 92, 224506 (2015)

P16 Induced electron-hole triplet correlations in ferromagnet-BCS superconductor junctions

L. Di Lauro[1], P. Gentile[2], C. Noce[2]
[1]*Department of Physics and Astronomy,*
University of Sussex, Brighton, BN1 9RH, United Kingdom
[2]*CNR-SPIN, I-84084 Fisciano (Salerno), Italy and Dipartimento di Fisica "E. R. Caianiello",*
Università degli Studi di Salerno, I-84084 Fisciano (Salerno), Italy *

Quasiparticle reflection at an interface is at the heart of the quantum transport phenomenon in artificial structures [1]. The most famous electron reflection is the electron/hole Andreev reflection at a metal/superconductor interface. Although this mechanism can be either specular or retro-type, electron/electron reflection is limited to only the specular type. On the other hand, a hole of opposite spin is retro-reflected, creating a spin-singlet Cooper pair in the superconductor. When the metal is a ferromagnet, the ferromagnetic exchange energy can suppress the Andreev retroreflection [2]. Nevertheless, when the tunneling barrier acts as a spin-filter a retro-reflected hole it is found in the ferromagnetic side if its magnetization lies in a plane perpendicular to the barrier. Within this frame, an induced spin-triplet pairing correlation is produced in the ferromagnet side, as a consequence of the interplay between the ferromagnetic and superconducting phases [3].

We apply the extended Blonder, Tinkham, and Klapwijk formalism to a ferromagnetic/*s*-wave superconducting junction, and we solve the Bogoliubov-de Gennes equations considering an arbitrary magnetization strength and direction in the ferromagnet, and a spin-active barrier. Noticeably, as far as the ferromagnetic side is concerned, we assume that its ferromagnetic state can be due to a conventional Stoner mechanism, but also to an asymmetric mass renormalization of carriers of opposite spin [4]. Such spin bandwidth asymmetry is at the basis of the well-known double exchange mechanism originating within degenerate orbitals because of spin pairing caused by the Hund's rule. Moreover, an analogous mechanism of mass undressing for majority spins has been found by Hirsch to be responsible for itinerant ferromagnetism in systems with non-degenerate bands (as the one we consider), due to the interplay of Coulomb repulsion and the Pauli principle [5]. Thus, we calculate the conductance spectrum in the proximity regime as well as in the tunneling case comparing the effects rising from the conventional Stoner mechanism and the spin bandwidth asymmetry. We show that in the latter case interesting features emerge, suggesting remarkably application in the contest of spin-polarized spectroscopy.

[1] A. I. Buzdin, Rev. Mod. Phys. 77, 935 (2005).
[2] M. J. M. de Jong and C. W. J. Beenakker, Phys. Rev. Lett. 74, 1657 (1995).
[3] J. Linder and A. Sudbø, Phys. Rev. B 75, 134509 (2007).
[4] M. Cuoco, A. Romano, C. Noce, and P. Gentile, Phys. Rev. B 78, 054503 (2008); A. Romano, M. Cuoco, C. Noce, P. Gentile, and G. Annunziata, Phys. Rev. B 81, 064513 (2010); P. Gentile, M. Cuoco, A. Romano, C. Noce, D. Manske, and P. M. R. Brydon, Phys. Rev. Lett. 111, 097003 (2013); A. Romano, P. Gentile, C. Noce, I. Vekhter, and M. Cuoco, Phys. Rev. B 93, 014510 (2016).
[5] J. E. Hirsch, Phys. Rev. B 59, 6256 (1999).

P17 Low density polyethylene coated by graphene nanoplatelets

M. Palomba[1], G. Carotenuto[1], A. Longo[1], A. Di Bartolomeo[2], L. Iemmo[2], F. Urban[2], F. Giubileo[3], G. Ambrosone[4], U. Coscia[4,5]

1 Institute for Polymers, Composites and Biomaterials - National Research Council (IPCB-CNR). SS Napoli/Portici, Piazzale E. Fermi, 1-80055 Portici (NA), Italy.
2 Department of Physics 'E.R.Caianello',University of Salerno, Via Giovanni Paolo II, 132 - 84084 - Fisciano (SA), Italy.
3 Superconducting and Other Innovative Materials and Devices Institute - National Research Council (SPIN-CNR), Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.
4 Department of Physics 'Ettore Pancini', University of Naples 'Federico II', Via Cintia, I-80126 Napoli, Italy.
5 CNISM, Naples Unit, Via Cintia, I-80126 Napoli, Italy.

An advantageous micromechanical technique to deposit large area graphene nanoplatelet (GNP) thin films on a low-density polyethylene substrate is proposed. This method, based on the application of shear-stress and friction forces to a graphite platelets/ethanol paste on the surface of a polymeric substrate, allows to obtain films of overlapped nanoplatelets mainly made of 13-30 graphene layers. X-ray diffraction (XRD), atomic force and transmission electron microscopy (TEM) measurements support the occurrence of a partial exfoliation of the graphite platelets due to shear-stress and friction forces applied during film formation. Scanning electron microscopy (SEM) observations point out that the surface of the polymer is uniformly coated by GNP unities, and the TEM analysis reveals the tendency of the nanoplatelets to align parallel to the interfacial plane. It has been found that the deposited samples, under white light illumination, exhibit a negative photoconductivity and a linear photoresponse as a function of the applied voltage and the optical power density in the -120÷120 mV and 20.9÷286.2 $mWcm^{-2}$ ranges, respectively. These structural and electrical characteristics will be compared to those of LDPE films coated with thin layers deposited by spraying a commercial graphite-based product.

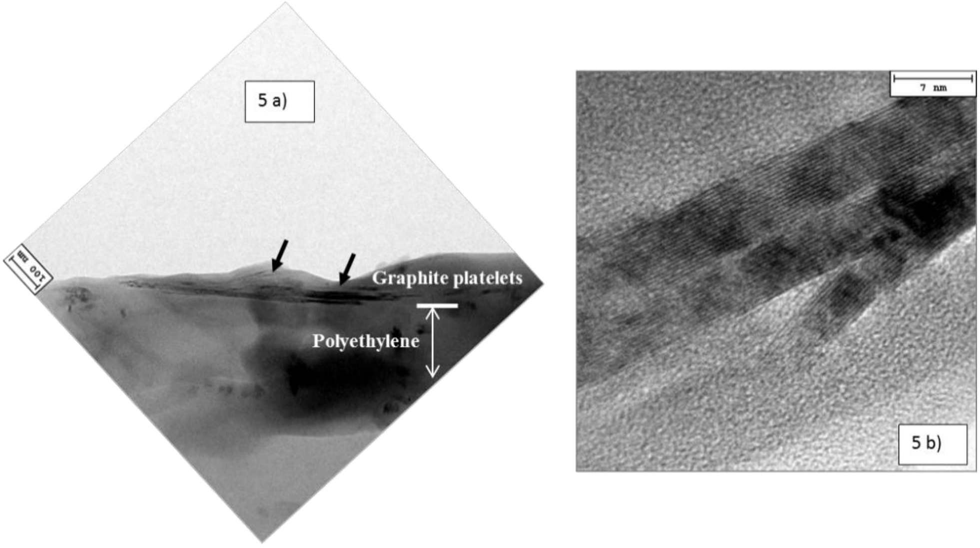


Fig. 1 - Cross sectional TEM micrographs of the graphene nanoplatelets-LDPE sample. The graphene nanoplatelets deposited on the LDPE surface is arrowed.

P18 Metal-Metal oxide nanostructures as a bifunctional electrocatalysts for simultaneous catalytic oxidation of hydrazine and hydroxylamine

Maria Sarno, Eleonora Ponticorvo

Department of Industrial Engineering and Centre NANO_MATES University of Salerno, Via Giovanni Paolo II ,132 - 84084 Fisciano (SA), Italy

A number of studies have been reported concerning the development of sensitive and fast detection of several toxic chemical compounds. Among them, hydrazine is a volatile toxic material which is widely used in industry as an antioxidant, emulsifier, photographic developer, corrosion inhibitor, explosives, pharmaceutical intermediate, dyes, pesticide and insecticide, chemical blowing agent, catalyst, rocket fuel, and plant growth regulator. Hydrazine exposure can be very dangerous for living organism at even very low concentrations (i.e. skin irritation, dermatitis, and lethal damage to the central nervous system, kidney and liver). Hydroxylamine is one of the intermediate products of nitrogen-cycle and a reducing agent widely used in industry and pharmacy. Modest levels of hydroxylamine can be toxic to humans, animals, and plants. Moreover, some hydroxylamine derivatives constitute a great part of anticancer drugs. There are some studies on hydrazine and hydroxylamine electrocatalytic determination alone at various modified electrodes. Also, there are a

few reports about the simultaneous determination of them using titration, chronopotentiometric and spectrophotometric methods. It is known that the oxidation peaks of hydrazine and hydroxylamine are nearly at the same potential, which results in an overlapped voltammetric response making their discrimination highly difficult. In addition, the electrochemical oxidation of hydrazine and hydroxylamine at bare electrode surfaces requires high-overpotentials. Ruthenium oxide nanoparticles [1] were used as a bifunctional electrocatalyst for simultaneous catalytic oxidation of hydrazine and hydroxylamine, founding acceptable results in term of RSD% and recovery rates, furthermore CuO/ZSM-5 [2] were also used for hydrazine and hydroxylamine oxidation presenting good electrocatalytic behavior (i.e. decrease in overpotential and increase in oxidation peak currents). Moreover it is still necessary to make further efforts for the fabrication of simple, rapid, selective, and sensitive electrochemical modified electrodes that can be used for simultaneous determination of the above-mentioned analytes in the presence of each other.
In this work, in the prospective that the catalytic activity of the nanostructures can be significantly improved when metal nanoparticles grow directly and simultaneously in electrode oxide substrate, exhibiting catalytic activity superior to that of pure metal or metal oxide catalysts, we have, for the first time, introduced a new excellent bifunctional nanoelectrocatalyst, based on ruthenium and iridium oxide with metallic inclusions, for the effective and simultaneous hydrazine and hydroxylamine oxidation in mixtures samples. The results display that the modified electrode successfully separates the electro-oxidation of these species into well-defined peaks, showing excellent sensitivity, wide linear range, low detection limit, better long-term stability and good reproducibility and selectivity.

[1] Zare et al., Anal. Chim. Acta 2010,668, 182–187.
[2] Rostami et al., New J. Chem. 2017,41, 13712–13723.

P19 Heterostructures Based on Epitaxial Oxide Thin Films

P. Prieto[1], M.E. Gómez[2]

[1] Excellence Center for novel Materials CENM, (www.cenm.org) Physics department Universidad del Valle, A. A. 25360, Cali, Colombia
[2] Thin Film Group, Physics department , Universidad del Valle, A. A. 25360, Cali, Colombia

Metal oxides show fascinating physical properties such as high temperature superconductivity, ferro- and antiferromagnetism, ferroelectricity or even multiferroicity. Progress in oxide thin film technology allows us to integrate these materials with semiconducting, normal conducting, dielectric, in complex oxide heterostructures. The combination of magnetic properties with dielectric, semiconducting, or ferroelectric materials in one and the same material (e.g. magnetic semiconductors (MS) or intrinsic multiferroics) as well as in artificial heterostructures (e.g. ferromagnetic/dielectric heterostructures for magnetic tunnel junctions (MTJs) or artificial multiferroic heterostructures) allows for the design of materials with novel functionalities. For many possible electronic applications as well as fundamental studies, it is essential to fabricate epitaxial layered structures of insulators, semiconductors or normal metals as well as magnetic layers together with high temperature superconductors (HTS). However, HTS materials have complex lattice structures and this makes difficult to grow multilayers with sharp interfaces, preserving epitaxiallity through the whole structure. Here we describe transport measurements and microstructural analysis of $YBa_2Cu_3O_{7-\delta}$/ $PrBa_2Cu_3O_{7-\delta}$ /$YBa_2Cu_3O_{7-\delta}$ (YBCO/PBCO/YBCO), $Bi_2Sr_2CaCu_2O_{8+\delta}$/$Bi_2Sr_2YCu_2O_{8+\delta}$ / $Bi_2Sr_2CaCu_2O_{8+\delta}$ (BSCCO/BSYCO/BSCCO) and $La_xCa_{1-x}MnO_3$/$YBa_2Cu_3O_{7-\delta}$ (FM/HTS) heterostructures deposited on (001) $SrTiO_3$ substrates by using an in situ DC sputtering technique at high oxygen pressures. Conductance measurements on this type of multilayers showed a clear quasiparticle tunneling indicating a gap structure around 25 mV in the case of YBCO compounds, 30 – 35 mV and a zero bias anomaly in the case of BSCCO materials. We will present also the Josephson behavior in heterostructures based on BSCCO compounds as well as the interplay between superconductivity and magnetism in superconductor/ferromagnetic heterostructures and superlattices. We report the study of the temperature dependence of magnetization and magnetotransport properties in [AF-LCMO(tAF)/F-LCMO(tF)]N superlattices grown"in situ" on (001)-oriented $SrTiO_3$ substrates via a high-pressure dc sputtering process. Recent results on the electric and magnetic properties of multiferroic $BiFeO_3$ and $YMnO_3$ thin films exhibiting both ferromagnetic and ferroelectric polarizations along with coupling between them will also be presented.

This research was supported by "El patrimonio Autónomo Fondo Nacional de Financiamiento para la Ciencia, la Tecnología y la Innovación Francisco José de Caldas" under contract RC-No. 275-2011 with the Excellence Center for Novel Materials (CENM)

List of participants

Aarts J.	Leiden University, The Netherlands
Abate S.	CNR-SPIN, Salerno, Italy
Amoruso B.	University of Salerno, Italy
Aprili M.	Université Paris-Sud, France
Arutyunov K.Yu.	HSE, Russia
Asmaa B.	LMCDD, Algeria
Attanasio C.	University of Salerno, Italy
Avallone G.	University of Salerno, Italy
Bakurskiy S. V.	Lomonosov Moscow State University, Russia
Barbara P.	Georgetown University, USA
Barone C.	University of Salerno, Italy
Beltram F.	Scuola Normale Superiore, Pisa, Italy
Birge N.O.	Michigan State University, USA
Bobba F.	University of Salerno, Italy
Bøggild P.	Technical University of Denmark, Denmark
Bokai K.	St. Petersburg State University, Russia
Carotenuto G.	IPCB-CNR, Portici, Italy
Casoli F.	IMEM-CNR, Italy
Cavaliere C.	Università di Genova, Italy
Cirillo C.	CNR-SPIN Salerno, Italy
Cirillo Cl.	University of Salerno, Italy
Citro R.	University of Salerno, Italy
Cucolo A.M.	University of Salerno, Italy
D'Apolito C.	University of Salerno, Italy
De Pasquale S.	University of Salerno, Italy
Di Bartolomeo A.	University of Salerno, Italy
Di Giorgio C.	University of Salerno, Italy
Di Marino V.	University of Salerno, Italy
Durante O.	University of Salerno, Italy
Eschrig M.	Royal Holloway, University of London, UK
Filatrella G.	University of Sannio, Italy
Fiorani D.	ISM CNR, Rome, Italy

Fusco Girar M. University of Salerno, Italy	University of Salerno, Italy
Galluzzi A.	University of Salerno, Italy
Garcia Corral A.	University of Grenoble, France
Gentile P.	CNR-SPIN, Salerno, Italy
Giannazzo F.	CNR-IMM, Catania, Italy
Giazotto F.	CRN-NANO, Pisa, Italy
Giubileo F.	CNR-SPIN, Salerno, Italy
Gobbi M.	Materials Physics Center, San Sebastian, Spain
Goldobin E.	University of Tübingen, Germany
Golubov A.A.	University of Twente, Enschede, The Netherlands
Gomez M.E.	Universidad del Valle, Colombia
Granozzi G.	University of Padova, Italy
Greene L.	National MagLab, USA
Grimaldi G.	CNR -SPIN Salerno, Italy
Guarcello C.	CRN-NANO, Pisa, Italy
Hänze M.	Max Planck Institute, Germany
Herrera Vasco E.	Universidad Autonoma de Madrid, Spain
Heun S.	NEST and Scuola Normale Superiore, Pisa, Italy
Hla S.W.	Argonne National Laboratory, USA
Iavarone M.	Temple University, USA
Iuliano M.	University of Salerno, Italy
Kalaboukhov A.	Chalmers University of Technology, Sweden
Kelardeh Koochaki H.	Georgia State University, USA
Koplak O.	Institute of Problems of Chemical Physics, Moscow, Russia
Krasheninnikov A.V.	Aalto University, Finland
Liu B.	Electronic department of Chang Gung University, Taiwan
Loffredo A.	CNR-SPIN, Salerno, Italy
Longo A.	IPCB-CNR, Portici, Italy
Martucciello N.	CNR-SPIN, Salerno, Italy
Maggio-Aprile I.	University of Geneva , DQMP, Switzerland
Manske D.	Max Planck Institute, Germany
Martucciello N.	CNR SPIN Salerno, Italy

Massarotti D.	Università Federico II di Napoli, Italy
Miranda R.	Universidad Autónoma de Madrid, Spain
Munoz Noval A.	Universidad Complutense de Madrid, Spain
Nappi T.	I.I.A.S.S., Italy
Neilinger P.	Department of Experimental Physics, Comenius University, Slovak Republic
Neu V.	Leibniz Institute for Solid State and Materials Research, Germany
Noce C.	University of Salerno, Italy
Nouchi R.	Osaka Prefecture University, Japan
Pace S.	University of Salerno, Italy
Pagano S.	University of Salerno, Italy
Palomba M.	PCB-CNR,Portici, Italy
Peddis D.	ISM-CNR, Monterotondo Scalo, Italy
Polichetti M.	University of Salerno, Italy
Ponticorvo E.	University of Salerno, Italy
Prieto P.	Universidad del Valle, Colombia
Rekab Djabri H.	ENPO, Algeria
Robinson J.	University of Cambridge, UK
Ryazanov V.V.	Moscow Institute of Physics and Technology, Russia
Sanvito S.	Trinity College Dublin, Ireland
Scarpa R.	University of Salerno, Italy
Schleberger M.	Universität Duisburg-Essen, Germany
Shevelev V.	Saint-Petersburg State University, Russia
Silhanek A. V.	Université de Liège, Belgium
Trainer D.J.	Temple University, USA
Truccato M.	University of Torino, Italy
Ustinov A.	Karlsruhe Institute of Technology, Germany
Vaglio R.	University of Naples, Italy
Vicent J. L.	Universidad Complutense de Madrid, Spain
Volodin A.	University of Leuven, Belgium
Wasio N.A.	*RHK Technology, Inc., USA*
Wenger C.	IHP GmbH , Germany
Yakimova R.	Linkoping University, Sweden
Yamina S.	Laboratory of Technology and of Solids Properties, Algeria
Zaikin A.D.	Karlsruhe Institute of Technology, KIT, Germany

Zasadzinski J. Illinois Institute of Technology, USA