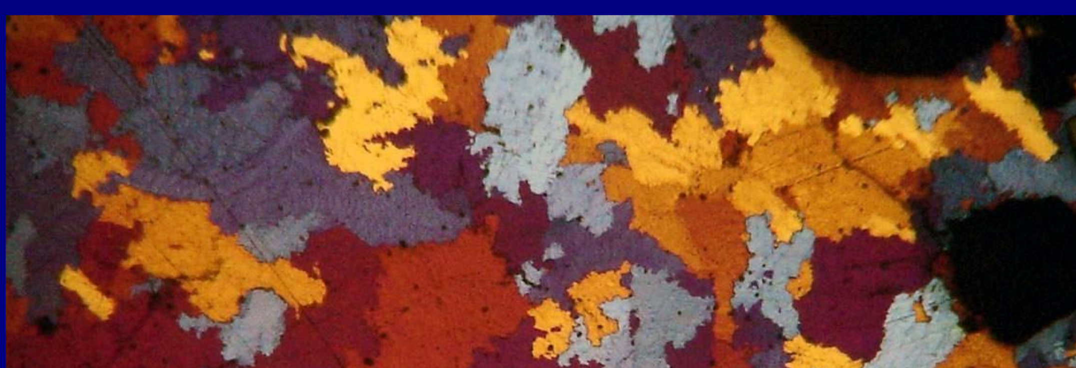
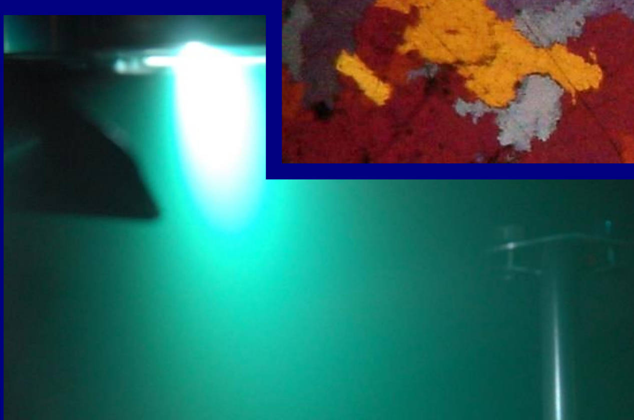
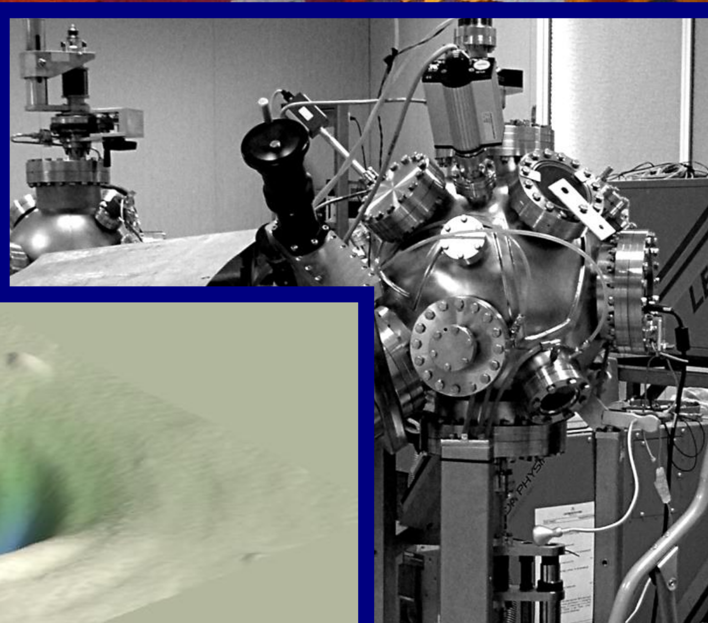
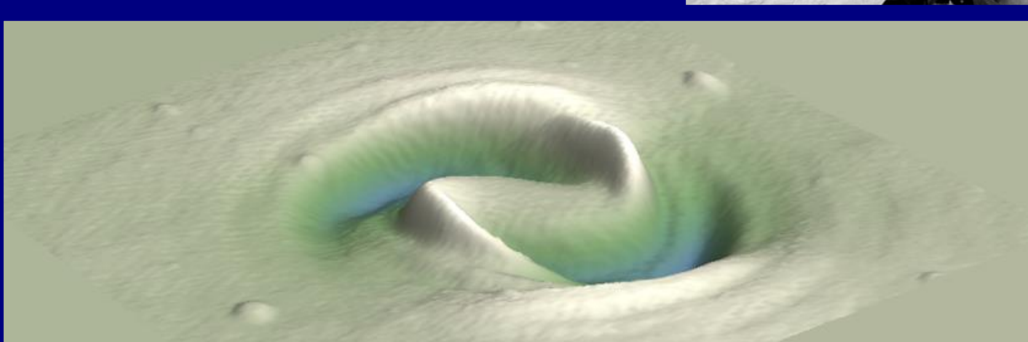
Scientific Report 2012 - 2013

Consiglio Nazionale delle Ricerche









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SPIN

Scientific Report 2012 - 2013

Contributions from all SPIN Researchers

Edited by
Roberta De Donatis, Elisabetta Narducci

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Foreword

This is the second biennial scientific report of the Institute SPIN (SuPerconducting and other INnovative Superconducting Materials and devices) of the National Research Council.

SPIN, in fact, was born in 2010 from the merging of five INFM centres and groups located in Genoa, Naples, Salerno, L'Aquila and Rome: today's branch network reflects this origin.

SPIN's headquarters are in Genoa, at the Villa Balbi-Brignole, while the other units are housed at the Universities of Genoa, Naples, Salerno, L'Aquila and Rome.

Spin is becoming an important player on the national and international scene since it has considerably grown both in its participation in many projects of various nature and in its size, with more than 50 staff researchers, about 70 associated researchers from Universities, and a huge number of PHD students and Post-doc researchers.

The scientific activity of SPIN is focused on innovative materials, superconductors, oxides, and hybrid nanostructured materials.

The research activities are characterized by a multidisciplinary approach, ranging from basic experimental and theoretical studies on magnetic and superconducting materials, strongly correlated oxides, organic and other innovative materials, to material preparation (bulk, single crystals, thin films, multilayers, epitaxial superlattice). They also comprise advanced material characterization based on the radiation-matter interactions, and electronic transport properties measurements in the presence of high external fields as well.

Moreover, SPIN researchers deal with micro/nano superconducting electronic devices (for quantum computation and other applications), electronic devices based on oxides (" oxide electronics"). They also fabricate sensors and superconducting cables and tapes for power applications in the fields of biomedicine and high energy physics.

Many of these activities are focused on the so-called Key Enabling Technologies (KETs), as referred to by Horizon 2020, so that SPIN will be able to play an important role in this new EU programme.

SPIN researchers are strongly committed also in communication and education promotion activities, in the innovative material area. They have also given a strong support to the organization of conferences and events.

These pages offer an overview of the research activities, of the facilities and the main achievements over the last two years; also some of the projects that characterize the institute are listed and described.

I would like to thank Elisabetta Narducci and Roberta De Donatis, for their help in the preparation of the report, and all the activities leaders and deputy directors of the various units.

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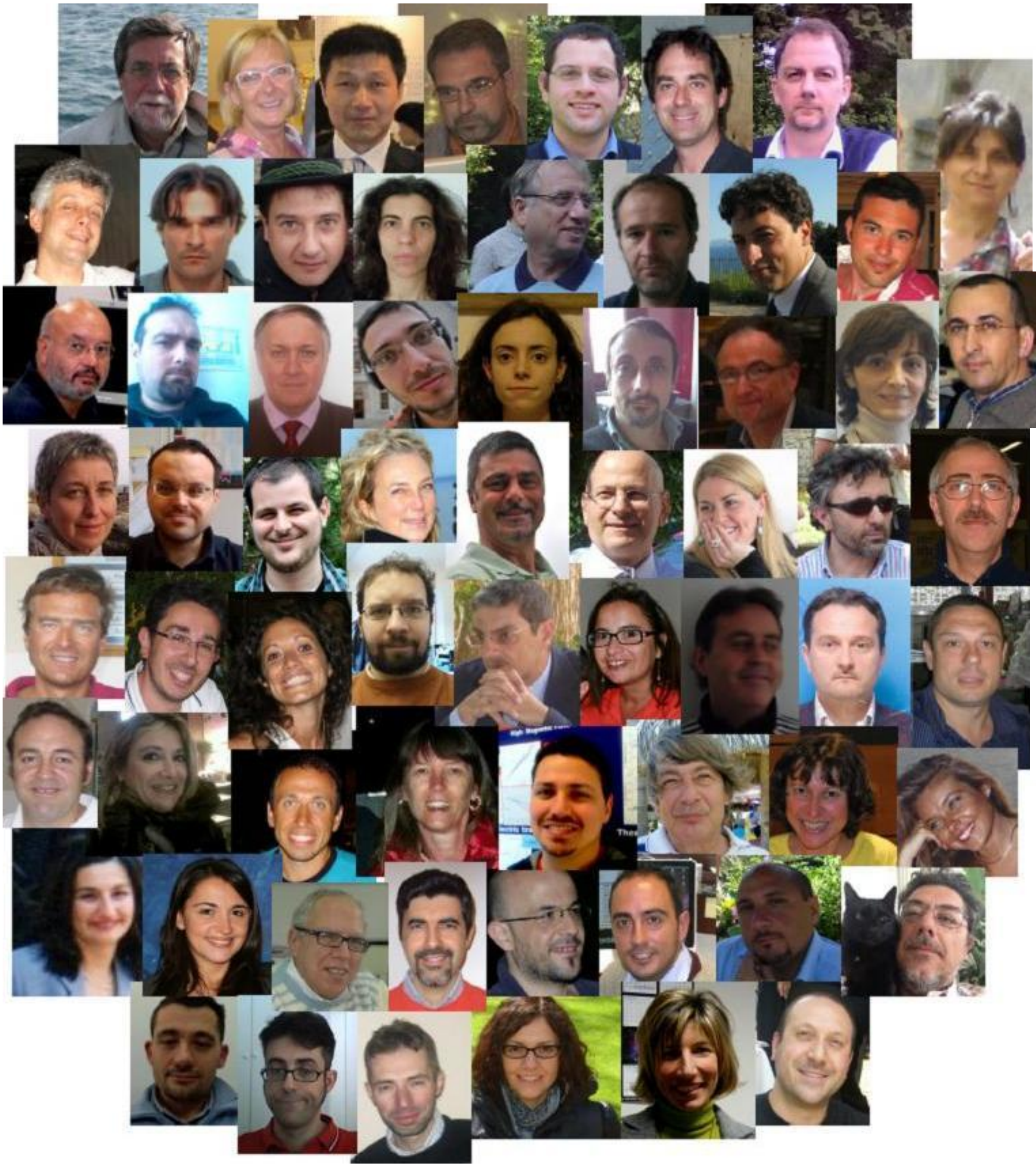
People



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Locations

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Genova - *main focus: superconductivity, innovative materials*

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16152 Genova, Italy

www.spin.CNR.it

University of Genova
Physics Department

Deputy Director: Daniele Marrè

Napoli - *main focus: superconducting devices/oxide and organic electronics*

University of Napoli Federico II
Physical Science Department

Deputy Director: Giovanni Piero Pepe

Salerno - *main focus: superconductivity and magnetic hybrids*

University of Salerno
Physics Department

Deputy Director: Sergio Pagano

L'Aquila - *main focus: ferroics and multiferroics*

University of L'Aquila
Physics Department

Deputy Director: Silvia Picozzi

Roma - *main focus: oxide thin films/optical properties*

University of "Tor Vergata"
University of "La Sapienza"

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Research Lines

Research Lines

The Research Lines are organized into five “Activities” internally divided in specific “sub-activities”:

1. Materials and mechanisms of superconductivity and its power applications
(Activity leader: Marina Putti)

2. Superconductive and hybrid quantum nanostructures and devices
(Activity leader: Francesco Tafuri)

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering
(Activity leader: Antonio Vecchione)

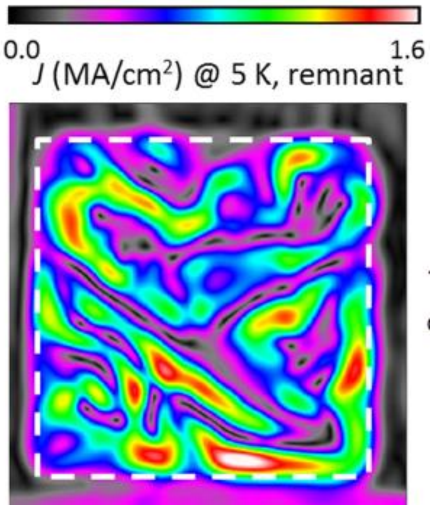
4. Functional materials and novel devices for electronics and energy applications
(Activity leader: Daniele Marre’)

5. Dynamical, electronic and transport properties of complex systems and functional materials
(Activity leader: Vittorio Cataudella)

Research Lines

1. Materials and mechanism of superconductivity and its power application

Activity leader: Marina Putti



General Description

The mission of this activity is focused on the study of superconductivity and its power applications. This research is carried out by Genoa and Salerno units which share several skills and expertises: the Genoa unit is mainly active on the preparation of superconducting materials in form of bulks, films and wires and their characterization. The Salerno unit is mainly devoted to the investigation of pinning mechanisms which may be of significant interest for technological application. During the last years the collaboration between the Salerno and Genoa units have been reinforced. A fruitful provision of samples from Genoa to Salerno has been started and will be further promoted in the future.

In the last two years the Genoa UNIT has been involved in two Europe-Japan projects aimed to the exploration of the potential of iron based superconductors (IBS) for applications. Several IBS materials have been prepared in order to investigate and optimize the critical current density also in collaboration with the Salerno UNIT.

More fundamental information on the interplay between superconductivity and magnetisms has been extracted from the investigation of phase diagrams of IBS: this activity has been performed within a national network established with MIUR PRIN projects.

The development of superconducting wires and tapes has been focused on MgB2 and Bi(2212).

The Salerno UNIT activity has been focused on the characterization of dissipative regimes in superconductors by current-voltage measurements and by the so-called “electric noise spectroscopy”. The investigation of the magnetic properties of superconductors and magnetic materials have been carried out by means of the “Multi-harmonic AC Susceptibility” method. Fabrication and characterization of thin films of the electron-doped NCCO compound have been carried out.

The researchers of Salerno UNIT are involved in a national project PON “NAFASSY” to realize an infrastructure for measuring power devices and superconducting materials.

Research Lines

1. Materials and mechanism of superconductivity and its power application

Activity leader: Marina Putti

1.1 Superconductivity: materials, mechanisms e technological transfer (Genoa)

Contact person	Marina Putti (marina.putti@spin.CNR.it)
Researchers	C. Bernini, V. Braccini, C. Ferdeghini, A. Gerbi (50%), G. Lamura, A. Malagoli, A. Martinelli, A. Massone, I. Pallecchi (50%), A. Varlamov , M. Vignolo,
Associate Researchers	M.R. Cimberle, E. D'Agliano, P. Dore, P. Manfrinetti, A. Palenzona, V. Palmieri, M. Piana, M. Putti, A. Siri (50%),

The activities of this UNIT are mainly devoted to the study of superconductivity addressing it from several points of view: **material preparation**, **structural and chemical characterization**, **investigation of properties**, **theoretical modelling** and **developing of wires** for power application. In the last year the **image analysis** activity has been included and the researchers devoted to this topic will be involved in solving problems of core business of the UNIT.

The activities of the last two years have been mainly focused on the investigation of **iron based superconductors** (IBS). Indeed, this UNIT has been involved in two Europe-Japan projects: SUPER-IRON, coordinated by CNR-SPIN, devoted to the exploration of the potential of IBS for power application, and IRON-SEA devoted to establishing the basic science and technology for IBS electronics applications. These projects have allowed to carry on these researches in an international, exciting environment and yelded the achievements of important results. Among them we mention the development of a new synthesis technique for Fe(Te,Se) bulk materials. These samples exhibit global critical current density, J_c, much enhanced as compared to the values reported in the literature for bulk samples of the same family, reaching about 10^3 A/cm^2 at zero field at 4.2 K, nearly independent of the field.

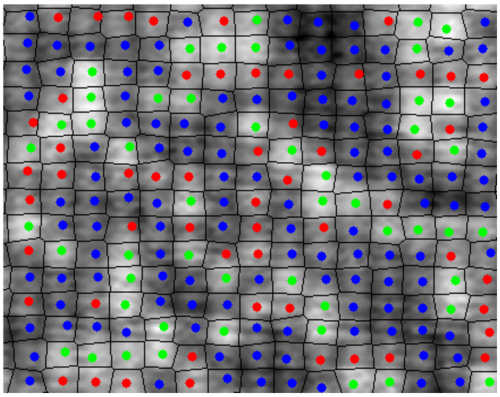


Fig.1
Soft computing elaboration of a scanning tunneling microscopy image of a Fe(Se, Te) thin film.

A comprehensive study of effects of the substrate on the superconducting properties of Fe(Te,Se) thin films has been performed: The best results have been obtained on CaF_2(001) substrate with J_c values larger than 1MA/cm^2 in self field and liquid helium with a weak dependence on the magnetic field and a complete isotropy.

The investigation of the phase diagrams of IBS, based on careful analysis of synchrotron and neutron powder diffraction data, SQUID, and muon spin rotation (μSR) measurements has been carried out.

A direct comparison between the magnetic and structural properties in IBS has been carried out in La($Fe_{1-x}Ru_x$)AsO, where it has been found that the magnetic transition is always associated with structural symmetry breaking, suggesting that orbital ordering could be the driving force for symmetry breaking.

Research Lines

1. Materials and mechanism of superconductivity and its power application

Activity leader: Marina Putti

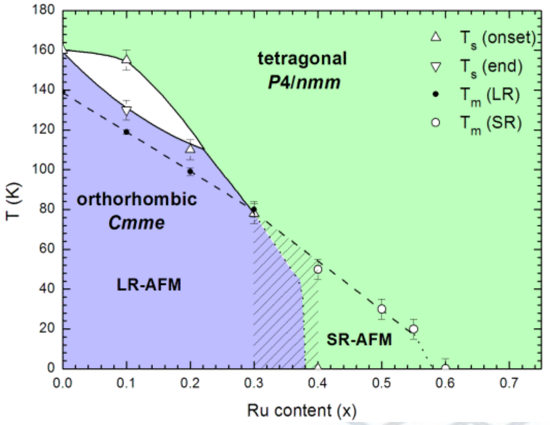


Fig.2:
Phase diagram of of $La(Fe_{1-x}Ru_x)AsO$

Interesting results have been obtained by the investigation of **new superconducting materials**: after the discovery of superconductivity on picene ($C_{22}H_{14}$), high-quality optical data in the infrared region and density functional perturbation theory calculations for the vibrational spectrum of solid picene under pressure up to 8 GPa have been obtained. In another recently discovered layered superconductor, $LaO_{0.5}F_{0.5}BiS_2$, magnetic and superconducting properties have been investigated by means of mSR. These experimental results suggest a fully-gapped conventional BCS picture of superconductivity in this compound.

The activity devoted to **developing superconducting wires** have been focused on MgB_2. The most remarkable improvements are the following: 1) the use of MgB_4 as precursor (in collaboration with Columbus Superconductor). This approach allows to obtain a purer MgB_2 phase and large J_c values in wires, suggesting that this could be an alternative to both ex situ and in situ routes. 2) The efficacy of the new boron synthesis process (CNR-SPIN patent) has been proven, achieving the best performances of MgB_2 both ball milled that one derived by plasma-spray. The manufacturing of Bi(2212) wires, recently undertaken, has obtained interesting results with the application of a scalable groove-rolling process to avoid bubble agglomeration.

The **modelling** activity has been devoted to the study of thermoelectricity and superconductivity. The anomalous growth of thermoelectric power in gapped graphene has been investigated showing that the opening of a gap in the spectrum results in appearance of a fingerprint bump of the Seebeck signal when the chemical potential approaches the gap edge. Moreover, the mesoscopic variations of inhomogeneous local density of states for impure superconductors with different symmetries of the order parameter (s wave and d wave) and different types of scatterers (elastic and magnetic impurities) has been explored theoretically.

The activity on data and **image analysis** has focuses on the realization of regularization algorithms for inverse problems and soft computing methods in pattern recognition. The applications involve problems in biomedicine, neuroscience and physics. Collaborations with high-tech companies and SMEs lead to the realization of software packages for industrial applications. The most significant result in 2013 has been the extension of the Hough transform procedure to the recognition of complex shapes in images; this approach has allowed the detection of the intra-bone space in X-ray tomography images of the human skeleton for applications in hematology.

Finally, we would like to mention the huge effort carried on by the most of researchers of the UNIT in the organization of the European Conference on Applied Superconductivity **EUCAS2013** which has been be held in Genova in September 2013 with more than one thousand participants.

Research Lines

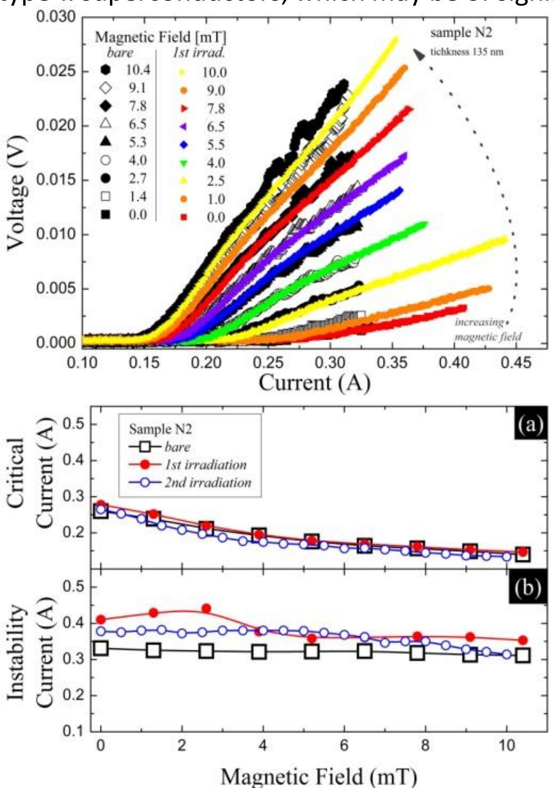
1. Materials and mechanism of superconductivity and its power application

Activity leader: Marina Putti

1.2 Static and dynamic properties of type-II superconductors, and their functional use for energy applications (Salerno)

Contact person	Gaia Grimaldi (gaia.grimaldil@spin.CNR.it)
Researchers	F. Giubileo, G. Grimaldi
Associate Researchers	U. Gambardella, A. Nigro, S. Pace, M. Polichetti, P. Romano

Research activities in Salerno focus on thin films fabrication and characterization of innovative materials by means of transport, magnetic, electric noise and thermal measurements. In particular we study the current carrying capability of type-II superconductors and the dissipative regimes related to the vortex dynamics and the pinning properties of the material. Samples, mainly in the form of micrometric bridges by epitaxial thin films of both low and high critical temperature superconducting materials, are characterized by current-voltage measurements. The intrinsic pinning properties of the materials can be modified by different ways: the introduction of artificial pinning sites, the irradiation by ions and tuning the temperature. We probe that maximum pinning does not always correspond to highest stability of the superconducting state, as a consequence we suggest how to increase the current carrying stability in type-II superconductors, which may be of significant interest to technological applications.



In close collaboration with Genoa research unit which provides samples realized in forms of thin films and bulks, we study the pinning properties in the 11-family of iron-based superconductors. We compare the intrinsic anisotropy and pinning energy of the single crystal with films and bulk, in order to highlight that this compound can be a competitive technological material for high magnetic field applications. The so-called “electric noise spectroscopy” is applied to study the electrical conduction and voltage-noise properties of these materials. In particular a comparison between $FeTe_{0.5}Se_{0.5}$ epitaxial thin films and Co-doped Ba-122 compound shows that this latter material can be a good candidate for electronic applications.

Fig.1
Light ion irradiation effects on the flux flow state of Nb thin films.

Research Lines

1. Materials and mechanism of superconductivity and its power application

Activity leader: Marina Putti

The magnetic properties of superconductors and magnetic materials are analyzed both in dc and in ac fields. In particular, the innovative "Multi-harmonic AC Susceptibility" method of analysis based on the study of the higher harmonics of the ac susceptibility, is used to interpret the data in ac field. We use a comparison among the components of the experimental first and third harmonics, together with the support of the results coming from dc magnetization measurements and from numerical simulations of magnetic flux diffusion processes in the material. With this method we extract detailed information about the properties of the flux line lattice, of the pinning centers, and of the different vortex dynamical regimes.

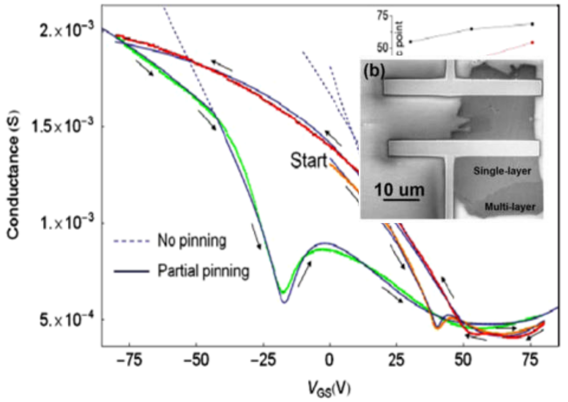


Fig.2 Electrical cycles produce the appearance of two conductance minima. The double dip is the result of a different Fermi level alignment within the graphene at the contacts with respect to the bulk channel .

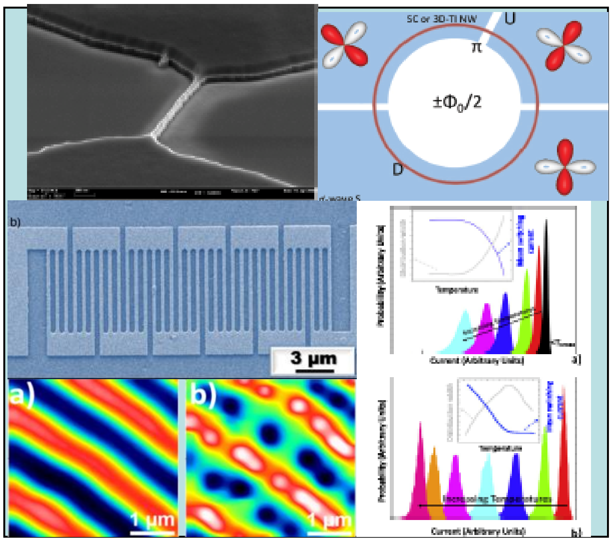
According to the mission of studying "innovative materials and their application in the fields of electronics and energy" our activity is also devoted to the fabrication and characterization of thin films of the electron-doped $Nd_{2-x}Ce_xCuO_{4-d}$ (NCCO) compound, which is routinely fabricated in Salerno by on-axis dc sputtering technique. The characterization of its electrical transport properties, the identification of the charge carriers and the study of the influence of its optical properties, on the normal as well as the superconducting state of this material, constitute a preliminary analysis to select the samples with the best performance to design optical devices.

The same group of Salerno Researchers is also engaged on a new research topic, i.e.: the fabrication and characterization of graphene based devices (field effect transistors, field emitters, gas sensors, memories, etc.). Graphene-based FETs (GFETs) combine an ultra-thin body suitable for aggressive channel length scaling, with excellent intrinsic transport properties. The contacts between graphene and metal electrodes can significantly affect the electronic transport and limit the full exploitation of the graphene intrinsic properties, making the choice of materials and fabrication techniques - both for the contacts and the gate dielectrics- crucial. The use of a four-point setup for electrical characterization is clearly suitable to prevent the problems related to contact resistance, but real electronic applications are based on two-terminal devices where the effect of contact resistance cannot be avoided. For this reason we study the physical effects due to the contact resistance on the graphene layers. We stress here the observation of a clear double-dip feature in the transistor transfer characteristics that we explained in terms of graphene doping under metal contacts.

Finally, we emphasize that all researchers of Salerno unit are hardly involved in a national project PON "Ricerca e Competitivita'" 2007-2013 funded by the Italian Ministry of University and Research, namely NAtional FAcility for Superconducting Systems (NAFASSY), to realize an infrastructure for measuring power devices and superconducting materials in high magnetic fields and at low temperatures.

2. Superconductive and hybrid quantum nanostructures and devices

Activity leader: Francesco Tafuri



General Description

The research activity is focused on the study of superconducting hybrid and quantum devices and on the search of the unique superconducting properties arising at the nanoscale. Low (LTS) and high (HTS) critical temperature superconductors suitably patterned and engineered with materials of complementary functionalities, offer flexible solutions to explore new fundamental problems in solid state physics and to design new sensors and devices.

Effects of coherent nano domains have been identified in the escape phenomena of Josephson junctions, and the codes of phase-slip dynamics retraced. These studies have been carried out in high critical current density junctions with barriers composed of nano-channels, as in YBaCuO grain boundary junctions. Escape dynamics has been studied in NbN junctions with ferromagnetic barriers with evidence of macroscopic quantum phenomena. Superconducting/ferromagnetic (S/F) heterostructures are also used to possibly study odd frequency triplet superconducting pairs and to understand the mechanisms for generation and control of spin-polarized supercurrent. Al junctions incorporating topological insulators barriers (BiSe, Bi Te, BiSeTe) have been realized, providing up to now evidence of ballistic proximity effect in 2-dim edge states. InAs nanowires work as barriers connecting Al or YBCO electrodes, with YBCO requiring an innovative suspended wire geometry. Nanowire and topological insulator barriers support the notion of unique state-of-the-art hybrid devices, with new functionalities and with potential of revealing Majorana fermions .
We have investigated other phenomena where superconductivity and nanophysics coexist and cooperate, as occurring for instance in superconducting interface (NGO/LAO) systems or in superconducting nanowires (SNs) of various materials. SNs support various applicative projects, and specifically photon detectors.
The research line funds on the capability of using different experimental techniques and know-how (time-resolved optical spectroscopy measurements, Scanning Probe Microscopy, low temperature magnetic force microscopy, transport and noise characterization of patterned thin films and junctions, escape dynamics,…) on a variety of superconductors (i.e. pnictides and oxides and YBCO/manganite, NbN/NiCu hetero-structures) and devices.

Research Lines

2. Superconductive and hybrid quantum nanostructures and devices

Activity leader: Francesco Tafuri

2.1 Quantum and non-equlibrium effects in junctions and hybrid nanostructures (Naples)

Contact person	Francesco Tafuri (tafuri@na.infn.it)
Researchers	P. Lucignano, A. Porzio, M. Valentino
Associate Researchers	A. Andreone, C. De Lisio, L. Parlato, G.P. Pepe, F. Tafuri, A. Tagliacozzo

The research activity is focused on the study of superconducting hybrid and quantum devices and on the search of the unique superconducting properties arising at the nanoscale. Low (LTS) and high (HTS) critical temperature superconductors suitably patterned and engineered with materials of complementary functionalities, offer flexible solutions to explore new fundamental problems in solid state physics and to design new sensors and devices.

Superconducting hybrid nano structures: from macroscopic quantum phenomena to the search of Majorana fermions

High critical temperature superconductors (HTS) systems ranging from YBaCuO nano-junctions and nano-channels to hybrid systems incorporating semiconducting InAs nanowires have been realized and characterized. Reference samples employing Nb and NbN junctions with different types of barriers have been studied as well. Junctions with ferromagnetic barriers have been as well investigated in the quantum regime. Their quantum signature is encoded in the escape dynamics. Novel insights on the interplay between coherence and dissipation in the moderately damped regime have been achieved, of interest for various quantum hybrid architectures and for the physics of superconducting oxides. Nano-junctions point to possible quantum phase diffusion in the limit of charging energy larger than the Josephson energy. We have identified effects of coherent nano domains in escape phenomena and in some limits retraced codes of phase-slip dynamics .This experiment paves the way to the use of high_Jc junction in quantum architectures.

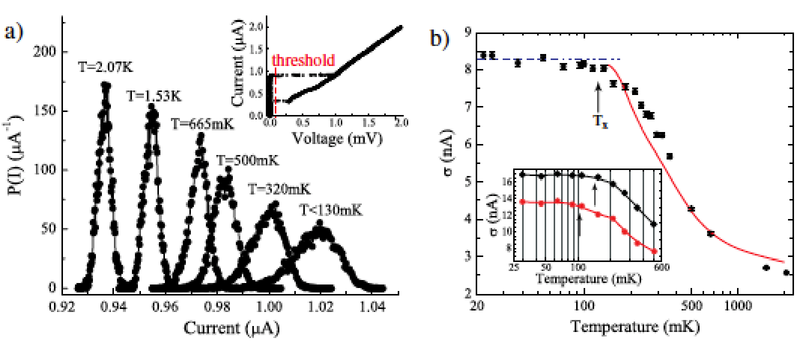


Fig.1
(a) Measured switching current probability distribution P(I) at different bath temperatures. The inset shows the device current voltage characteristic measured at 30 mK. The reference value for the threshold detector is also displayed. (b) Temperature dependence of the standard deviation, of the switching distributions. The dash-dotted line marks the temperature-independent SCD widths in the quantum tunneling regime, the red solid line is the result of simulations in the diffusive regime with a damping parameter of Q =1.3.

Research Lines

2. Superconductive and hybrid quantum nanostructures and devices

Activity leader: Francesco Tafuri

Topological insulators barriers (BiSe, Bi Te, BiSeTe) have been integrated into Al superconducting electrodes in the search of Majorana fermions. Integration of nanowires and two-dimensional flakes as barriers into high quality junctions has lead to novel device designs and concepts, which need to be further engineered and explored. The theoretical activity has been specifically focused on the study of Majorana Fermions in hybrid structures involving superconductors and semiconductors or topologica insulators. Closed loops trycristal geometries encompassing high Tc oxides have revealed a unique robustness of Majorana bound states, and offer novel benchmarks for probing Majorana states based on flux measurements. Phase slips dynamics in quasi one-dimensional superconductors and its influence on switching current distribution has been addressed by means of stochastic models. Studies on teleportation fidelity, quantum discord and mutual information in optical systems have been also carried out.

Physics and applications of superconducting nanowires

The experimental activity on oxide is completed by low temperature magneto-transport measurements on NGO/LAO interfaces, and by the realization of YBCO nanowires with critical current densities close to 10^8 A/cm^2. This is part of a quite broad activity on the physics and applications of superconducting nanowires. Large coverage area, good sensitivity and fast time response are key performances that have been addressed by innovative design of series parallel nanowire connections.

Photo-response experiments have been performed on YBCO and YBCO/LSMO nanowires (see Fig. 2) by optical laser pulses at 1550 nm wavelength.

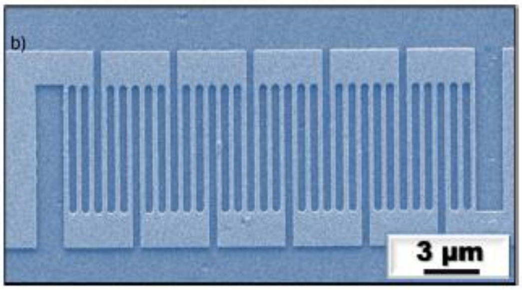


Fig.2
SEM picture of a device, made with 300 nm wide YBCO/LSMO nanowires.

Neat photo-response signals observed under wide current biasing conditions even at temperatures close the critical temperature of the nanowires, encourage further studies and possible applications. YBCO superconducting nanowire photon detectors have been used to study non-equilibrium effects under controlled optical stimulus in the flux-flow.

Ultrafast optical characterization

Time-resolved optical spectroscopy measurements employing “pump and probe” technique and femto-second laser source, have been performed to study electronic relaxation in unconventional superconductors, i.e. pnictides and oxides and YBCO/manganite, NbN/NiCu hetero-structures. Evidence on the influence of material properties of superconducting hybrid bilayers on fast relaxation processes, has been given. This technique has been used to investigate the potential role of different electron coupling mechanisms assisting superconductivity in iron-based superconductors within the framework of the EU project Iron-sea.

Research Lines

2. Superconductive and hybrid quantum nanostructures and devices

Activity leader: Francesco Tafuri

2.2 Superconducting and hybrid materials devices (Salerno)

Contact person	Carla Cirillo (carla.cirillo@spin.CNR.it)
Researchers	C. Cirillo, N. Martucciello
Associate Researchers	C. Attanasio, F. Bobba, G. Carapella, A. M. Cucolo, S. Pagano

The research activity is focused on fundamental aspects of superconductivity and their possible applications, mainly in the field of superconducting electronics. Junctions, hybrid nanostructures and nanowires of both traditional and unconventional superconductors are investigated and engineered in form of thin films based devices. The unit has a well known experience in the fabrication (including lithographic processes) and in the characterization of these materials.

The groups are intensively involved research lines synthetically described as follows:

-**Deposition and characterization of superconducting/ferromagnetic (S/F) heterostructures**

This research line encompass in itself different area of interest. The generation of odd frequency triplet superconducting pairs was pursued depositing and characterizing by electrical transport measurements hybrids (bilayers and trilayers) consisting of a spin-singlet superconductor (Nb) interfaced to ferromagnets with inhomogeneous magnetization profile (as thick NiFe striped films). The final goal is to advance in the understanding of the mechanisms for generation and control of spin-polarized supercurrents. S/F based photodetectors, with promising performances, as response velocity were also electrically characterized. The dynamics of superconducting vortices in S/F bilayers was controlled using Scanning Probe Microscopy (SPM) techniques, such as low temperature Magnetic Force Microscopy (see Fig. 1) to study the surface micro-magnetic configuration in F films, and AFM based field emission experiments to get electrical characterizations of materials at the nanometer scale.

-**Fluctuation phenomena in innovative materials and devices**

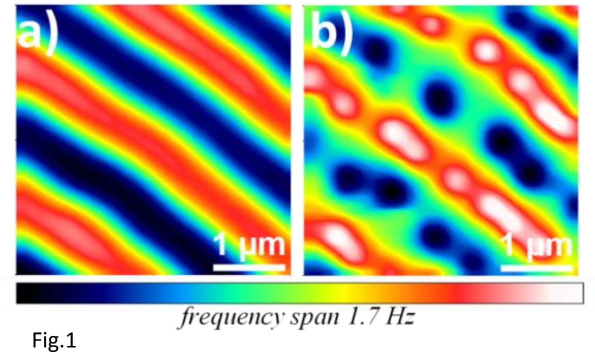


Fig.1
MFM maps showing vortex/antivortex chains nucleated in NiFe(2μm)/Nb(200 nm) bilayer at (a) T=11K and (b) T=6K (b). Image size : 3.8 μm x 3.8 μm.

The study focuses on novel iron-based superconductors (FeSeTe, Co-doped Ba122) mainly in the framework of the IRONSEA Project. The latter aims at development of technologies for possible electronic applications of these materials. The activity performed within the module regards the assessment of MgB2 (showing some physical properties common to iron-based superconductors) thin film technology, the development of micron and sub-micron scale patterning technology for iron-based S thin films, transport and noise characterization of patterned thin films and junctions.

Research Lines

2. Superconductive and hybrid quantum nanostructures and devices

Activity leader: Francesco Tafuri

The investigations rely on a photolithographic patterning process capable to produce lines down to 2 micrometers (see Fig. 2(a)).
Additionally, experiments were carried on other innovative materials and devices, such as LABMO, NCCO, 2-dimensional electron gas LAO/STO interfaces and polimer-fullerene solar cells, to extract physical informations from the noise spectroscopy analysis.

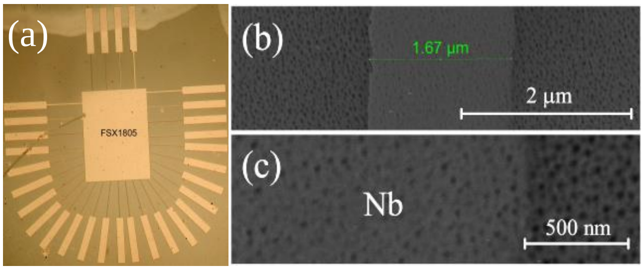


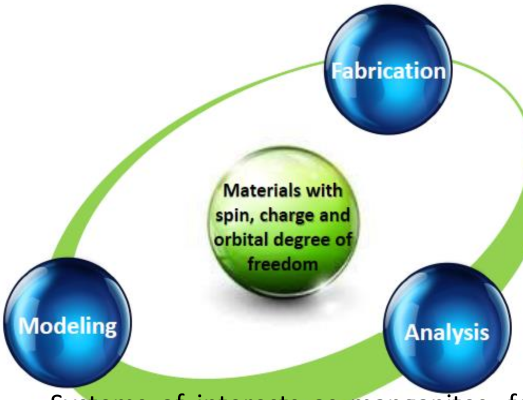
Fig.2
(a) patterned FeSeTe thin film with line widths ranging from 2 to 100 micrometers; (b), (c) particular of a nanoporous Nb bridge patterned by EBL, the average pores diameter and distance are 15 nm and 50 nm respectively.

Experimental activities involving lithography and thin film deposition
Devices based on superconductive strips with thickness variable on nanometer scale showed a diode like-behavior in the presence of an applied magnetic field, whose orientation with respect to the substrate generates asymmetry in critical current or in the voltage. The experimental results have been explained by numerical simulations in the framework of time dependent Ginzburg Landau model. Ultrathin Nb films deposited on nanoporous silicon substrates were patterned by Electron Beam Lithography (EBL) technique obtaining superconducting nanowire networks for the study of quantum phase slip processes. Moreover, Hall bars based on very thin Cu films were realized to study weak localization effects by electrical transport. Concerning the investigation of the photoresponse of nanostructured superconductors, the activity has been focussed to the realization of large area detectors for application to photon detection and macromolecule detection (for Mass Spectroscopy).
More recently, the activity for the development of single photon detectors based on high Tc materials,such as YBCO and NCCO, has been started.

Research Lines

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione



General Description

The last two-year activity of this Commessa has been focused on the synthesis, analysis and modeling of materials where the coupling of spin, charge, and orbital degrees of freedom emerging from the electron-electron and electron-lattice interaction lead to electrical and magnetic unconventional properties. The research has been centered on systems where the properties depend on cooperative phenomena of coexistence and/or competition of different types of long-range orderings.

Systems of interests as manganites, ferroics, multiferroics and magnetoelectrics materials, oxides of copper, titanium, manganese and ruthenium have been grown as thin films (via MBE, PLD, sputtering) and single crystals. The main subjects of study are the manufacturing of controlled interfaces in epitaxial heterostructures and eutectic, the production of nano-particles by laser ablation with ultra-short pulses and the problems inherent to the mechanism of growth. The effort devoted in these two years in the realization of materials with a high degree of orientation and purity were crucial gain a better control of the fundamental interactions that regulate the information and/or the competition of different correlated phases.

The properties of above mentioned systems have been carried by used techniques based on the interaction of radiation with matter such as linear and non-linear optical spectroscopy, tunnel and atomic force microscopy, electron diffraction and photoemission. Whereas, the thin films and multilayers, real-time diagnostic based on optical techniques have been developed getting atomic level control of the deposition process. This investigation has been complemented by experiments based on high and low temperature and applied magnetic field of magnetization, ac susceptibility and dc magnetoresistance, current-voltage characteristic. The goal of this research was the understanding of aspects related to the macroscopic properties related to electrical and magnetic fields arising in electronic structure investigating surface and bulk of the samples to obtain a multi-scale approach to the system in question.

Theoretical modeling techniques like ab-initio many-body approaches, analytical and numerical techniques have been used in the context of systems with strong correlation. The main effeort was devoted to the determination of the structural, magnetic, electronic and ferroelectric properties. The connection between the computational and experimental context has been of paramount importance to the objectives of the Commessa. Indeed, the combination of experimental investigation and theoretical modeling has allowed: i) an accurate description of the properties in bulk materials as well as in thin films, surfaces and interfaces of oxides based on transition metals and ii) a detailed analysis of multifunctional materials, such as multiferroics showing electronic mechanisms capable of inducing ferroelectric properties and / or magnetoelectric effects.

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione

3.1 Realization and study of materials with strong spin, charge and orbital correlations (Salerno)

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Researchers	M. Cuoco, P. Gentile, R. Fittipaldi, A. Vecchione, F. Forte, F. Chiarella
Associate Researchers	C. Noce, A. Romano

The activity of the present Modulo points to the synthesis of material within different methods of growth, such as single crystals and oriented samples showing strong correlations of spin, charge and orbital degrees of freedom and to their study by using ab-initio techniques, many-body approaches and numerical simulation techniques for the determination of the structural, magnetic, electronic and ferroelectric properties. Systems which are the focus of the activities include oxides based on transition metals, multiferroic perovskites and hybrid combination of them.

The very recent experimental activities mainly concern the growth of single crystals of the $Ba_2CuGe_2O_7$ helimagnet by floating zone technique. The aim of this research is to investigate the complex magnetic phase diagram and the electronic properties currently unknown for this material.

Moreover, it has been investigated the nature of the planar and apical oxygen in the family $Sr_{n+1}Ru_nO_{3n+1}$ (n = 1,2,3) thanks to the X ray absorption measurements performed on the produced samples. In addition, it was studied in detail the electronic structure of Sr_2RuO_4 crystals by ARPES measurements (Fig.1) and the origin of the metamagnetism in $Sr_4Ru_3O_{10}$ by elastic neutron scattering measurements.

The experimental activities have covered also measurements by scanning electron microscopy and X-ray diffractometry mainly devoted to the study of nanoparticles of titanium dioxide, of copper nanoparticles deposited on porous silicon and manganite doped with gallium as well.

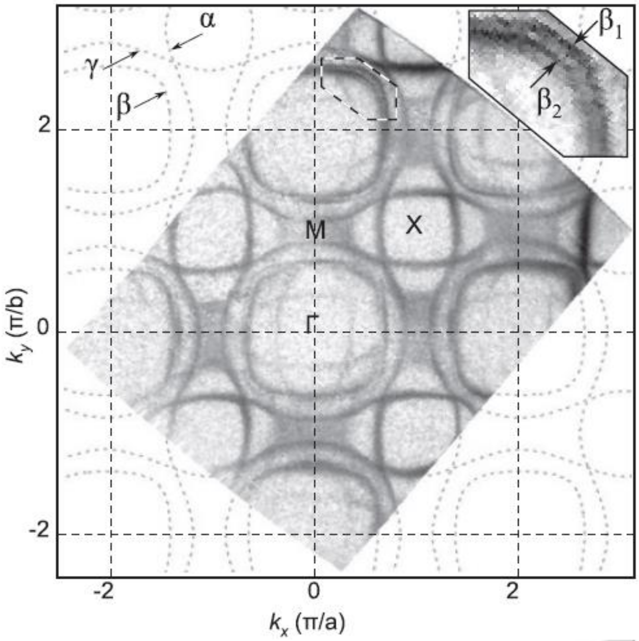

Fig.1: Fermi Surface map of Sr_2RuO_4 as obtained by ARPES measurements where the three bands contributing are observed. The inset shows the splitting of the β band.

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione

The theoretical activity of the Modulo has been focused on the study of unconventional superconductors and related heterostructures with special emphasis on those with spin-triplet and mixed-parity pairing symmetry. We found two remarkable effects when dealing with spin-triplet superconductors: i) there is an effective spin-orbital coupling between the magnetization of the ferromagnet and the orbital symmetry of the pairs emerging at the interface with a ferromagnet that controls the physical properties, ii) the Andreev states at their edge can become magnetic if the system allows for singlet pairing in a subdominant channel.

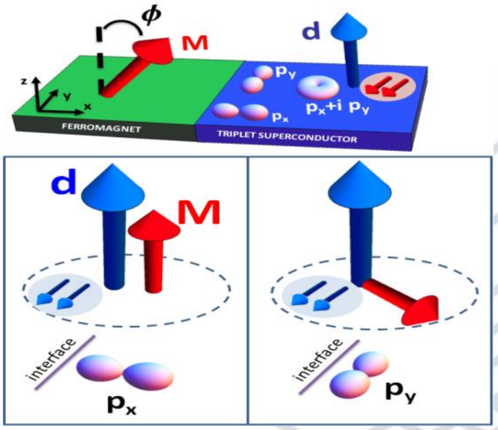

Fig.2: Spin-orbital coupling emerging at the interface of a spin-triplet superconductor with a ferromagnet

The study of atomically matching heterostructure has been also performed by means of ab-initio calculations for instance for superlattice systems based on perovskite oxides with the aim to determine the electronic reconstruction and the structural modification occurring at the interface. The theoretical investigation has been then devoted to the nature of the spin, charge and orbital excitations of correlated oxides. A remarkable result is represented by the determination of the magnetic spectrum of a three dimensional hyperkagome system whose ground state is believed to be of spin liquid type.

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione

3.2 Growth and characterization of epitaxial and nanostructured films, and interfaces: pulsed laser deposition, in-situ analysis, optical, magnetic and transport properties (Naples)

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Associate Researchers	G. Abbate, S. Amoruso, G. Ausanio, R. Bruzzese, V. Iannotti, L. Lanotte, L. Marrucci, U. Scotti di Uccio

The study of physical properties and technological applications of innovative materials, like thin films of 'half metal' oxides or magnetic nanoparticles, high electronic mobility interfaces between insulating oxides and heterostructures with different functionalities (dielectric, ferroelectric, superconductive), require a fine control of the fabrication process as well as the use of advanced characterization techniques. In our unit the samples are grown by means of pulsed laser ablation, in the ns as well as fs time regime. The growth is monitored in real time through different complementary techniques, capable of probing both the generated plasma and the surface. The 'in situ' characterization of the samples are performed by means of photoemission spectroscopy and electronic diffraction. The study of the electronic, magnetic, optical and structural properties of the fabricated samples exploit several advanced characterization techniques: surface second harmonic generation (SSHG), spectroscopic ellipsometry, transport measurements in external fields, magnetization measurements, THz spectroscopy, and advanced spectroscopies at large scale facilities. In this respect Figure 1 summarizes well the core research activity of our unit.

The most recent and future activity of the majority of our researchers is largely dictated by those topics that have been recently financed by different national and european projects: EUFP7 2009 – 'MAMA – Unlocking research potential for multifunctional advanced materials and nanoscale phenomena'; EUFP7 2012 – 'FOXIDUET – Functional oxides interfaces charge dynamics under ultrafast electric transients'; EUFP7 2013 – 'TOBE - Towards an oxide-based electronics'; PRIN 2008 – '2DEGFOXI – Two dimensional electron gases at functional oxide interfaces'; PRIN 2012 – 'OXIDE – Oxide Interfaces: emerging new properties, multifunctionality, and devices for electronics and energy'.

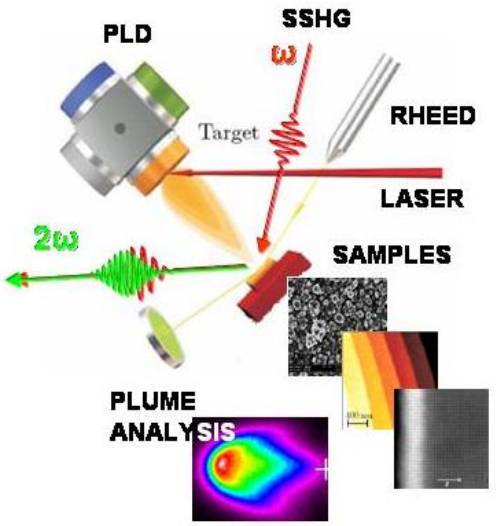


Fig.1
The picture summarizes the core research activity of our unit. It highlights the growth and characterization techniques that are often combined together.

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione

In particular in the last two years the activity of our unit have been principally focused on the following themes:

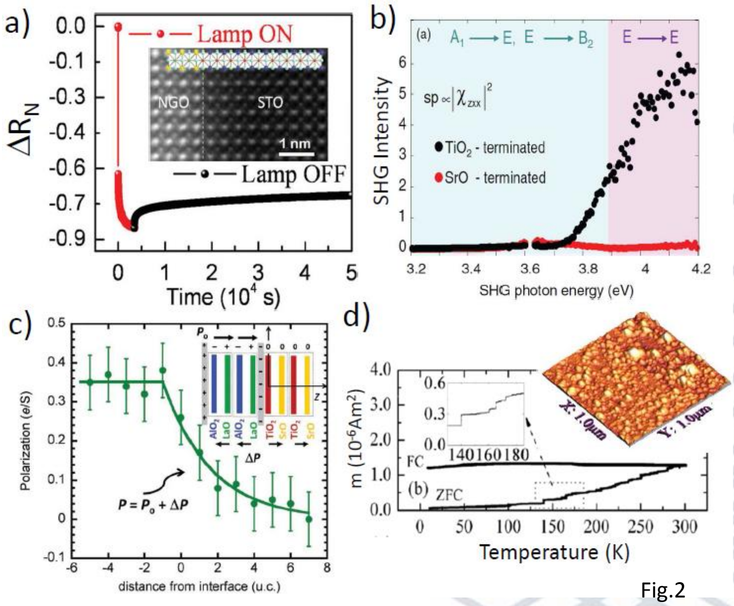


Fig.2
Some of the main experimental results characterizing the research activity of our unit (see text for details).

<u>Fabrication and study of polar/non-polar oxide interfaces</u>

This activity is inserted in the huge research mainstream followed after the discovery of the formation of a two-dimensional electron gas (2DEG) at the interface between the two band insulators $LaAlO_3$ (LAO) and $SrTiO_3$ (STO). The origin of the charge carriers is still a highly debated question, since different doping mechanisms can be at play in this oxide heterostructure. One of the most important physical ingredient is the polar discontinuity that occurs between LAO and STO, but the final phenomenon explanation appears more complex.

We have investigated many aspects of this phenomenon. We have shown its generality by growing different polar/non-polar interfaces and demonstrating the 2DEG formation in them. Interfaces, where the polar discontinuity is removed by depositing an amorphous layer of LAO, have been also grown. The latter also display an insulator-to-metal transition, but in this case a major role of oxygen vacancies is at play. The growth mechanisms of these interfaces have been studied in detail, and the critical role of the target-substrate distance and of the atom kinetic energy have been evidenced. All these interfaces have been deeply investigated by means of different spectroscopic techniques, as time-resolved photo-conductivity (Fig 2a), electron energy-loss spectroscopy combined with STM (Fig. 2c), and SSHG spectroscopy (Fig. 2b) and SSHG microscopy.

<u>Fabrication of nanoparticles and composite thin films by ultrafast laser ablation</u>

Ultrashort pulses (<1ps) offer new interesting possibilities in the field of laser-solid interactions due to the peculiar features of this interaction regime. High intensity laser pulses heat a material target to higher temperature and pressure than do longer, ns pulses of comparable fluence, since laser energy is delivered before significant thermal conduction. As a consequence, under these extreme conditions of temperature and pressure, nanoaggregates of the target material are generated that may display special properties. In particular, in the last two years, magnetic nanostructured films have been fabricated and characterized. The dependence of the nanoparticle size, shape, and coalescence degree, from the growth conditions and their influence on the film magnetic properties have been investigated in detail. Finally an intriguing step-behavior of the magnetization as a function of temperature has been observed in dense films of iron nanoparticles (Fig 2c).

Research Lines

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione

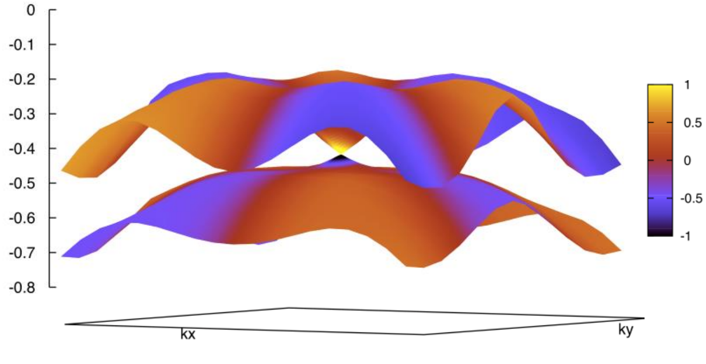
3.3 Structural, electronic and vibrational properties of strongly-correlated systems (L'Aquila -Rome)

Contact person	Silvia Picozzi (silvia.picozzi@spin.CNR.it)
Researchers	P. Barone, A. Ciattoni, A. Stroppa, S. Picozzi
Associate Researchers	P. Calvani, P. Maselli, A. Nucara, L. Ottaviano, G. Profeta

Our activities can be broadly divided in three different subfields: First-principles calculations on advanced materials with cooperative orders (PIcozzi, Stroppa, Profeta), theoretical approaches to metamaterials (Ciattoni) and infrared spectroscopy (Calvani, Maselli, Nucara).
As for ab-initio simulations, our research has focused on several directions:

1. Multiferroic and magnetoelectric effects, with focus on metal-organic frameworks (where we have shown the hybrid-improper origin of ferroelectricity and the possibility to tune the polarization. We've also shown a strong link between the direction of ferroelectric polarization and the rotation direction of the magnetization in the spin-cycloid magnetic domains of the prototypical multiferroic, $BiFeO_3$.

2. Spin-orbit induced phenomena, such as Rashba effects and topological insulator (TI) behaviour in narrow-gap semiconductors. In this framework, we've proposed a new class of materials, labeled as Ferroelectric Rashba Semiconductors (FERSC), whose prototype is GeTe and whose potential for electrically controlled spintronic devices seems very promising. FERSC feature a huge Rashba spin-splitting in the bulk (see Fig.1) and a strong link between spin-degrees of freedom and ferroelectricity: the spin-texture direction can be switched upon switching of ferroelectric polarization.



3. Superconducting materials, with focus on iron-based pnictides and on the possibility of inducing superconductivity in a graphene sheet by doping its surface with alkaline metals. In particular, Li-covered graphene was found to be superconducting at a much higher temperature wrt to Ca-covered graphene.

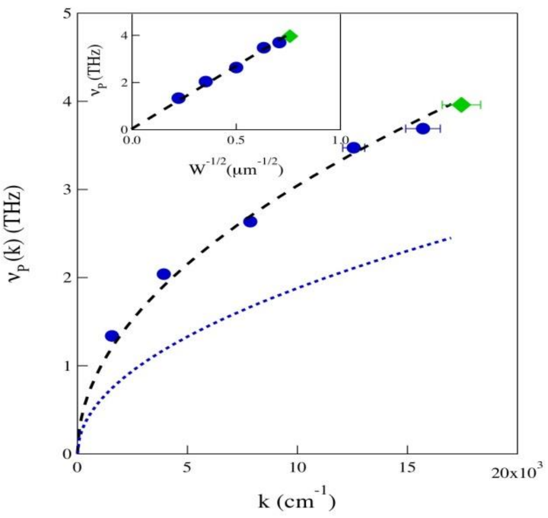
Research Lines

3. Cooperative phenomena in advanced materials with magnetic and/or dipolar electric ordering

Activity leader: Antonio Vecchione

In the general frame of metamaterials and their optical functionalities, several activities were carried out: (i) tailoring of metamaterials with dielectric permittivity close to zero at a specified frequency; (ii) proving the possibility of using modulated infrared (IR) beam to write a metamaterial meta-atoms (reconfigurable) pattern within a semiconductor able to control the THz radiation ; (iii) introducing the novel concept of fast and deep grating in the metamaterial subject and proving that the effective medium response allows diffractionless propagation of ultra-tightly focused optical beams.

The Infrared Spectroscopy Group at the Sapienza Univ. of Rome continued its activity on two main subjects: plasmons in two-dimensional electron gases (2DEG) and electronic excitations in correlated materials, In the former case, we have reported for the first time the observation of Dirac plasmons in a topological insulator (TI), through transmittance measurements of micro-patterned thin films of Bi2Se3. By comparing spectra with different polarizations in differently patterned samples we could determine the dispersion law of the collective 2DEG excitation and demonstrate its excellent agreement with the theoretical predictions for the plasmon of surface Dirac carriers in a TI (dashed line in Fig.2) .



Surface plasmons in conventional metals can instead be used for the detection of IR photons. By illuminating a micrometric metal mesh by a mid-IR tunable Quantum Cascade Laser we have shown that the intrinsic linewidth of its response is many times smaller than that previously believed basing on experiments with conventional interferometers. In the field of correlated materials we have studied the visible and UV spectra of thin films of manganites either Ga-substituted or defective in La, with the aim to assign the observed bands to the electronic excitations of Mn in different valence states (samples provided by the SPIN UOS of Na and Sa). The decennial research on high-Tc superconductors has continued by completing the IR study on the insulator-to-metal transition in BSCO and that on the charge ordering phenomena in LaEuSrCuO4. We have also started spectroscopic experiments on the LAO/STO interfaces, in collaboration with the SPIN UOS Na, within a PRIN project. The anisotropic spectral properties of the multiferroic compound BaCuGeO have been also determined, theoretically supported by calculations made at the SPIN UOS of L'Aquila and at the ISC UOS of Rome.

Research Lines

4. Functional materials and novel devices for electronics and energy applications

Activity leader: Daniele Marrè

General Description

The activity within the "commessa", has been focused on transition metal compounds and organic materials whose properties are appealing for applications in electronics and energy. The research activity can be resumed in three main tasks.

-Deposition or preparation of studied compounds in form of nanoparticles, thin film or heterostructures

-Deepening understanding of their physical properties

-Tailoring of physical properties and device design.

In particular, a large effort has been devoted to the investigation of interfacial properties both in transition metal oxide heterostructures and in organic multilayers.

During the 2012-2013 period, the following main lines of research have been carried out:

-Materials and Devices for Electronics

Study of transport, electronic and magnetic properties of $SrTiO_3$-based and ZnO-based heterostructures;

Investigation of ferromagnetic and ferroelectric properties of multiferroic films

Study of electronic and magneto-electronic properties of manganite and cuprate thin films and heterostructures

Analysis of charge transport and trapping phenomena in organic semiconductors

Study of interfacial electronic phenomena in organic-organic and organic-inorganic heterostructures

Development and characterization of magnetic nanoparticles

Investigation of mechanical and electrical memory effects on oxide-based MEMS.

-Materials and Devices for Energy

Engineering materials/heterostructures with high proton/ion conductivity for application in micro-Solid Oxide Fuel Cells

Tailoring of plasmonic resonances of transition metal nanoparticles for photovoltaic cells absorption enhancement.

Investigation of thermoelectric properties of transition metal oxides; determination of the role of quantum confinement in enhancing thermoelectric properties.

Investigation of basic mechanisms ruling high T_c superconductivity in cuprates

Research Lines

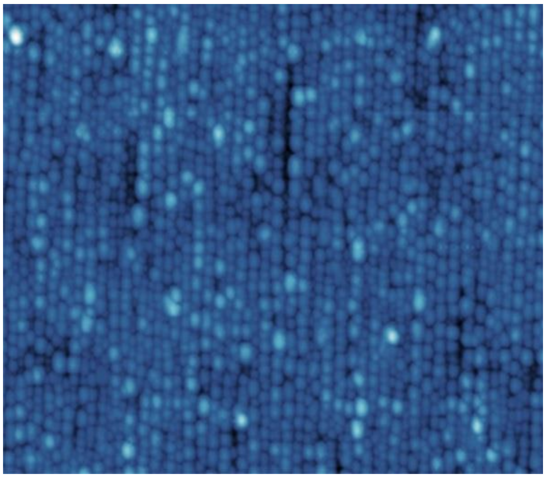
4. Functional materials and novel devices for electronics and energy applications

Activity leader: Daniele Marrè

4.1 Functional materials and novel devices for electronics and energy (Genoa)

Contact person	Daniele Marré (Daniele.Marre@spin.CNR.it)
Researchers	E. Bellingeri, F. Bisio, R. Buzio, A. Gerbi, R. Moroni, I. Pallecchi, L. Pellegrino
Associate Researchers	G. Costa, M. Ferretti, D. Marré, A. Sergio Siri

The main goal of this research module is to investigate (multi)functional transition metal compounds (oxides, chalcogenides, etc..) whose properties are appealing for future applications in electronic and energy fields and to design and realize innovative devices exploiting such materials.
During the 2012-2013 period, a special emphasis has been placed on materials and devices for energy applications; in particular we focused our efforts on photovoltaics and thermoelectrics, by studying:
-*plasmonic resonances of transition metal nanoparticles*; we have succeeded in fabricating ultradense bidimensional arrays of nanosized aluminum particles exhibiting a Localized Surface Plasmon resonance in the deep UV region of the spectrum, a spectral range never before accessed in plasmonics. The key aspect that enabled this achievement is the use of a bottom-up approach for sample fabrication that allows to obtain nanostructures beyond the current limit of lithography.
- *rectifying behavior of transition metal oxide junctions* from macroscale to nanoscale, (the latter studied by Ballistic Electron Emission Microscopy). The research activity has been focused on the investigation of electronic transport on Au/Nb:$SrTiO_3$ and Au/HfO_2/TiN junctions. Nanoscale characterization of the inhomogeneity at metal-oxide and metal-semiconductor contact barriers have been correlated with the macroscopic response of the devices.
- *enhancement of thermoelectric properties of strongly correlated oxide confined structures*. We have investigated the effect of the confinement of a two-dimensional electron gas in oxide heterostructures. We have found a large thermopower enhancement in Nb doped $SrTiO_3$ superlattices due to dilution of the mobile charge over many weakly occupied bands.



We have found also a huge enhancement of the thermopower in $SrTiO_3$/$LaAlO_3$ interfaces in depletion regime due to a large electron phonon coupling.
Moreover, within the energy related activities, a seed project has been launched aiming at the development of a low cost high throughput material deposition technique based on ink-jet .

Fig.1: AFM image of a self-organized array of Al nanoparticles with DUV plasmonic functionality.

Research Lines

4. Functional materials and novel devices for electronics and energy applications

Activity leader: Daniele Marrè

Concerning activity focused on materials and devices for electronics, the main research topics in that period have been:

-*Investigation of electric and optoelectronic properties of 2DEGS lying at the interface between oxides.* 2DEGS have been realized in semiconducting ZnO/ZnMgO heterostructures; high field characterization, performed at Nijmegen (NL), has evidenced quantum phenomena both in electrical and in thermoelectrical transport properties. On the other hand, insulating $SrTiO_3/LaAlO_3$, or similar interfaces showing polar discontinuity, have been realized and characterized, shedding some light on the origin of interface magnetism.

Finally, by combining theoretical and experimental efforts, new oxide based interfaces hosting a 2DEG have been proposed.

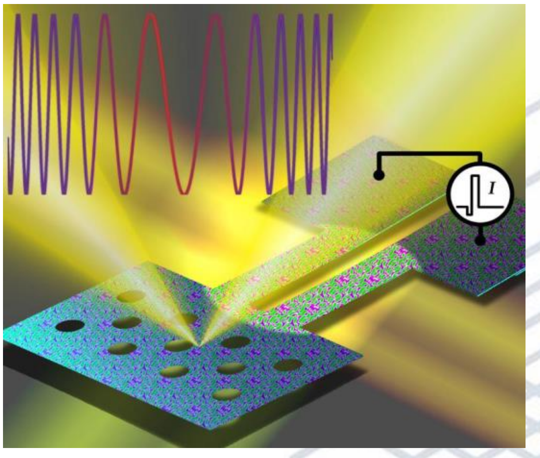


Fig.2: A programmable micromechanical resonator based on a VO2 thin film. Multiple mechanical eigenfrequency states can be programmed using Joule heating..

- *Investigation of mechanical and electrical memory effects on MEMS fully based on transition metal oxides*; promising results have been obtained for TiO_2 based MEMS (see figure). The activity on oxide-based microelectromechanical systems concerns the use of micrometric free-standing elements made of crystalline oxide films to investigate phase transitions in transition metal oxide films. We have realized a multilevel resistance and a programmable mechanical resonator made with VO2 thin films cantilevers (collaboration with Prof. Kanki and Prof. Tanaka from ISIR, Japan), using Joule heating as local power source to gradually drive the phase transition of VO2 around its Metal-Insulator transition temperature. Microbridges of manganite films ((La,Sr)MnO3) for bolometric detection and microheaters have been also realized starting from epitaxial all-oxide heterostructures.

- *Development and characterization of magnetic nanoparticles.* Nanoparticles and bulk of (La1-xCax)MnO3 with x=Cu, Ni have been synthetized and characterized evidencing size and substitution effects.

As final remark, it must be noticed that, as in the previous period, researchers within this module, have carried out important research tasks on both fundamental and applied superconductivity. Report about such research topics can be found in activity 2 pages.

4. Functional materials and novel devices for electronics and energy applications

Activity leader: Daniele Marrè

4.2 Fundamental properties of functional materials suitable for application in energetics (Rome and Salerno)

Contact person	Pasquale Orgiani (pasquale.orgiani@spin.CNR.it)
Researchers	C.Aruta, P.Orgiani
Associate Researchers	G. Balestrino, D. Di Castro, L.Maritato, A.Tebano

The main goal of the module is to integrate knowledge and techniques present at CNR-SPIN to get a deeper understanding of the underlying mechanisms correlating the structural, magnetic and electrical properties of materials for microelectronics and energetics. By using molecular beam epitaxy (MBE) and pulsed laser deposition (PLD) systems, novel materials, mostly oxides in the form of thin films, are investigated. Physical properties of heterostructures and/or single-phase films are investigated by combining different laboratory characterization techniques (such as x-ray diffraction, electrical and magneto-electrical analysis) as well as by using synchrotron radiation based techniques (such as x-ray absorption and x-ray photoemission spectroscopy). The intrinsic behavior, closely linked to the fundamental interactions of materials, are discriminated with respect to extrinsic effects, mostly due to the structural/chemical disorder, by systematically varying materials and structural features (e.g. substrate induced strain) and comparing the experimental data. The study of the fundamental physical characteristics allows to highlight the most promising systems in view of practical applications.

Within the research activity of the module, the group in Salerno is focused on the study of electronic and magneto-electronic properties of metal oxides, in particular manganites and cuprates. Starting from the consolidated activities regarding the thin film deposition (by both MBE and PLD), the structural characterization (by x-ray diffraction) and the magneto-transport characterization (e.g. resistivity curves as a function of temperature with/without the presence of a magnetic field up to 7 Tesla), the 2012-2013 period has witnessed a considerable increase of the group's activities in the field of electronic characterization of materials by synchrotron radiation based techniques, including long-term projects at the large scale facility ELETTRA and several short-term experiments on proposal at the European synchrotron facility ESRF and at the French facility SOLEIL.

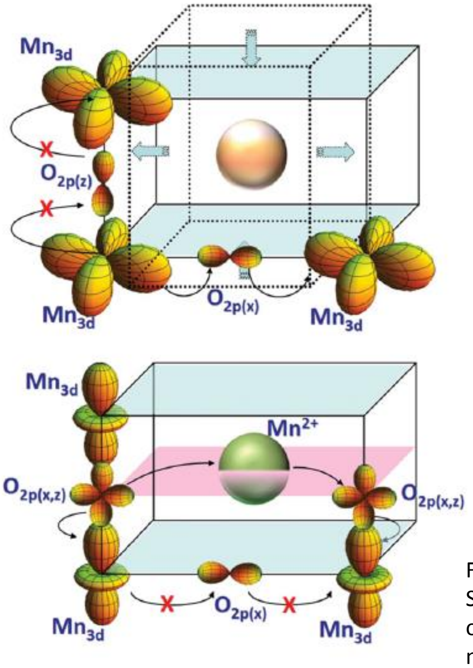


Fig.1
Schematic diagram of preferential orbital occupation in stoichiometric and off-stoichiometric LSMO manganites. The kinetic energy of electrons in the new channel of conduction through the A-site can explain the different orbital occupation.

Research Lines

4. Functional materials and novel devices for electronics and energy applications

Activity leader: Daniele Marrè

These activities have been framed within a scientific collaboration agreement with ELETTRA synchrotron facility (more specifically with the CNR-IOM institute) on the morphological and the chemical characterization (SEM-EDS), structural analysis (XRD) and electronic characterization (XPS, XAS, ARPES) of functional oxides produced in form of thin films at Salerno's facilities.

The research activities carried out by the SPIN-group of Rome Tor Vergata cover mainly two scientific arguments: a) getting new functional properties in artificial structures formed by infinite-layers cuprates and other perovskite oxides, b) engineering materials/heterostructures with high proton/ion conductivity for application in micro-Solid Oxide Fuel Cells.

Samples are grown by PLD with in-situ RHEED diagnostic and characterized by conventional laboratory instrumentation and advanced synchrotron radiation techniques at the ESRF in France and at the Diamond light source in England. In particular, polarization dependent x-ray absorption and high-energy x-ray photoemission (HAXPES) spectroscopies are used to investigate the electronic properties at interface. In the case of ionic and proton conductors the role of interfaces and granularity on the electrochemical activity and, thus on the conduction, is investigated through the comparison between macroscopic measurements of impedance spectroscopy (EIS) and the use of a specific scanning microscopy technique called electro-chemical strain microscopy (ESM) in collaboration with the NAST Center of Tor Vergata and the Oak-Ridge National laboratory (USA) where several peer review experiments were performed.

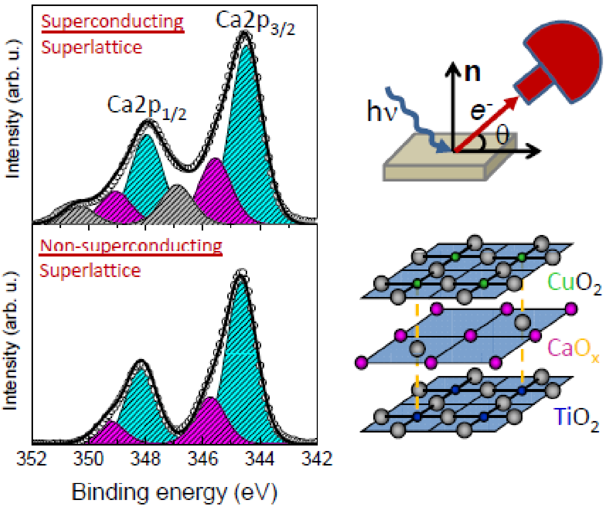


Fig.2
Ca 2p core level HAXPES measurements show the oxygen redistribution in the CaCuO2/SrTiO3 interface at the orgin of the superconducting properties.

The most important results of the research group in Salerno has been obtained in the field of the physical properties of ferromagnetic (e.g. manganites) and superconducting (e.g. cuprates) functional oxides. In particular, by using x-ray absorption spectroscopy and the photo-emission effect by hard x-ray light, phenomena such as the effect of charge concentration in the redistribution of electronic bands in strongly correlated systems, has been deeply investigated by making possible the better understanding of fundamental physical phenomena at the basis of these materials. About the activities of the group in Roma, one of the main relevant achievement is the superconductivity obtained in $CaCuO_2/SrTiO_3$ heterostructures with Tc about 40 K. The fundamental role of the oxygen redistribution at the interface has been highlightened by synchrotron spectroscopic measurements. In addition, the research activity on ionic/proton conductors made it possible to clarify the relevant effect of defects on the conductivity of micro-Solid Oxide Fuel Cells.

4. Functional materials and novel devices for electronics and energy applications

Activity leader: Daniele Marrè

4.3 Emerging routes for the control of the (opto)electronic properties of multifunctional materials and devices (Naples)

Contact person	Mario Barra (mario.barra@spin.CNR.it)
Researchers	A. Ambrosio, M. Barra, G. M. De Luca, S. Lettieri, M. Salluzzo
Associate Researchers	G. Ambrosone, F. Bloisi, L. Braicovich, A. Cassinese, F. Ciccullo, R. Di Capua, G. Ghiringhelli, P. Maddalena, L. Vicari.

The activities are focused on the emerging routes for control and analysis of the electronic properties of innovative materials, systems and devices going beyond the present state-of-the-art. The research efforts are basically devoted to study the physical properties of materials exhibiting sensitivity to the strain, light, electric or magnetic field, chemical and electrical doping, charge transfer or phase transition phenomena. Two main material categories are investigated:

- Carbon-based compounds: organic p- and n-type semiconductors (Perylene diimide, Picene, polythiophene), Azobenzene-containing polymers, bio-polymers, silicon carbon;
- Oxides: Strongly correlated oxides like cuprates, manganites ($BiMnO_3$), titanates ($SrTiO_3$) and related heterostructures; Conducting and semiconducting binary oxides (ZnO, TiO_2).

A wide number of deposition techniques (OMBD, PLD, MAPLE, Sputtering, ,SuMBD) are employed for the growth of the materials in form of thin films. Their fundamental properties are then characterized through the use of advanced spectroscopic techniques such RIXS, GIXD and XAS based on synchrotron radiation, SPM, SHG, SNOM.

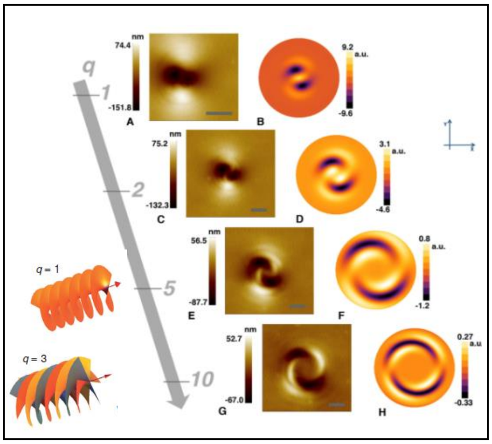


Fig.1 Spiral relief patterns on the surface of azobenzene polymer surface achieved by vortex-beam illumination[7].

During the 2012-2013 period, the main lines of research dealt with:

Charge transport and trapping phenomena in n-type organic semiconductors;

Interfacial electronic phenomena in organic-organic and organic-inorganic heterostructures;

Basic mechanisms ruling high T_c superconductivity in cuprates;

Electronic and magnetic properties in $SrTiO_3$-based heterostructures;

Ferromagnetic and ferroelectric properties of $BiMnO_3$ films;

Light-driven complex surface structuring of azobenzene-containg polymers;

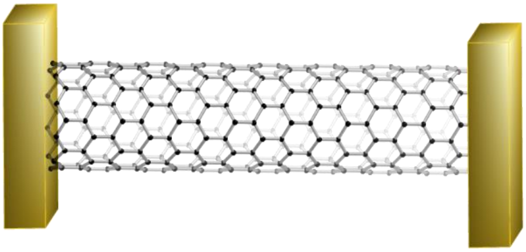
Fluorescence properties of nano-structured binary oxides and related response to gas exposure;

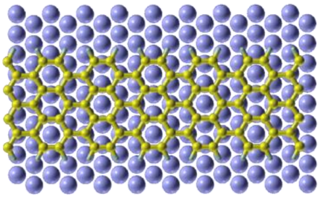
Deposition and characterization of bio-functional films;

Deposition of nanostructured silicon-carbon films.

5. Dynamical, electronic and transport properties of complex systems and functional materials

Activity leader: Vittorio Cataudella





General Description

The focus of our theoretical activity is on modeling equilibrium and transport properties of nano-systems and nano-devices, such as quantum hall liquids and topological conductors, nano-electro-mechanical systems, strongly correlated systems such as cuprates, optical lattices and nanotubes, hybrid superconductor-normal metal devices as well as polimeric structures and biological systems. Our research ranges from the study and prediction of equilibrium and transport properties of novel nano-devices and materials, to the analysis of experimental data from existing systems.

Concerning nanotubes we have investigated charge and spin correlations mainly focusing on nanotube-based electronic devices also employed in nano-electromechanical applications. We have analysed the effects of Wigner correlations probed with an AFM or STM tip. We also investigated the nano-electromechanical properties of suspended nanotubes showing the extreme sensitivity of the induced current to the change in mechanical properties. One of our goals was to assess the performances of carbon nanotubes as molecular sensors based on transport properties. Furthermore, based on DFT calculations, we addressed two fundamental aspects on graphene nanoribbons (GNR) which are still controversial and debated in the literature, namely, how and to what extent the presence of both the substrate and the covalent functionalization of the GNR affects the device electronic properties.

We have enhanced our understanding of particle suspensions (colloids, foams, bubbles, granular materials and the like),i.e. systems of finite-size particles in a solvent, pointing out that it is important to go beyond a two-body approach. We have also shown that the dynamic properties of a polymeric gel display a non trivial interference between the gel and the glass transition lines.

Finally we addressed the open problem of Chromatin spatial organization in the cell nucleus that serves vital functional purposes. Introduced the ”strings and binders switch” model we were able to explain the origin and variety of chromatin behaviors that coexist and dynamically change within living cells.

5. Dynamical, electronic and transport properties of complex systems and functional materials

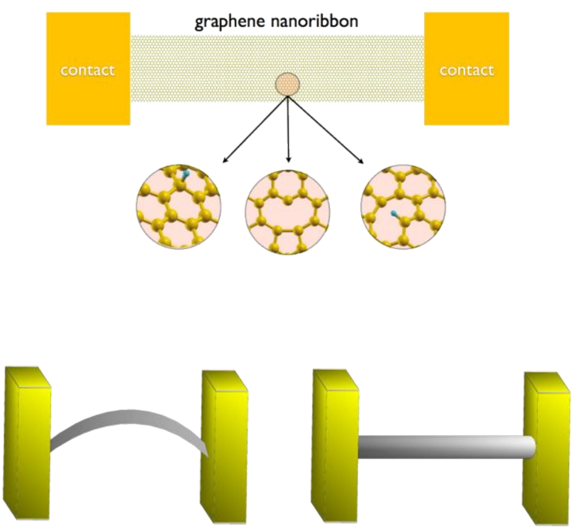
Activity leader: Vittorio Cataudella

5.1 Models and first-principles approaches for functional materials and complex systems (Naples)

Contact person	Vittorio Cataudella (vittorio.cataudella@unina.it)
Researchers	G. Cantele, A. Fierro, M. Pica Ciamarra
Associate Researchers	V. Cataudella, R. Citro, A. Coniglio, A. De Candia, G. De Filippis, M. Nicodemi, D. Ninno, C.A. Perroni

Carbon nanostructures have been shown to fit a wide range of applications. Size-dependent properties, together with the unique mechanical and electronic features of the underlying graphene lattice, allow the desing and engineering of new classes of devices. Among the many, we mention single-electron transistors for nanoelectronics and nanoelectromechanical resonators. These devices are driven by the nanostructure ability of carrying an electronic current, the coupling to the metallic substrate and/or contacts, the coupling of electron transport and mechanical motion, charge transfer processes.

To shed light on these properties, both first principles calculations based on density functional theory (DFT) and effective model calculations based on the Holstein model have been applied to different systems based on carbon nanostructures, as sketched in Fig. 1. In the case of carbon nanotube (CN) we have shown that the extreme sensitivity of the induced current to the change in mechanical properties of the suspended CN (due, for instance, to an adsorbed molecules or an external magnetic fields) allows to use these devices as sensors.



Graphene nanoribbons covalently immobilized on a metallic substrate. The study, based on extensive large-scale DFT calculations, addresses two fundamental aspects which are still controversial and debated in the literature, namely, how and to what extent the presence of both the substrate and the covalent functionalization of the GNR affects the device electronic properties. The results indicate a route for the realization of nanopatterned GNR-based nanodevices and highlight the role of the local chemistry in the performance and functionality of such devices.

Fig.1
Graphene nano structures contacted between two metallic electrodes. Applications range from nano electronic (top panel) to nanoelectromechanic (bottom panel) devices. Device engineering needs control over size, shape, functionalization or even defects distribution.

Research Lines

5. Dynamical, electronic and transport properties of complex systems and functional materials

Activity leader: Vittorio Cataudella

Particle suspensions (colloids, foams, bubbles, granular materials and the like),i.e. systems of finite-size particles in a solvent, are commonly investigated via an effective interaction approach, where they are considered to behave as point particles interacting via an effective two body potential. We have questioned the correctness of this approach for system of macroscopic soft particles, such as suspension of gel particles, that shrink and deform when compressed. The figure illustrates a numerical study allowing to measure the interaction energy of a particle fixed in the origin, with other confining particles placed at a distance r.

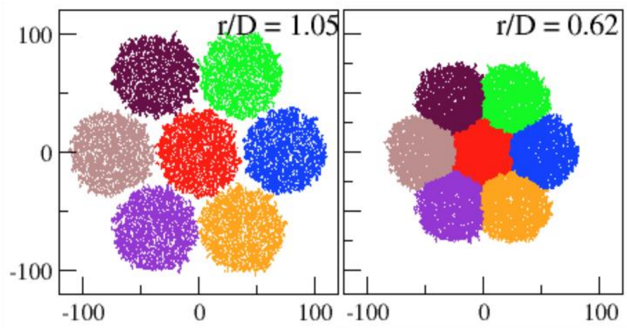


Fig.2
The investigation of the energy of interaction of soft polymeric particles reveals that these interact via a many-body effective potential.

By studying the dependence of the average energy of interaction of the central particle with the other particles, as a function of the number of 'confining' particles, we have demonstrated that soft particles interact via a many-body potential.

Chromatin has a complex spatial organization in the cell nucleus that serves vital functional purposes. A variety of chromatin folding conformations has been detected by single-cell imaging and chromosome conformation capture-based approaches. However, a unified quantitative framework describing spatial chromatin organization is still lacking. We introduced the ”strings and binders switch,” model to explain the origin and variety of chromatin behaviors that coexist and dynamically change within living cells. This simple polymer model recapitulates the scaling properties of chromatin folding reported experimentally in different cellular systems, the fractal state of chromatin, the processes of domain formation, and looping out.

The dynamic properties of a polymeric gel display a non trivial interference between the gel and the glass transition lines. Focusing on a system with permanent bonds where the sol-gel and the glass transition lines intersect we observe the interference of a continuous and a discontinuous transition of structural arrest. Our findings are in agreement with Mode CouplingTheory for schematic F_{13} model, which predicts the presence of logarithmic decay in the relaxation.

5. Dynamical, electronic and transport properties of complex systems and functional materials

Activity leader: Vittorio Cataudella

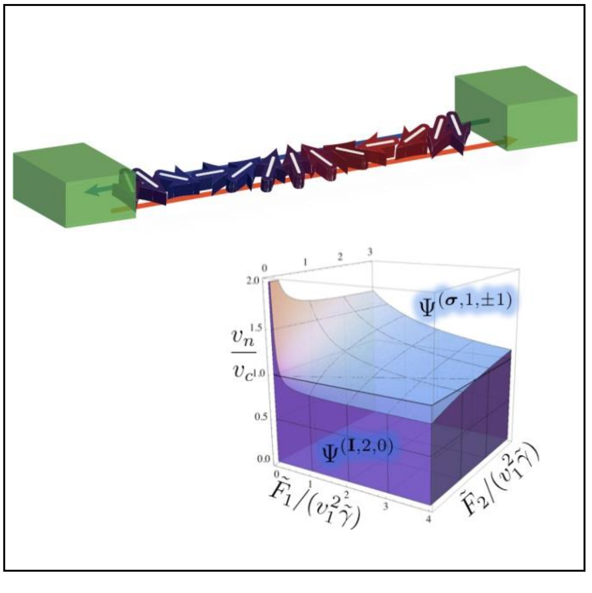
5.2 Quantum nano devices and complex systems (Genoa)

Contact person	Maura Sassetti (sassetti@fisica.unige.it)
Researchers	A. Braggio, P. Solinas
Associate Researchers	M. Sassetti

In this theoretical activity we investigate the properties of nano-systems and nano-devices, such as quantum hall liquids and topological conductors, nano-electromechanical systems, strongly correlated nanotubes and nanowires, hybrid superconductor-normal metal devices.

Our research ranges from the study and prediction of equilibrium and transport properties of novel nano-devices, to the analysis of experimental data from existing systems.

Concerning nanotubes we have investigated charge and spin correlations mainly focusing on nanotube-based electronic devices also employed in nano-electromechanical applications. We have analysed the effects of Wigner correlations probed with an AFM or STM tip. We also investigated the nano-electromechanical properties of suspended nanotubes and in the quantum coherent regime. One of our goals was to assess the performances of carbon nanotubes as molecular sensors based on transport properties.



Another line of research has been devoted to system characterized by a topological order such as topological insulators and quantum Hall systems. In particular, we investigated the nature of the edge states, their interference properties, the possibility to produce spin current pumping, Coulomb blockade detection and tunnelling in extended contacts within the helical Luttinger liquid arising at the boundaries of a topological insulator. The transport and noise properties of fractional non-Abelian quantum hall states were investigated, analyzing signatures of the edge state model taking also into acccount the non-equilibrium 1/f noise.

Fig.1
Top: Helical Luttinger liquid at the edge of topological insulator.
Bottom: Dominance of Abelian over non-Abelian excitation as a function of 1/f noise strength.

Research Lines

5. Dynamical, electronic and transport properties of complex systems and functional materials

Activity leader: Vittorio Cataudella

Motivated by the existence of topological materials we investigated the boundary states that automatically stem from topological field theories, describing the bulk properties of topological insulators, when fundamental properties such as gauge symmetries, are imposed. Their properties are peculiar and universal, since they are "protected" by topological order and/or discrete symmetries (such as time reversal). A non-trivial result was the demonstration that "background field" topological field theories could be an appropriate description of topological insulator in 2+1D (also in the non-Abelian case) and in 3+1D or, via dimensional reduction, in another topological material such as a Weyl semimetal. Recently we have started to investigate how holographic methods could be used to investigate unconventional superconductors and their peculiar properties, in close collaboration with researchers at INFN.

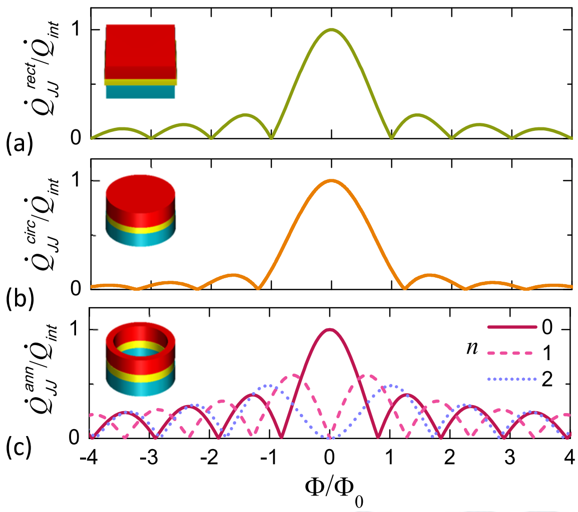
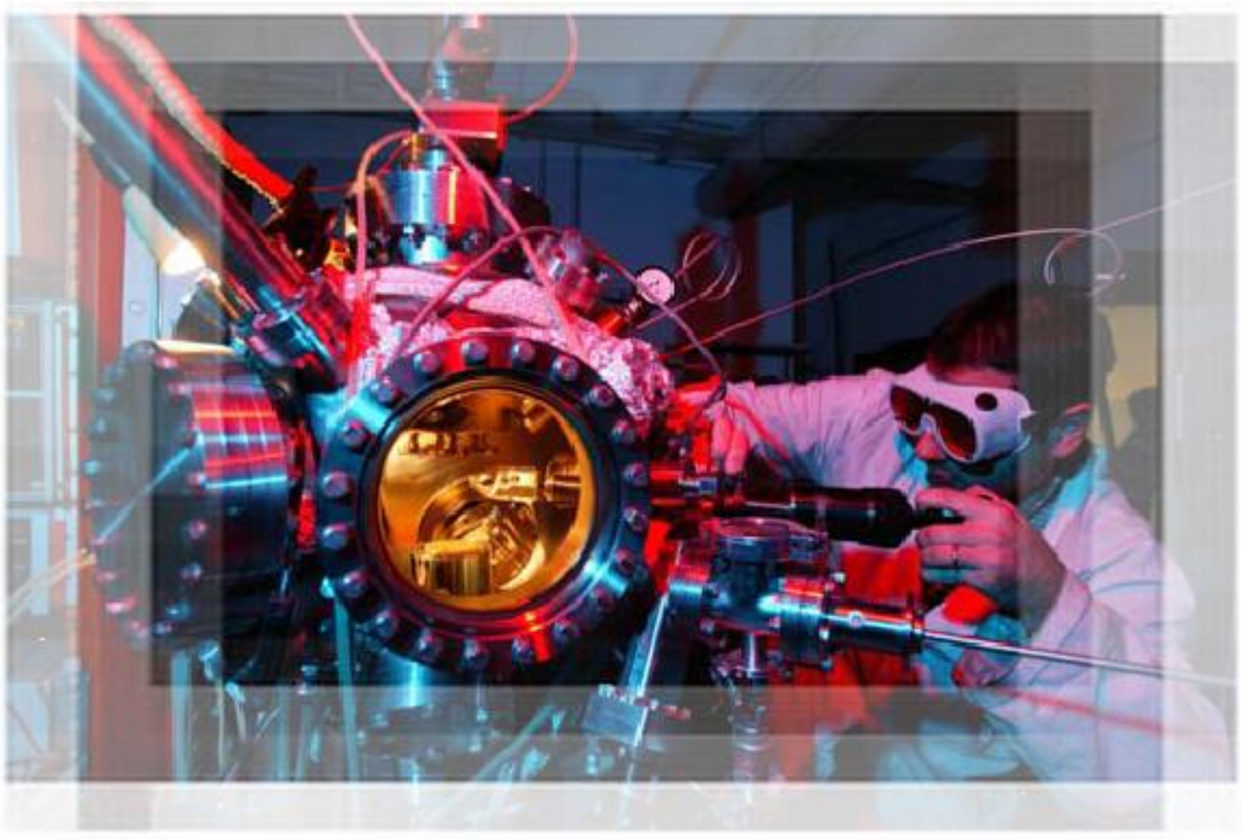


Fig.2
Heat transport interference in extended Josephson junctions under an externall magnetic field.

Our last research topic is devoted to the transport properties of hybrid superconductor-normal metal devices. In particular we studied the effects on the transport and noise properties and the full counting statistics of a quantum dot mediating the coupling between the superconducting and normal metal lead, considering Andreev currents and non-local pair breaking phenomena. The inclusion of spin-orbit interaction in the hybrid system, also including a magnetic field, opens the possibility to investigate the existence and the properties of Majorana fermions which recently have attracted much attention.

The investigation of thermal transport in extended Josephson junctions when an external magnetic field is applied has been performed in collaboration with researchers at CNR-NANO in Pisa. In particular interference patterns of the thermal transport were predicted, in strong analogy with optics, suggesting the interpretation of coherent thermal transport. Such interference patterns were recently observed in experiments, starting the new field of coherent thermal transport. Future developments of this research will address the thermal transport statistics of coherent nano-systems also the presence of dissipative baths. Electro-thermal transport properties will be also analysed in novel superconducting materials such as iron-pnictide, experimentally studied at the CNR-SPIN.

Equipment



Equipment

SPIN is endowed with a large set of advanced scientific equipments, including nearly 20 thin film deposition systems, 3 clean rooms, 3 low temperature - high field STM systems, numerous laser sources emitting form IR to UV and ranging form CW mode to femtosecond pulses.

SPIN equipment can be grouped into the following homogeneous Areas :

Thin film Deposition (Resp. Giuseppe Balestrino)

Lithography (Resp. Nadia Martucciello)

Bulk material preparation (Resp. Alberto Martinelli)

Structural, morphological and chemical properties (Resp. Umberto Scotti di Uccio)

Optical properties and characterization (Resp. Domenico Paparo)

Electronic and transport properties (Resp. Luigi Maritato)

Computation (Resp. Mario Cuoco)

The role of the Area Responsible is to guarantee the optimal use of the Institute equipments and to promote new acquisitions to improve the Institute potentialities in the specific area.

Some of the main equipment divided by Research Units are described in the following pages.

Main experimental facilities

Genova

The UOS of Genova has a large amount of scientific equipment allowing preparation of different materials in bulk, wire, tape and thin film form, as well as morphological, structural magnetic and transport properties characterization. The UOS own also a Helium liquefier allowing L-HE production of about 15 liters per hour and a setup for He gas recovery and storage.

Main equipments in SPIN-Genova Laboratories are:

Bulk and (nano) powders preparation

Different chemical laboratories equipped for synthesis of different materials by solid state reactions and chemical characterization.

Superconducting Wires and tapes

Rollling and Drawing machines allowing the realization of tapes and wires on kilometer length scale using the powder in tube technique. Various furnaces in different controlled atmosphere

Thin Film Deposition

2 excimer lasers and two PLD systems with multitarget carousel and RHEED tools for in situ monitoring of the growth. One mixed MBE/PLD system, several effusive cells for transition metal deposition. The lab own also an ink-jet printer for low cost material deposition

Device fabrication

Clean room equipped with optical lithography facilities, DC sputtering system, AFM nanolithography system, supercritical drier system.

Scanning Probe Microscopy:

Atomic Force Microscope and Low Temperature Scanning Tunnel Microscope allowing investigation of morphological and functional properties of thin films and devices.

Optical Spectroscopy and transport and magnetic properties measurements

Variable temperature MOKE system, Spectroscopic ellipsometry, 2 Squid systems for magnetic characterization and a Physical Properties Measurement System by Quantum Design, several cryostats for electrical, thermoelectrical and thermal transport properties measurements.

Deformation Laboratory

SEM equipped with high speed, high resolution EDX

Ink-jet printer for material deposition

Main experimental facilities

Napoli

The UOS-Napoli has a considerable set of scientific equipment covering the following areas: advanced material fabrication of thin films, structural/morphological and transport characterization down to low temperatures (30mK) and high magnetic fields (8T), advanced optical characterization and spectroscopy, low noise electronic characterization of devices and sensors, micro- and nano-patterning, high/performance scientific calculus. Some equipment is part of a larger pool belonging to the University host Department (Dept. of Physics of the University of Napoli "Federico II") and is located in shared laboratories.

Some relevant equipments are:

MODA system : Modular facility for oxide deposition and in-situ analysis of epitaxial thin films

SuMBD facility: a multi-chamber system with a supersonic highly homogeneuos molecular beam for high quality organic thin films

Computational facility: Multiprocessor cluster for high-performance parallel computing, equipped with a fast intra-node interconnect (Infiniband). 212 computing units (*cores*) are available, with a total RAM memory of 648 Gb.

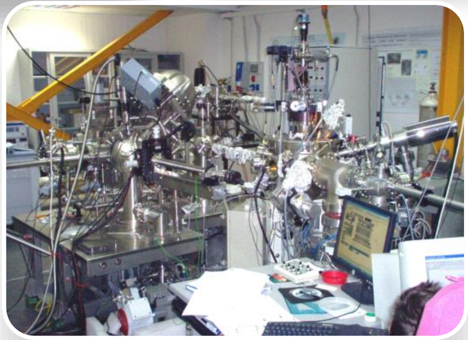
White Light generation system: amplified Laser source, which delivers ultra-short and high-powerpulses (4 mJ, 1 KHz, 35 fs).

Plasma filamentation and White Light Generation in air, produced by an amplified Laser source

Supersonic Molecular Beam Deposition

Computational facility

M.O.D.A.



Main experimental facilities

Salerno

The UOS Salerno has a large amount of scientific equipment covering the following areas: advanced material fabrication in bulk and thin film form, structural and transport characterization, micro and nano patterning, advanced calculus. Some equipment is part of a larger pool belonging to the University host Departments (Physics and Engineering) and is located in shared laboratories.

Some relevant equipments are:

Electron microscopy facility: one tungsten/LaB6 SEM (LEO EVO 50) with a secondary electron and 4-quadrant back-scatter electron detectors, EDX, WDX and EBSD analysis; one FESEM (Σigma by ZEISS) with InLens, SE2 and BSE detectors, and nano-manipulators.

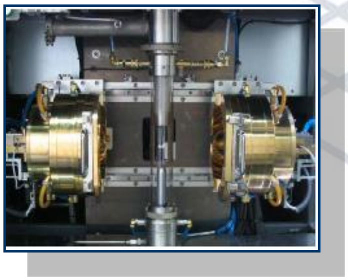
Bulk: Infrared image furnace for floating zone crystal growth

Thin Films: molecular beam epitaxy system equipped with different effusive cells and e-gun for RHEED analysis.

Transport:

Cryomagnet system equipped with a superconducting magnet and a variable temperature insert cooled by means of a cryo-refrigerator able to operate in the temperature range from 1.6 K to 300 K under magnetic field up to 9T.

FESEM (Sigma by ZEISS)



Infrared image furnace

Molecular beam epitaxy deposition system

Cryogen Free Magnet Variable Temperature Insert

Main experimental facilities

L'Aquila

The research Unit in L'Aquila is mostly composed by theorists. The computational resources used by the SPIN-Aq researchers are predominantly located at Supercomputing centers all around Europe (Cineca, Barcelona Supercomputing Centers, etc). Therefore, no specific equipment is located in L'Aquila.

Roma

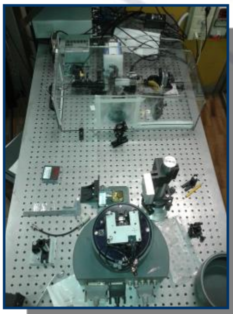
The working sites of SPIN in Rome are located at Tor Vergata and La SapienzaUniversities.

At University of Tor Vergata, SPIN is hosted in the Engineering Department. The relevant equipments are devoted to the thin films growth (mainly heterostructures and superlattices based on oxide perovskite systems) by pulsed laser deposition and their characterization by structural and transport measurements: three deposition chambers, a 3 circle diffractometer allowing reciprocal space mapping and two cryocoolers able to go down to 15 K are available, one of the two cryocoolers also equipped with an electromagnet able to produce a magnetic field up to 1 T along an arbitrary crystallographic direction.

At University of La Sapienza, SPIN is hosted in the Physics Department. The scientific equipments are covering the investigation of solid-state materials, nanostructures and biological systems by optical spectroscopy from the very far-infrared range through the mid-infrared up to the ultraviolet: broadband Fourier-transform spectroscopy is the main experimental tool, but grating spectrometers, infrared microscopes, quantum cascade lasers and terahertz amplifier-multiplier chains are also available.

Pulsed laser Deposition system with in-situ RHEED Diagnostics equipped with a multitarget system for oxide heterostructures and superlattices deposition in oxygen deposition atmosphere enriched with 12% of ozone.

@ SPIN Tor Vergata



AFM coupled to a Quantum Cascade Laser for infrared microscopy below the diffraction limit.

@ SPIN La Sapienza

Interferometer BRUKER 66V for Infrared Spectroscopy equipped with an infrared microscope and a cryogenic apparatus for transmittance and reflectivity measurements down to 5 K.

@ SPIN La Sapienza

Projects and Grants

Projects & Grants

SPIN Active Projects - 1

Type of Project	Coordinator	Title	SPIN Leader	UOS	Grant (€)
EU FP7 NMP - 2011	SPIN Genova	Exploring the potential of Iron-based Superconductors SUPER-IRON	Marina Putti	GE	493.912,00
UE FP7 ERC Starting Grants 2010	SPIN Aquila	Breaking Inversion Symmetry in Magnets: Understand via Theory	Silvia Picozzi	AQ	684.000,00
EU FP7 REGPOT - 2010	SPIN Salerno	Unlocking research potential for multifunctional advanced materials and nanoscale phenomena	Mario Cuoco	SA	2.400.00,00
EU FP7 NMP 2009	Univ. de Liege	Engineering Exotic Phenomena at Oxide Interfaces	Daniele Marrè	GE	354.797,00
EU FP7 ITN 2008	Lancaster Univ.	Nanoelectronics : concepts, theory and modelling	Maura Sassetti	GE	266.838,90
EU FP7 SPACE 2010	Univ. Carlo III de Madrid	Magnetic-Superconductor Cryogenic Non-contact Harmonic Drive	Carlo Ferdeghini	GE	251.658,00
EU FP7 ICT 2013 C	IFW	Curved nanomebranes for topological Quantum Computation	Paola Gentile	SA	308.220,00
EU FP7 COST	SPIN Napoli	Towards an Oxide-Based Electronics	Fabio Miletto	NA	600.000,00
PRIN 2008	Univ. Napoli	Spettroscopie ottiche, caratterizzazione strutturale e calcolo ab-initio applicati allo studio di gas bidimensionali alle interfacce di ossidi funzionali	Domenico Paparo	NA	48.498,00
PRIN 2008	Univ. Bologna	Studio, definizione e sviluppo di un cavo in MgB2 con proprietà elettriche e termiche adatte al suo utilizzo in un limitatore di corrente	Carlo Ferdeghini	GE	21.684,00
PRIN 2008	Univ. Genova	Studio teorico e con tecniche spettroscopiche degli effetti del disordine e della presenza di piu' bande nei pnictidi supercondutori Fe-As	Andrei Varlamov	RM	26.200,00
PRIN 2008	SPIN Genova	Protonic Conductirs Solid Oxide Fuel Cells	Daniele Marrè	GE	19.600,00
PRIN 2009	Politecnico Milano	Ordine orbitale e di spin nelle eterostrutture di cuparti e manganiti	Marco Salluzzo	NA SA RM	92.896,00
PRIN 2011	SPIN AQ	Interfacce di ossidi nuove proproetà emergenti, multifunzionalità e dispositivi per l'elttronica e l'energia	Silvia Picozzi	AQ SA NA	197.277,00
Progetti bilaterali	-	Accordo di cooperazione scientifica CNR - FCT (Portogallo)	Silvia Picozzi	AQ	5.000,00
Progetti bilaterali	-	Accordo di cooperazione scientifica CNR - BAS (Bulgaria)	Massimiliano Polichetti	SA	12.000,00

Projects & Grants

SPIN Active Projects - 2

Type of Project	Coordinator	Title	SPIN Leader	UOS	Grant (€)
Progetti bilaterali	-	Accordo di cooperazione scientifica CNR - BAS (Bulgaria)	Salvatore Amoruso	NA	12.000,00
FIRB Futuro in Ricerca 2011	Univ. Napoli	Nanostrutture ibride superconduttore: applicazioni nanoelettriche proprietà topologiche correlazione e disordine	Procolo Lucignano	NA	212.778,00
FIRB – Futuro in Ricerca 2008	SPIN Napoli	Transizione di unjamming nei materiali granulari e precursori sismici: teoria, esperimenti e simulazioni	Massimo Pica Ciamarra	NA	209.990,00
FIRB – Futuro in Ricerca 2011	SPIN Genova	Nanostrutture ibride superconduttore-semiconduttore: applicazioni nanoelettriche, proprietà topologiche, correlazione e disordine	Alessandro Braggio	GE	201.845,00
FIRB – Futuro in Ricerca 2012	NANO-CNR	Caloritronica coerente in circuiti mesoscopici superconduttori	Paolo Solinas	GE	251.292,00
FIRB – Accordo di Programma	Università di Firenze	Nanomagnetici molecolari su superfici metalliche e magnetiche per applicaizoni nella spintronica molecolare	Silvia Picozzi	AQ	242.611,00
FIRB – Accordo di Programma	Università di Milano Bicocca	Ossidi nanostrutturati: multi-funzionalità e applicazioni	Ruggero Vaglio	GE SA	220.360,00
PON 2007 - 2013	BioGem Scarl	Nuove strategie nanotecnologiche per la messa a punto di farmaci e presidi diagnostici diretti verso cellule cancerose circostanti	Gianpiero Pepe	NA	102.000,00
PON_03	SPIN Salerno	National Facility for superconduction system - NAFASSY	Gaia Grimaldi	SA	75.000,00
POR FESR Regione Basilicata	SPIN Napoli	Laser deposition for sensor (LDFS)	Massimo Valentino	NA	--
POR Campania 2007/2013 OB. OP. 2.1 e 2.2.	Magnaghi Aeronautica	Controllo ed “Health Monitoring and Management” di Sistemi Complessi e Strutture Miste Metallo-Composito operanti in Ambienti Ostili sottoposte a Sollecitazioni Gravose (SiHM)	Giampiero Pepe	NA	27.588,16
REGIONAL project (CAMPANIA)	ORION	Sistemi innovativi Integrati di Analisi di gas prodotti da scarichi industriali	Pasqualino Maddalena	NA	52,320,00
Regional Projects L.egge 5 Regione Campania	SPIN Na-Sa	Argomenti vari: Superconduttori, Ossidi, Organici	Orgiani, Gombos, Salluzzo, Perroni, Aruta	SA NA	52.000,00
Regione Liguria PO CRO FSE 2007-2013	SPIN Genova	Sviluppo di un cavo di diboruro di magnesio adatto per l’applicazione di un sistema SMES Cryogen Free	Carlo Ferdeghini	GE	52.000,00
Regione Liguria PO CRO FSE 2007-2013	SPIN Genova	Integrazione PET/MRI con applicazioni all’ematologia	Anna Maria Massone	GE	50.000,00

Projects & Grants

SPIN Active Projects - 3

Type of Project	Coordinator	Title	SPIN Leader	UOS	Grant (€)
Regione Liguria PO CRO FSE 2007-2013	SPIN Genova	Potenzialità applicative dei nuovi superconduttori a base di Ferro	Carlo Ferdeghini	GE	52.000,00
Fondazione CARIPLO	Politecnico Milano	Electronic Control of Magnetization in Spintronic Devices	Silvia Picozzi	AQ	50.000,00
Compagnia di San Paolo	SPIN Genova	Potenziamento della strumentazione nell'ambito delle attività di ricerca sui nuovi materiali per l'energetica	Emilio Bellingeri	GE	70.000,00
Compagnia di San Paolo	SPIN Genova	Sviluppo di fili innovativi superconduttori a base di ferro per applicazioni in alto campo magnetico	Andrea Malagoli	GE	50.000,00
Cooper Standard srl	SPIN Salerno	Analisi SEM / EDS	Vecchione, Fittipaldi	SA	10.000,00
ENEA	SPIN Salerno	Studio di stabilità temica e delle perdite in regime AC di avvolgimenti superconduttori ad alta temperatura critica	Umberto Gambardella	SA	10.000,00
ASG Superconductors spa	SPIN Genova	Sponsorizzazione Conferenza Internazionale EUCAS-2013	Caro Ferdeghini	GE	25.000,00
PARAMED srl	SPIN Genova	Sviluppo di tecnologie di elaborazione di immagini MRI	Anna Maria Massone	GE	25.000,00
Columbus Superconductors spa	SPIN Genova	Caratterizzazione di campioni di cavi e precursori	Caro Ferdeghini	GE	20.000,00
ASG Supercondutros spa	SPIN Genova	Caratterizzazione di materiali	Andrea Malagoli	GE	7.500,00
ENEA	SPIN Napoli	Progetto SMARTAGS	Ruggero Vaglio	NA	205.000,00

Projects & Grants

Main industrial partners

ASG Superconductors

Columbus Superconductors
GRUPPO MALACALZA

PARAmed MEDICAL SYSTEMS

PIAGGIO AERO

fondazione CARIGE

Compagnia di San Paolo

CooperStandard

Criotec IMPIANTI S.r.l.

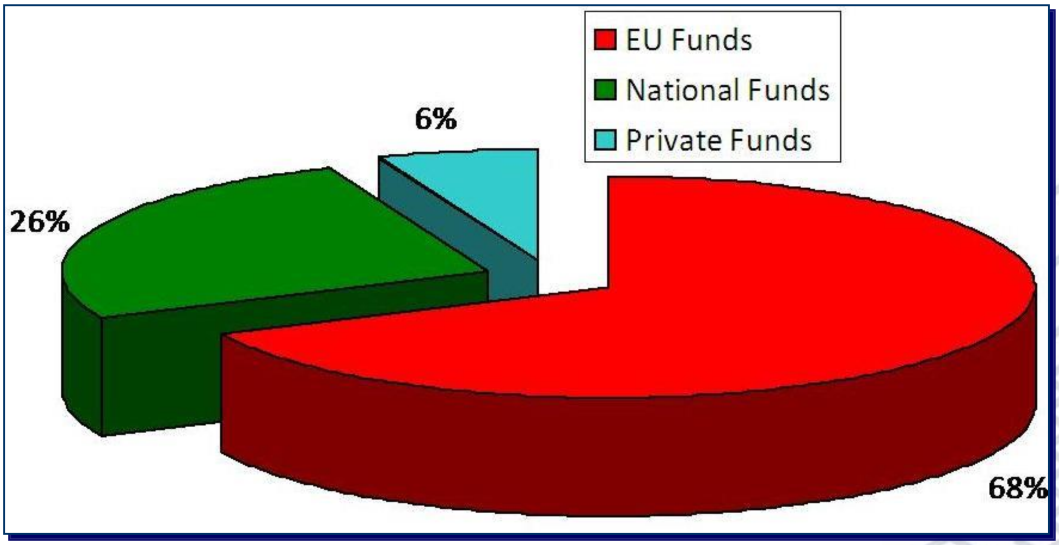
F.O.S.
Fibre Ottiche Sud Spa

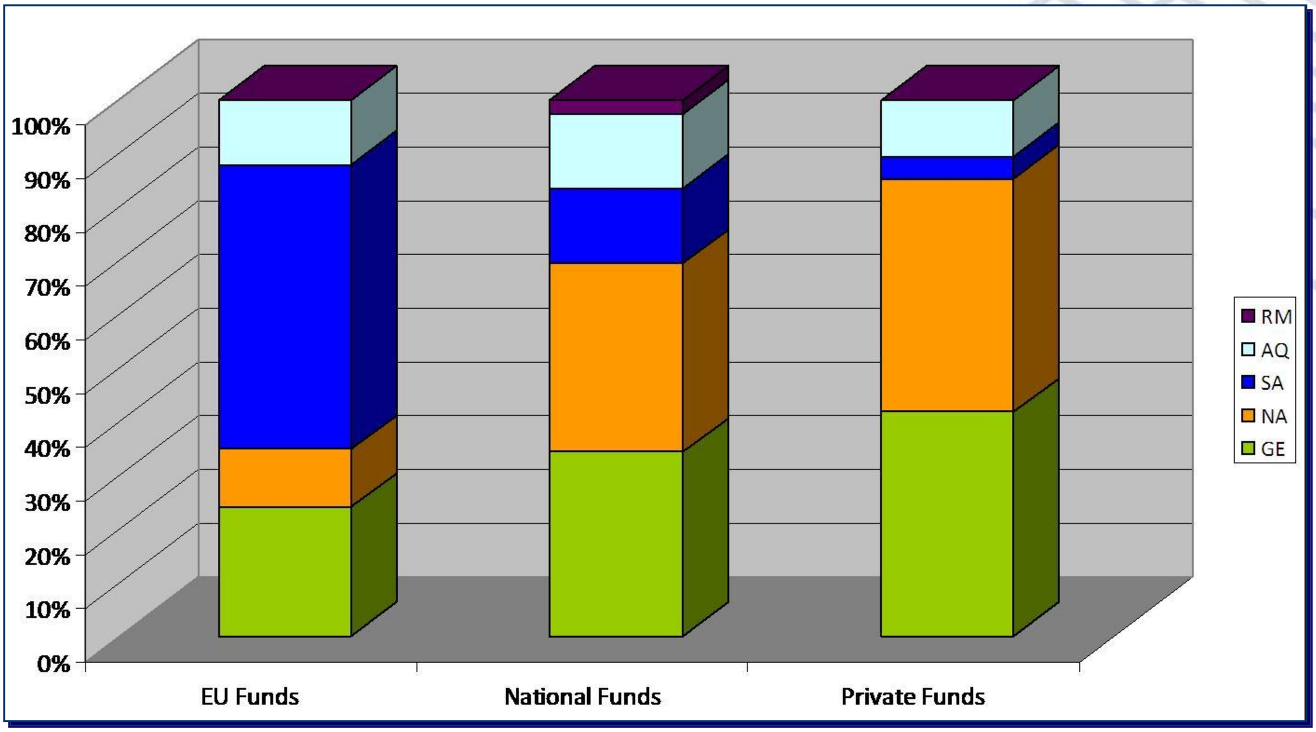
TFE Thin Film Equipment

Centro Sviluppo Materiali S.p.A.

KME

Projects & Grants





Projects

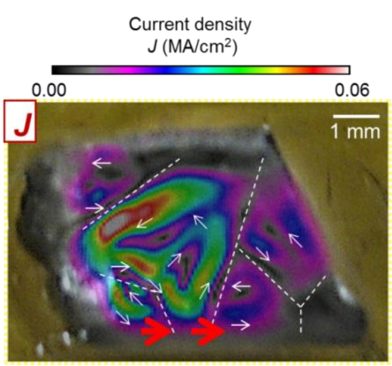
Main Projects

Title	Exploring the potential of Iron-based Superconductors
Acronym	**SUPER-IRON**
Source of funding	EC
Specific funding program	FP7-NMP-2011-Eu-Japan
Project Coordinator	SPIN GE
SPIN Coordinator	Marina Putti, SPIN GE
Other partners	J Karpiski, EPFL B. Holtzapfel, IFW D. Johrendt, Ludwig-Maximilians-Universität München M. Eisterer, Vienna University of Technology J.-I. Shimoyama, University of Tokyo T. Kiss, Kyushu University Y.Takano, NIMS H.Eisaki, AIST

Project objectives

In 2008 the group of Prof. Hosono discovered the superconductivity in a new compound containing FeAs planes, thus opening the age of Fe-based superconductors (FeSC). Several different phases were rapidly discovered and today the FeSCs show the second high Tc behind the high-Tc superconductors and very high critical fields. These characteristics suggested that FeSCs can be candidates for power application. Within SUPER-IRON we depict the roadmap for exploring and exploiting the potentialities of these materials: 1) understanding the fundamental mechanisms of superconductivity and their implication, 2) control material quality, 3) manipulate superconducting properties, 4) assess the potential of FeSCs with respect to other superconductors, 5) identify application fields, where FeSCs lead to a step-like change with respect to the current state of the art.

To cover this road SUPER-IRON has joined the efforts of the leader groups involved in the investigation of FeSCs throughout EU and Japan. Different phases of FeSCs and also the new pnictide oxides SC, in form of single crystals, polycrystals, thin films, tapes and wires will be realized by using different synthesis methods. Superconducting properties will be investigated also under high magnetic field and/or pressure and visualization of local electric field and current will be carried out with sophisticated techniques. This wide variety of experimental activities will be supported by an intense theoretical work including ab-initio calculations and theoretical modelling. The achievement of the planned objectives through synergic and coordinated activities will set the basis for future collaborations between Japan and EU.



Local Critical Current Density at 5 K in polycrystalline $FeTe_{0.5}Se_{0.5}$ sample (CNR) evaluated by Hall Probe Microscopy (Khyushu University)

Projects

Main Projects

Title	Magnetic-Superconductor Cryogenic Non-contact Harmonic Drive
Acronym	**MAGDRIVE**
Source of funding	EC
Specific funding program	FP7 Collaborative Project. Small or medium-scale focused research project
Project Coordinator	Prof. José Luis Pérez Diaz, Universidad Carlos III de Madrid, Spain
SPIN Coordinator	Carlo Ferdeghini, SPIN GE
Other partners	Universitá degli Studi di Cassino, Italy, CAN Superconductor, Czech Republic, BPE Germany, LIDAX, Spain, Fundacao da Faculdade de Ciencias da Universidade de Lisboa, Portugal

Project results

The objective of this project was to design, build and test a harmonic drive able to work at low temperatures for space application.

The Harmonic Drive (HD) mechanism is a power transmission capable of developing high ratios, providing a high positional precision to the assembly, with relatively low weight/volume ratio, high torque capability and near zero backlash. It was invented by Musser (1955) for aerospace applications, but it is widely used now in robotics, medical equipment, printing presses, vehicles or military industry. The application of HD mechanisms at low temperature (T<100 K) is limited by lubrication. Any kind of oil or grease freezes at cryogenic conditions, losing all the lubricant properties. The objective of this project is to design, build and test a magnetic-superconductor cryogenic non contact harmonic drive. This harmonic drive will be a mechanism with a great reduction ratio and it will be able to operate at cryogenic temperatures. It will be based on a non-contact interaction between magnets, soft magnetic materials and superconductors. Therefore the drive has not any wearing neither fatigue and it will not need any lubrication. As drives are profusely used in many different fields the result of this project is a qualitative jump that will open many opportunities. The role is in the SPIN project was to characterize and qualify the magnetic and superconducting materials used in MAGDRIVE.

The project was completed at the end of 2013 with a successful test of a working system at cryogenic temperatures and in vacuum useful for space application with the following characteristics:

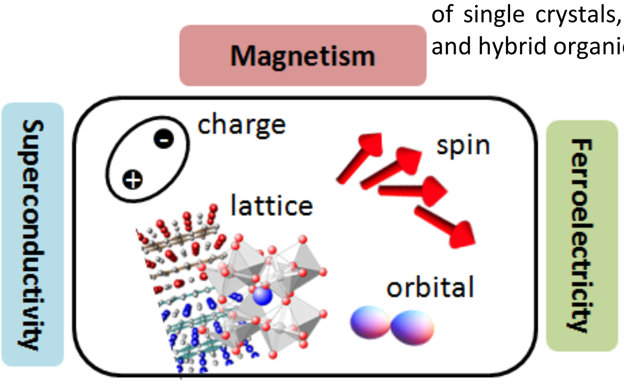
• Contactless levitating system • Through-wall capability. • No lubrication required. • Extended operation lifetime. • Overload protection. • Vacuum suitable. • Cryogenic temperatures up to -240 º C (33 K).

It was also made a room temperature version of MAGDRIVE (ie, without the bearings superconductors) that can find great technological applications in the field of robotics.

Projects

Main Projects

Title	Unlocking research potential for multifunctional advanced materials and nanoscale phenomena
Acronym	**MAMA**
Source of funding	EC
Specific funding program	FP7-REGPOT-2010-1
Project Coordinator	SPIN SA
SPIN Coordinator	Mario Cuoco, SPIN SA
Other partners	Kamerlingh Onnes Laboratory, Leiden School of Physics & Astronomy, St. Andrews IFW, Institute for Theoretical Solid State Physics, Dresden Institut für Festkörperforschung - Institute for Advanced Simulation, Jülich University of Twente, Twente University of Geneve, DPMC, Geneve Risø National Laboratory, Roskilde ETH, Zurich IMDEA, Madrid Chalmers University of Technology, Chalmers University of Warwick, Warwick
Project results	The project contributed to significantly increase the research potential on multifunctional materials. In particular, due to the exploitation of the project actions (know-how exchange, upgrade of equipment, and dissemination) the team of MAMA researchers succeeded in developing a leading position in the growth, characterization and theoretical modelling of single crystals, epitaxial thin films, complex all oxide heterostructures and hybrid organic-inorganic structures. The main achievements refer to:



- the increase of the human potential: eight researchers have been recruited, four of which have gained a permanent position in SPIN.

-the reinforcement of the visibility of the research capacity especially due to the successful organization of four international events (three workshops and a conference) and the intense exchange with all the partner institutions.

- the support for a successful participation to calls within the FP7 programme and to the national research project calls.

- the strengthening of the interaction with SMEs that led to the development of new partnerships.

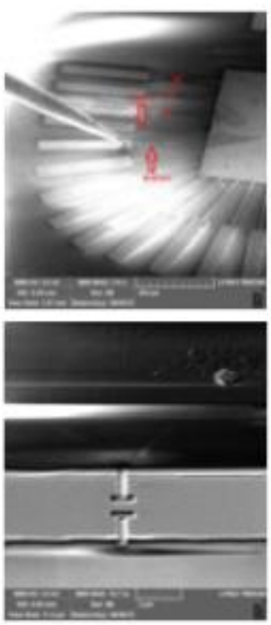
- the increase of research production: about 70 publications in peer-reviewed high-impact international journals were published in the framework of the MAMA project.

Projects

Main Projects

Title	Establishing the basic science and technology for Iron-based superconducting electronics applications
Acronym	**IRONSEA**
Source of funding	EC
Specific funding program	NMP.2011.2.2-6 Fundamental properties of novel superconducting materials (coordinated call with Japan)
Project Coordinator	Kazumasa Iida, Leibniz-Institut Fuer Festkoerper- Und Werkstoffforschung Dresden E.V. IFW Dresden Germany
SPIN Coordinator	Sergio Pagano, SPIN SA
Other partners	Friedrich-Schiller-Universitaet Jena FSU Jena Germany Univerzita Komenskeho V Bratislave Bratislava Slovakia Politecnico di Torino Italy Consiglio Nazionale Delle Ricerche - Istituto SPIN Italy Universiteit Twente Netherlands

Project results



Example of nanostructures realized with iron-based superconductors

Recent investigations on iron-based superconductors have revealed many similarities to MgB2 and the cuprates, for instance, a multiband nature, high upper critical fields and a short coherence length. An immediate interest of a new class of materials is the exploration of potential electronics applications such as Josephson devices and SQUIDs. In this project, we address the feasibility of electronics applications by establishing the fundamentals of the iron-based superconductors. Examining the Josephson effect and SQUIDs, through phase-sensitive experiments, we try to understand fundamental properties such as order parameters symmetry and energy gap, which is one of the main objective in this project. Investigations by point contact spectroscopy, infrared spectroscopy and transport properties are also conducted within the same frame of this work. Such fundamental studies may find unique physical properties, which lead to exploring new kinds of devices and applications. Since the iron-based superconductors are multi-band natures, comparative studies to MgB2 are also carried out.

CNR contributes to several activities using expertise and facilities available in various locations. The Genoa SPIN section is mainly involved in preparation of Fe-based (11) thin films on ordinary and bicrystal substrates and their morphologic and transport characterization. The Salerno SPIN section deals with the realization of high quality MgB2 thin films, noise spectroscopy and fast photo-response measurement on iron-based superconductors. The Naples SPIN section is mainly involved in performing pump probe measurements for characterisation of non-equilibrium processes in the materials and devices developed. The researchers at ICIB fabricate and characterize iron-based bicrystal grain boundary junctions, and develop theoretical modeling of Josephson processes.

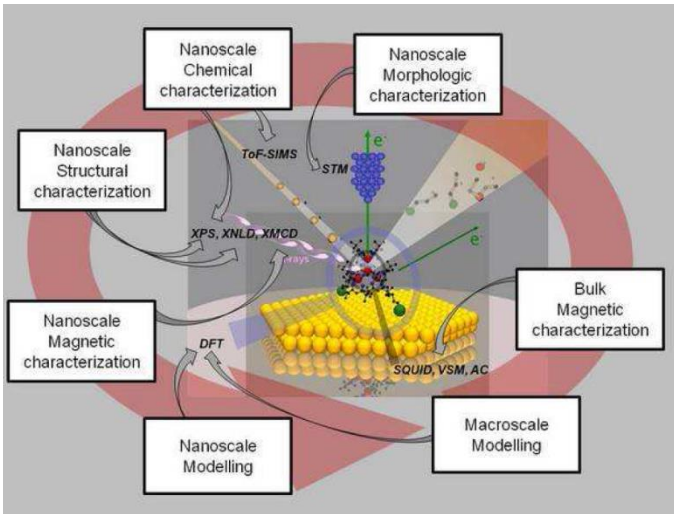
Projects

Main Projects

Title	Molecular nanomagnets on metallic and magnetic surfaces for applications in molecular spintronics
Acronym	--
Source of funding	MIUR
Specific funding program	FIRB Accordi di Programma
Project Coordinator	Università di Firenze
SPIN Coordinator	Silvia Picozzi, SPIN AQ
Other partners	Università di Firenze Università di Modena e Reggio Emilia Università del Salento CNR ISMN

Project results

The Project addresses, from both experimental and theoretical sides, radically new nanostructured materials for spintronics based on hybrid organic-inorganic architectures and containing Single-Molecule Magnets (SMMs) as active components. Specifically,the Project aims at understanding how an electric current driven through a SMM can control and sense the large molecular magnetic moment.



New phenomena in electronic magneto-transport (MT) are expected to arise, with a potentially large impact in data storage and manipulation technologies.Chemical design and synthesis target new SMMs to be deposited on surfaces by either self-assembly from solution or thermal evaporation. SMMs interacting with ad-hoc prepared ferromagnetic (FM) substrates are investigated by scanning probe and synchrotron-based techniques. Attention is focused on the effect of the magnetic substrate on the structural, electronic and magnetic properties of molecules, as well as on the chemical tailoring of such an effect. Substrates include FM metals and alloys and metal oxides like manganites (LSMO).

Theoretical work aims at elucidating the microscopic interaction between deposited SMMs and the underlying FM substrate, providing support to all other activities. SMM-based spintronic devices are assembled and their MT properties measured to reveal the role of the large molecular spin.

Projects

Main Projects

Title	OXide Interfaces: emerging new properties, multifunctionality, and DEvices for electronics and energy
Acronym	**OXIDE**
Source of funding	MIUR
Specific funding program	PRIN 2011
Project Coordinator	Università di Napoli
SPIN Coordinator	Silvia Picozzi, SPIN AQ
Other partners	Università di Cagliari Università di Genova Università di Roma "La Sapienza" Università di Roma "Tor Vergata" Università di Salerno

Project results

The OXIDE project plans to tackle different issues of the interface physics of complex oxides belonging to the perovskite family, with the double aim of clarifying a number of basic open questions and of exploring some of the most promising application prospects that result from it.

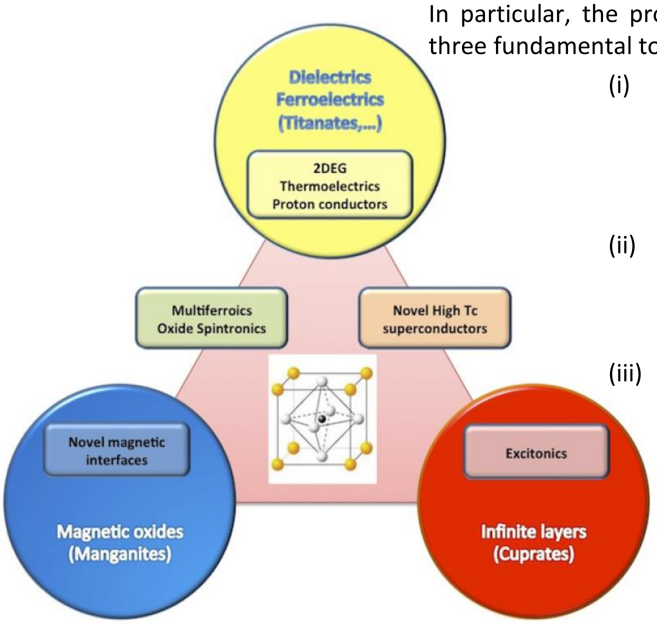
In particular, the project intends to investigate in depth the following three fundamental topics on the interfacial phenomena:

(i) electronic gases at interfaces: formation mechanisms, electrical transport properties, and applications for electronics and thermo-electric systems;

(ii) magnetic properties at interfaces and spin transport, fundamental mechanisms and spintronic applications for extremely low-power electronics;

(iii) ionic conduction at interfaces, mechanisms and properties, possible applications for fuel cells.

For each of these topics, we use a selected set of interfaces, studied with many different and complementary techniques. The project work plan includes also the realization of a series of devices based on oxide heterostructures, such as field-effect transistors, spin valves, thermoelectric devices, and micro-fuel-cells, used as proof-of-principle demonstrations of the applicability of these technologies and to begin assessing their real potential performances.



Schematic diagram showing the functional interfaces studied within OXIDE.

Projects

Main Projects

Title Orbital and spin order in cuprate and manganite heterostructures

Acronym --

Source of funding MIUR

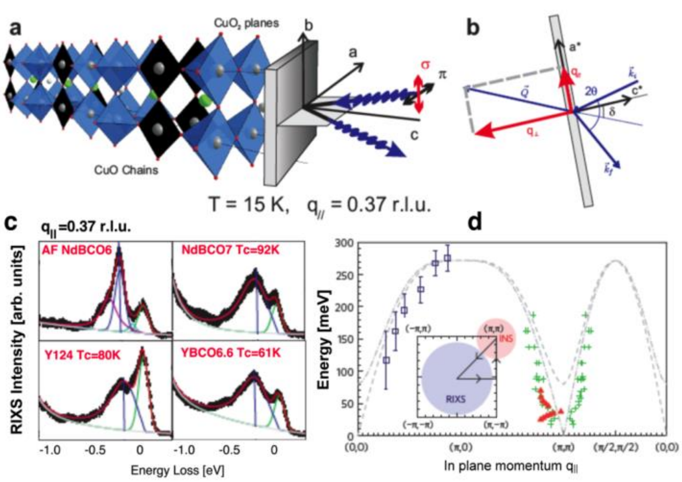
Specific funding program PRIN 2009

Project Coordinator Giacomo Ghiringhelli, Politecnico di Milano

SPIN Coordinator Marco Salluzzo, SPIN NA

Other partners --

Project objectives: The latest advances in oxide thin film deposition and characterization lead to the discovery that an "electronic reconstruction", adding unexpected functionalities to oxide systems, may occur at atomically sharp interfaces between metal transition oxides heterostructures.



Resonant Inelastic x-ray Scattering reveals charge and spin excitations in cuprates. a) and b) schematics of the RIXS experiment in the case of 123 cuprates. c) RIXS vs energy loss spectra for differently doped cuprates. d) Energy dispersion of magnon excitations obtained fro RIXS (open squares) compared to neutron scattering data.

The recent breakthroughs have stimulated many theoretical and experimental investigations of the electronic properties of oxide heterostructures, with the ambitious goal to create novel functionalities. In particular, many efforts around the world were devoted to the study of heterostructures based on Manganites, titanates and Cuprates epitaxial films, both for fundamental and applicative reasons.

Within the PRIN project "Orbital and spin order in cuprate and manganite heterostructures", we have engineered titanate/cuprate, manganite/titanate and manganite/cuprate heterostuctures characterized by very sharp interfaces and individual layer thickness controlled at the level of a single unit cell.

Among the main achievements of the project, we cite the observation of interfacial ferromagnetic order in $SrTiO_3$/Manganite heterostructures [M. Salluzzo, et al. Phys. Rev. Lett. **111**, 087204 (2013).], of High-Tc superconductivity in $SrTiO_3/CaCuO_2$ artificial superlattices [D. Di Castro,et al., Phys. Rev. B 86, 134524 (2012)], and the finding of a Charge Density wave and of in cuprate thin films [G. Ghiringhelli, Science **337**, 821 (2012)]. The results were obtained thanks to the combination of advanced deposition facilities (including MBE, PLD and Sputtering) and x-ray spectroscopy techniques using synchrotron radiation at large scale facilities (ESRF, SLS).

Projects

Main Projects

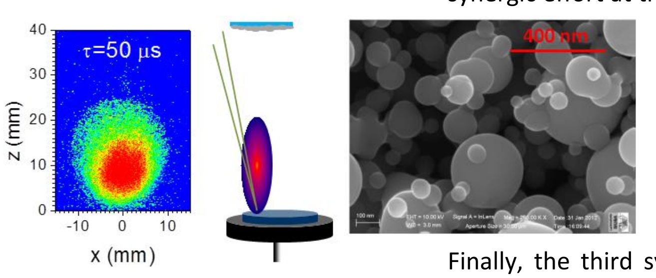
Title	Oxides at the nanoscale: multifunctionality and applications
Acronym	--
Source of funding	MIUR
Specific funding program	FIRB Accordi di Programma
Project Coordinator	Università di Milano Bicocca
SPIN Coordinator	Daniele Marrè, SPIN GE – Ruggero Vaglio, SPIN NA
Other partners	CNR-ISTM, Politecnico di MILANO, Università degli Studi di BRESCIA, Università degli Studi di TORINO, CNR-NANO, Università degli Studi di MILANO, Università degli Studi di PADOVA, Saes getters spa., E.T.C. srl, CNR-MDM, IIT

Project objectives:

Oxides at the nanoscale offer new and largely unexplored opportunities to establish novel advanced technologies or to improve existing technologies based on oxide materials.

Major barriers in the development of new applications and uses of oxides at the nanoscale are: (i) the ability to synthesize nanoparticles, nanostructures and ultrathin films with precisely controlled size, composition and shape in a way that is economically and ecologically sustainable; (ii) the achievement of an atomic level understanding of the physical and chemical properties of the materials and (iii) the development of advanced characterization tools so as to fully exploit the potentialities of the field. The project aims at a synergic effort at three different levels.

The first synergy is the merge of different expertise to study multifunctional oxides relevant in advanced technologies by connecting scientists with diverse background. The second synergy is to cover a broad range of materials shape and dimensionality, going from clusters to nanoparticles, from nanostructures to nanowires, from nanotubes to ultrathin films.



TiO2 nanoparticles by fs PLD for catalitic applications

Finally, the third synergy is related to the possibility to cover aspects which go from basic science, theoretical modeling, up to actual devices and applications. The research activities that have been identified for a cooperative effort can be grouped into four main topics:

- Nanostructured oxides for energy, environment and sensors (sub-topics: catalysis and photocatalysis, fuel cells, sensors);
- Nanostructured oxides for electronics and hybrid photonics (sub-topic: Light emitting transistors, transparent conductive oxides);
- Nanostructured oxides for magnetism and spintronics (sub-topic: Magnetic nano-structures, tunnel barriers);
- Nanostructured oxides for drug development and platforms for diagnostics (sub-topic: Drug delivery, drug development, diagnostics).

Highlights

2012

Strong vortex pinning in $FeSe_{0.5}Te_{0.5}$ epitaxial thin film

E. Bellingeri[1], S. Kawale[1], I. Pallecchi[1], A. Gerbi[1], R. Buzio[1], V. Braccini[1], A. Palenzona[1], M. Putti[1], M. Adamo[2], E. Sarnelli[2], and C. Ferdeghini[1]

[1] CNR-SPIN, corso Perrone 24, 16152, Genova, Italy
[2] CNR-ICIB Via Campi Flegrei, 34 - Comprensorio "A.Olivetti" , Pozzuoli (NA) Italy

Applied Physics Letter 100, 082601 (2012)

In this work, we present critical current density Jc curves of $FeTe_{0.5}Se_{0.5}$ thin films grown on $SrTiO_3$ as a function of magnetic field, temperature and orientation between the applied field and the crystalline axes. We find Jc values up to $4 \cdot 10^5$ A/cm^2 in self field at T=4K and weak field dependence (fig.1). Differently from what expected from the intrinsic mass anisotropy of the material and from previous measurements of films deposited on other substrates [1], the critical current is larger when the magnetic field is applied parallel to the c axis at all temperatures.
Both the analysis of the activation energy for vortex motion U_0 and of the angular dependence of Jc indicate the presence of strong correlated pinning for applied field parallel to the c axis. STM images (fig.2) suggest that evenly distributed nanoscale dislocations formed during the growth, possibly induced by the lattice mismatch with the substrate, may be identified as the effective pinning centers.
More generally, in this work and in previous publications, we showed how it is possible to tune the properties of $FeTe_{0.5}Se_{0.5}$ thin films enhancing its T_c up to 21 K [2], its upper critical field to more than 55T with low anisotropy [3] and its critical current density in-field dependence, by introducing strong correlated pinning centers. Such results, together with the fact that the 11 phase is quite simple to form and has a more handy chemistry as compared to other iron-bases superconducting families, make $FeTe_{0.5}Se_{0.5}$ appealing and suitable for applications.

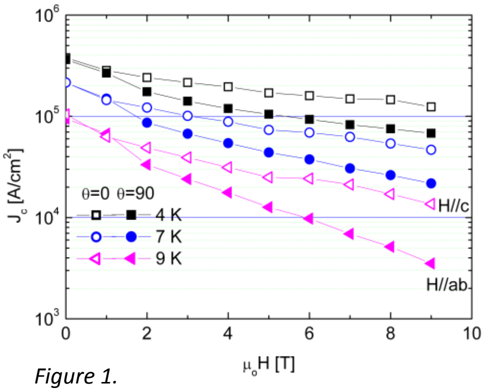


Figure 1.
Jc as a function of field for H // c (open symbols) and H⊥ c (filled symbols).

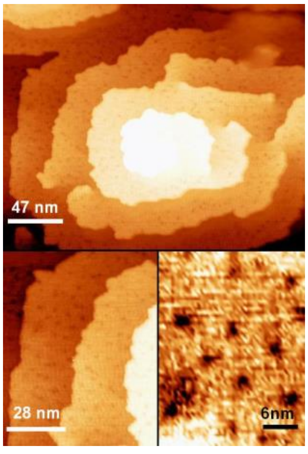


Figure 2.
High density of randomly distributed nanorods , originating from the lattice mismatch with the $SrTiO_3$ substrate. These defects have a diameter of 2 nm, which matches very well the coherence length.

References
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Highlights

2012

Quantum phase slips in superconducting Nb nanowire networks deposited on self-assembled Si templates

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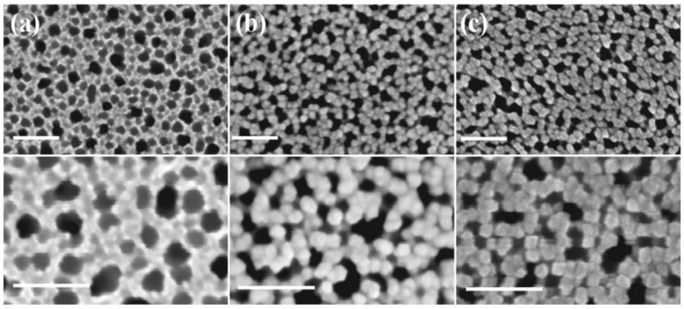
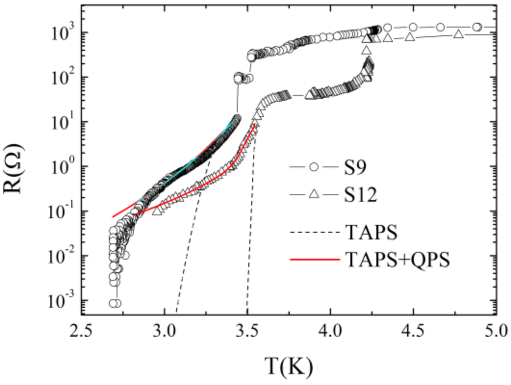
Applied Physics Letter 101, 172601 (2012)

The formation of interconnected networks consisting of Nb ultrathin superconducting nanowires is achieved by using porous silicon (PS) as template substrate. The extremely reduced film thickness (d_{Nb}) favours the deposited material to occupy only the substrate pitch; therefore, the assputtered films result as a network of interconnected wires, whose average width, due to the extremely reduced characteristic dimension of the substrates, is comparable to the superconducting coherence length. Scanning electron microscopy (SEM) analysis was performed to investigate the morphology of the samples, which constitute of polycrystalline single wires with grain size of about 10 nm. The samples exhibit nonzero resistance over a broad temperature range below the critical temperature, fingerprint of phase slippage processes. The transport data are satisfactory reproduced by models describing both thermal (TAPS) and quantum (QPS) fluctuations of the superconducting order parameter in thin homogeneous superconducting wires.



Top-view SEM images of (a) a free PS substrate (interpore spacing 50 nm, pore diameter 15 nm) and Nb nanowire networks deposited on PS with nominal thickness of (b) 3.5 nm, (c) 7 nm. In the upper (lower) panels, the images acquired at lower (higher) magnifications are reported. The white scale bar is 100 nm.

Resistive transitions, R(T), of samples with different Nb thicknesses, namely dNb= 9 (circles) and 12 (triangles) nm. Solid red lines are the results of the fitting procedure including both TAPS and QPS contributions, while the dashed black lines, strongly deviating from the experimental data, are obtained including only the TAPS term.



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Controlling flux flow dissipation by changing flux pinning in superconducting films

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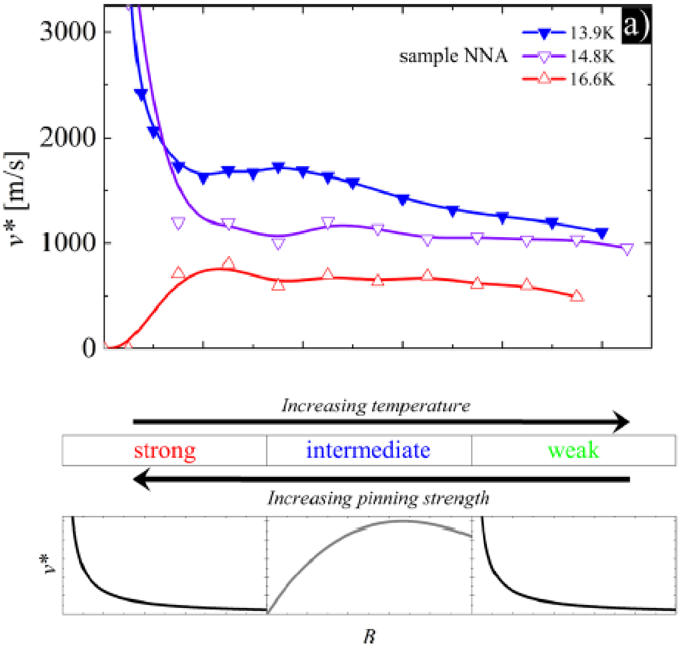
Applied Physics Letter 100, 202601 (2012)

The study of the flux flow state in superconducting materials characterized by rather strong intrinsic pinning, such as Nb, NbN, and nanostructured Al thin films, has been done by driving the superconducting dissipative state into the normal state by current biasing. Vortex pinning strength has been changed either by ion irradiation, by tuning the measuring temperature or by including artificial pinning centers. Maximum pinning does not always correspond to highest stability of the superconducting state. Indeed measurements of critical flux flow voltages for all materials show the same effect: switching to low flux flow dissipations at low fields for an intermediate pinning regime.



This mechanism offers a way to extend the stability of the superconducting state just above Jc, which may be of significant interest to technological applications.
This work stresses the relevance of the disorder and pinning at the microscopic scale to determine the vortex depinning transition.
In addition, it demonstrates that vortex instability transitions are strongly affected by pinning, a feature that has escaped to most of the theoretical works until now. Therefore, our results will encourage researchers to look beyond Jc, and widen the range of currents above Jc where low dissipation can be sustained.

2012

Electron Transfer and Ionic Displacements as the Origin of the 2D Electron Gas at the LAO/STO Interface: Direct Measurements with Atomic-Column Spatial Resolution

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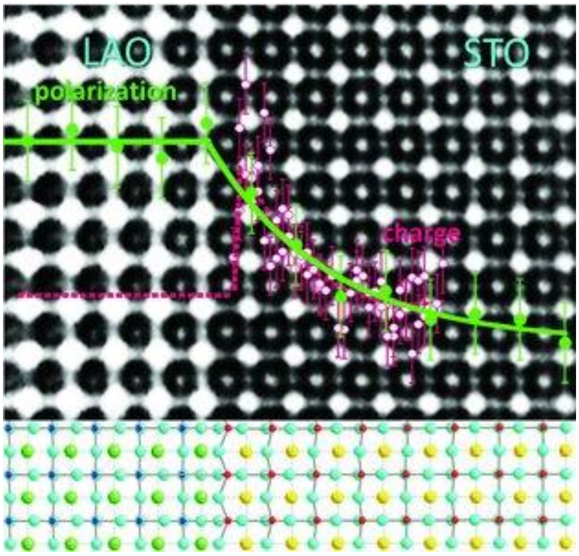
Advanced Materials 24, 29 (2012)

Interfaces between correlated oxides are currently among the most investigated systems in condensed matter. The interface between $LaAlO_3$ and $SrTiO_3$, which hosts a high-mobility 2D electron gas (2DEG) in spite of the large bandgap of its bulk constituents, is among the most intensely debated worldwide. After several years of sustained theoretical and experimental work, there is no consensus regarding the dominant mechanism responsible for electrical conductivity, superconductivity, and magnetism in this system. First principles calculations correctly predict the metallicity of the interface, as a result of a socalled electronic reconstruction (ER) taking place in response to the diverging electrostatic energy generated by the polar nature of the $LaAlO_3$ lattice. However, theoretical studies presuppose an atomically abrupt interface with negligible defects and/or disorder and a substantial polarization of the whole heterostructure. No conclusive evidence about these open issues has been reported so far.



Using state-of-the-art, aberration-corrected scanning transmission electron microscopy and electron energy loss spectroscopy with atomicscale spatial resolution, experimental evidence for an intrinsic electronic reconstruction at the LAO/STO interface is shown. We demonstrate that in a highly perfect interface, where cation intermixing is negligible, the lattice polarization and the amount of injected charge are in agreement with the predictions of the ER model.

Fig.:
High resolution electron microscopy image of a LaAlO3/SrTiO3 interface. The polarization profile, the surface charge density profile ad the lattice deformations are sketched

2012

Multistate Memory Devices Based on Free-standing VO_2/TiO_2 Microstructures Driven by Joule Self-Heating

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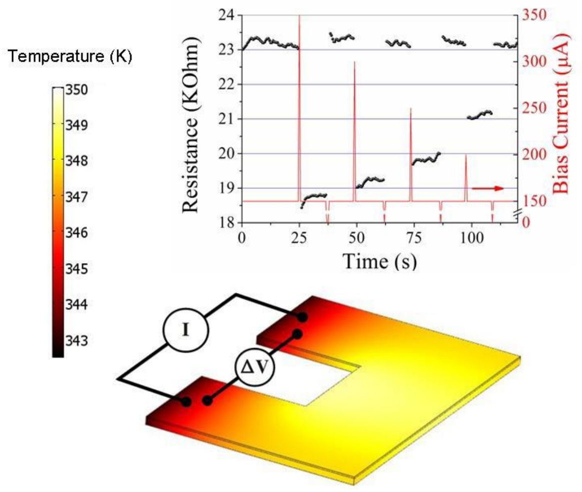
Advanced Materials 24, 2929-2934 (2012)

We report a two-terminal multistate memory devices based on crystalline (70 nm VO_2) / (200nm TiO_2 (100)) thin film microcantilevers. VO_2 shows a fast (sub-ps) thermally driven Metal-Insulator Transition (MIT) occurring above room temperature (68°C), where the electrical resistance decreases of more than 4 orders of magnitudes. This MIT is hysteretic and widens when moving from single crystals to thin films. VO_2 films grown on cantilevers show three orders of magnitude resistance change nearby 340 K and hysteretic behavior (width = 6.5 K) during thermal cycles.



Temperature distribution calculated on a VO_2 / TiO_2 cantilever under 100 uA bias current. Sample temperature is fixed at 343 K and multi-resistance states written by current pulses of different magnitude, cantilever is powered with 150 uA current bias. Erasing is possible by a short pulse to zero.

Within the thermal hysteresis region, where phase coexistence of metallic and insulating domains exists, we observe two types of memory effects upon current pulses applied to the microcantilever: non-volatile changes of the electrical resistance persist also if the current is switched-off and can be erased only by cooling the device below the hysteresis region. Volatile multilevel resistance states are instead possible by biasing the device with a fixed current and written with reproducibility by current pulses of different magnitude. Programmed resistance states can be erased by nullifying the bias with a short zero-current pulse. The memory mechanism is based on localized Joule heating of micrometric free-standing region, which allows the controlled creation of metastable metallic clusters at nanoscale. The higher thermal insulation of free-standing structures with respect to patterned thin film devices is a key point of these devices. Hot spots are created at the cantilever center-end, where thermal dissipation is lower and efficient Joule heating is possible.

Highlights

2012

Light-induced spiral mass transport in azo-polymer films under vortex-beam illumination

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Nature Communications 3, 989 (2012)

We report about a new feature in patterning azo-polymers deriving by light-matter interaction where the film is sensitive to the phase information carried out by optical vortexes of different topological charges. In fact, we have found the unexpected experimental observation of spiral-shaped relief patterns on the surface of an azopolymer that has been illuminated with a vortex laser beam, that is a beam having a helical wavefront. The spiral handedness of the polymer pattern is determined by the vortex one. This result is quite surprising because the common understanding hitherto was that these surface patterns respond to the light intensity distribution and its gradients. The intensity pattern of a vortex beam is shaped as a "doughnut" and carries no information whatsoever about the vortex handedness. We found an explanation for our observations that links them to a peculiar interference effect occurring between longitudinal and transverse field components of the vortex beam. Furthermore, we have found out that the main features of the observed phenomenon can be predicted by a phenomenological theory that does not rely on a specific microscopic model and therefore, in this sense, is a model-independent interpretation.
Our finding will benefit the development of new lithography schemes as well as the interpretation of the phenomenon driving the material-displacement and the imaging of phase-related information.

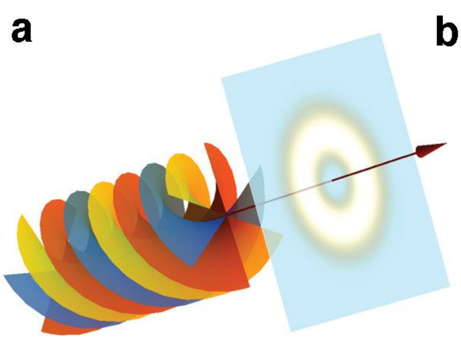

Fig. a) Wavefront helical structures for vortex topological charges q = 3 (the wavefront is composed of three intertwined helical surfaces) and the associated doughnutshaped transverse intensity distribution.

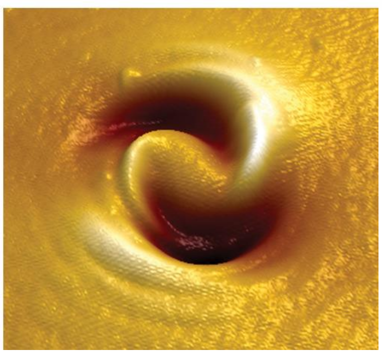

Fig. b) Three-dimensional AFM image of the topographical structure obtained at the sample surface when the polymer is illuminated by a focused q = 10 vortex beam.

2012

Phonon-mediated superconductivity in graphene by lithium deposition

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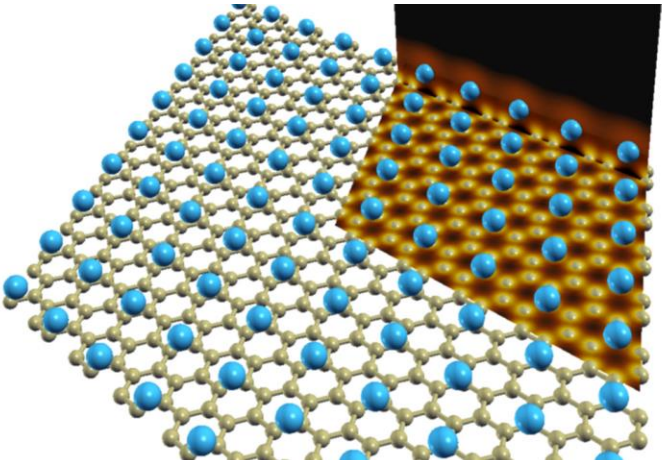
Nature Physics, 8, 131-134 (2012)

Of all the unique properties of strength, flexibility and intriguing optoelectronic behavior, one phenomenon is notably absent from the repertoire of graphene: superconductivity. If graphene could be a superconductor many new efficiencies of applications would emerge.
Graphene itself is not superconducting, because the density of states of the Dirac bands is very low, their coupling is strong only with ineffective high-energy phonon modes, while their coupling with out-of-plane phonon modes are forbidden by symmetry. So, phonon-mediated superconductivity must be induced by an enhancement of the electron–phonon coupling bringing new electronic states at the Fermi level as happens in GICs (Graphite Intercalated Compounds).
We discovered that in graphene doped with lithium adatoms, the removal of quantum confinement along the out-of-plane direction, brings the interlayer to the Fermi level, realizing a system without a bulk GIC counterpart.
We found that the interlayer is strongly localized around the adatom and closer to the graphene layer, switching on the electron–phonon coupling of carbon out-of-plane modes that is inactive in the bulk and increasing the contribution of intercalant modes.
Graphene can be made superconducting by the deposition of lithium atoms on top of it, with an estimated superconducting critical temperature of 18 K when lithium atoms are deposited on both sides of the graphene sheet



Lithium adatoms on graphene and charge density of the interlayer state

Highlights

2012

Spectral noise for edge states at filling factor ν = 5/2

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New Journal of Physics, 14 (2012)

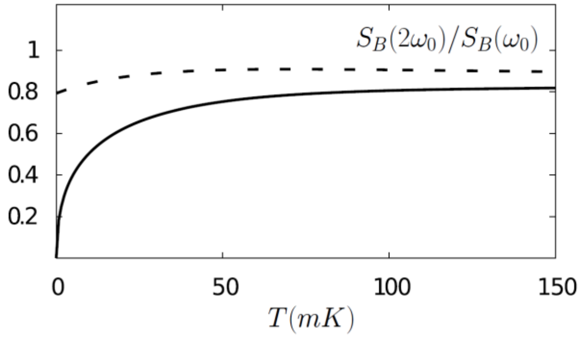
One of the more challenging and intriguing examples of strongly correlated electrons system is represented by the Fractional Quantum Hall fluid. In recent years this peculiar state of matter has been subject of many theoretical and experimental studies, leading to the observation of a large variety of states at different values of the filling factor ν.

Among them, the ν = 5/2 state has recently attracted increasing attention also in view of its promising application to topologically protected quantum computation. This peculiar value of the Hall fluid with even denominator has been observed in ultra high quality GaAs/AlGaAs eterostructure under very high magnetic field and low temperatures. This exotic and elusive state is predicted, for some models, to support excitations with fractional charge and non-Abelian statistics, key features towards the implementation of topologically robust quantum algorithm.

The low energy sector of an Hall fluid is characterised by the edge states, whose features can be explored monitoring the transport properties, such as the current and the noise in different geometries. The simplest geometry one can think of is the so-called quantum point contact geometry, from which one can infers e.g. which are the dominant edge state excitations in the low energy sector.

In this paper we investigated the finite frequency noise for the ν = 5/2 Hall state. We demonstrated that this quantity is a useful tool in order to discriminate excitations involved in transport. In particular Josephson resonances located at different frequencies are directly connected to the charge of the excitations. In principle the finite frequency noise allows a "spectroscopic" study of the low energy excitations and to discriminate between them, looking at the different peak structures.

A comparative study of the two best candidate for the ν = 5/2 Hall state ,i.e. the Pfaffian and the Anti-Pfaffian models, is also presented. We have found that the colored noise could be an important tool inorder to discriminate between these models.



Temperature evolution of the ratio between the heights of colored noise peaks at the Josephson frequency ω_0, of the single quasiparticle e/4 and at frequency 2 ω_0 of the double quasiparticle e/2. The solid line represent the Pfaffian model and the dashed line the anti-Pfaffian model.

2012

Surface and bulk electronic structure of the unconventional superconductor Sr_2RuO_4: unusual splitting of the β band

V. B. Zabolotnyy[1], E. Carleschi[2], T. K. Kim[1], A. A. Kordyuk[1,3], J. Trinckauf[1], J. Geck[1], D. Evtushinsky[1], B. P. Doyle[2], R. Fittipaldi[4], M. Cuoco[4], A. Vecchione[4], B. Büchner[1,5], and S. V. Borisenko[1]

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New Journal of Physics 14, 063039(2012)

Angle-resolved photoemission spectroscopy performed at extremely low temperatures (T ~ 1 K) with improved momentum resolution enabled us to observe bulk α, β, γ bands and their surface counterparts along *with an additional new feature*, in ultra-pure Sr_2RuO_4 single crystals. Indeed, the Fermi Surface contour corresponding to the β band appears to be split ($β_1$ and $β_2$). The multitude of the features we observed in the spectra must result from a superposition of bulk and surface states. Circularly polarized light has been used to disentangle the signals from the bulk and surface layers and allowed us to discuss the origin of the splitting of the β band and the possible connection with the Rashba effect at the surface.

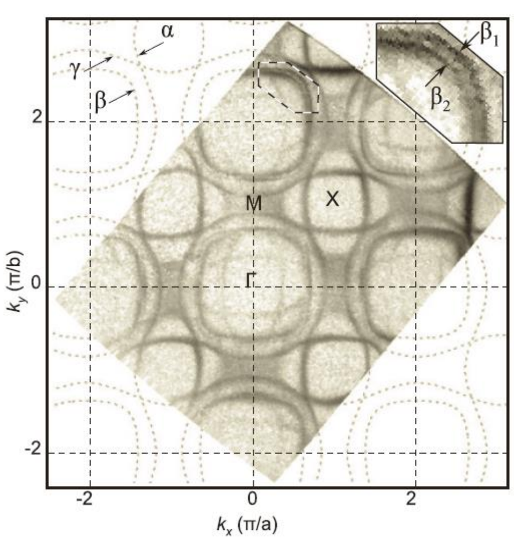

Fig. 1
Overview of Sr_2RuO_4 Fermi Surface map. The inset shows the splitting of the β band.

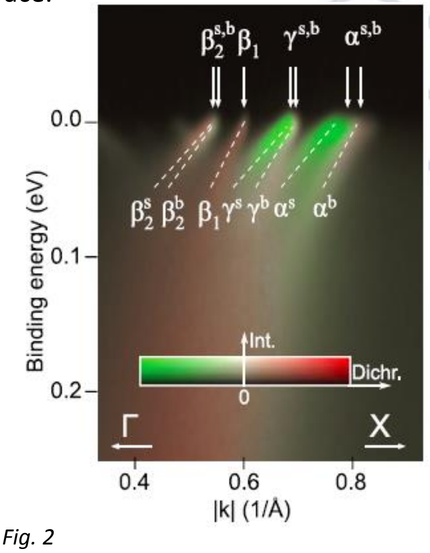

Fig. 2
Circular-dichroic signal to separate the surface and bulk bands in Sr_2RuO_4. In order to facilitate the comparison between the bands exhibiting circular dichroism and those with negligible dichroism, we plot them in this way: the brightness corresponds to the sum of intensities obtained with opposite polarizations (circular right + circular left) and the color, ranging from green through white to red, encodes the dichroism strength (circular right - circular left).

2012

Majorana Fermions in high Tc superconducting hybrid devices

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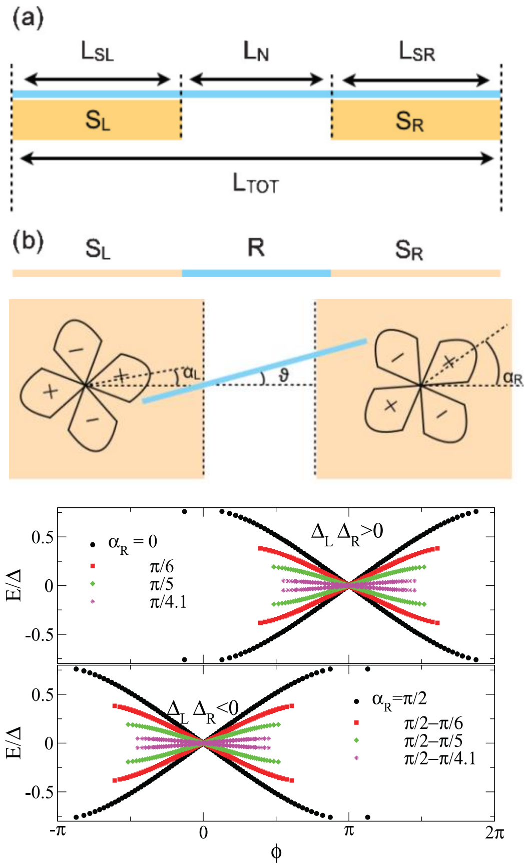
Phys. Rev. B 86, 144513 (2012)



(a) Side view of the superconductor-InAs nanowire - superconductor heterostructure.
(b) Top view of the structure and effective one-dimensional model.
Bottom panel) Energy spectrum of zero-energy Majorana bound states in the case of equal (opposite) sign gaps (in top and bottom panel, respectively).

Majorana Fermions have been predicted in a wide class of low-dimensional solid-state devices. Many of the proposals make use of superconductors in contact with topological insulators or quasi one-dimensional materials with strong spin-orbit interaction. We propose an alternative platform based on high critical temperature cuprate superconductors in the in the S/R/S configuration (Superconductor – Rashba semiconductor – Superconductor).
Superconductivity induced by proximity effect, by a high-critical temperatures superconductor, in nanowires with strong spin orbit coupling, gives rise to a wider and more robust range of conditions to stabilize Majorana Fermions due to the large gap values. It is well established that in order to obtain MBSs, in S/R/S heterostructures, the magnetic field has to dominate over the superconductivity.
Still, a sizable superconducting gap is needed, as the smaller energy between the magnetic and the superconducting gap sets the minimum energy sufficient to wash out the topological protection of the Majorana excitation.
In this respect, HTS appear to offer more chances in stabilizing MBSs. d-wave systems can offer novel functionalities in the design of the experiments determined by different dispersion for Andreev bound states as a function of the phase difference.

2012

Anomalous growth of the thermoelectric power in gapped graphene

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Phys. Rev. B 86, 035430 (2012)

The experiments indicate that thermo-electric effect in graphene accounts for up to one-third of the contact temperature changes (Fig. 1) and thus it can play significant role in cooling down of nano-devices based on graphene technology.

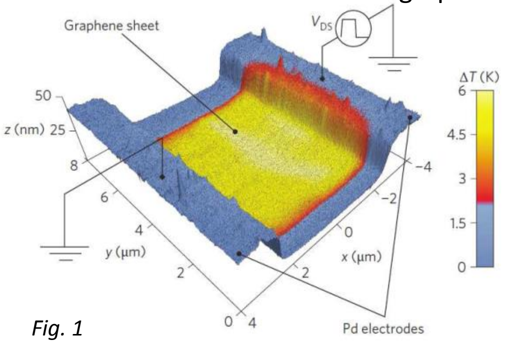


Fig. 1

At the same time other experiments indicate that at certain conditions, like an appropriate substrate, a gap D of the order of 10 meV can be opened at the Dirac points of a quasiparticle spectrum of graphene. We analyze behavior of conductivity and thermopower in such system accounting for quasi-particle scattering from impurities with the model potential in self-consistent scheme. Reproducing the existing results for the case of gapless graphene we demonstrate a failure of the simple Mott formula in the case under consideration.

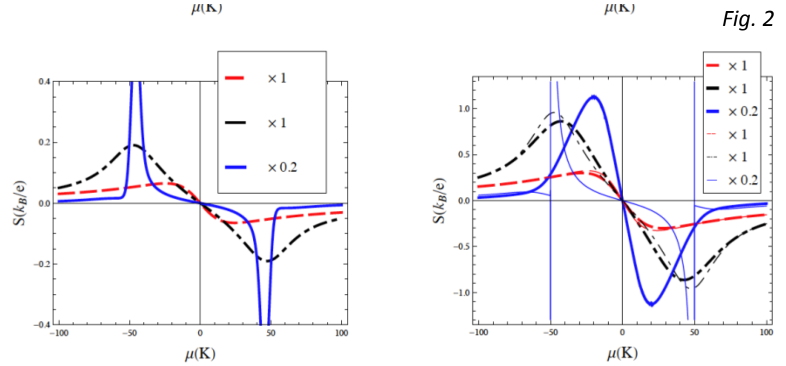
We demonstrate that opening of such a gap in graphene spectrum can result in appearance of the fingerprint bump of the Seebeck signal S(μ) when the chemical potential μ approaches the gap edge. A magnitude of the bump can be up to one order higher than already large value of the thermopower occurring in graphene. Such a giant effect, accompanied by the non-monotonous dependence on the chemical potential, is related to the emergence of a new channel of quasi-particle scattering from impurities with the relaxation time t strongly dependent on the energy e:

$$\tau^{-1}(\varepsilon)=\tau_0^{-1}\left(\frac{|\varepsilon+\mu|}{\mu}-\frac{\Delta^2}{|\mu||\mu+\varepsilon|}\right)\theta\left[(\varepsilon+\mu)^2-\Delta^2\right]$$

The specifics of thermopower consists of its sensitivity to derivative of the scattering rate. This is why presence of the step function in t (e)produces much stronger effect on S(μ) behavior in the vicinity of gap $m \approx$ D than a relatively slow energy dependence of relaxation time which could appear from the screened Coulomb potential.

The found dependency of Seebeck coefficient of gapped graphene on chemical potential is presented at the Fig. 2. The left pannel is for T=1 K while the right one is for T=5 K. The dashed (red) curves correspond to the gapless case with constant scattering.

Fig. 2



Quantum Dynamics of the Hubbard-Holstein Model in Equilibrium and Nonequilibrium: Application to Pump-Probe Phenomena

G. De Filippis[1], V. Cataudella[1], E. A. Nowadnick[2,3], T. P. Devereaux[2,4], A. S. Mishchenko[5,6], and N. Nagaosa[5,7]

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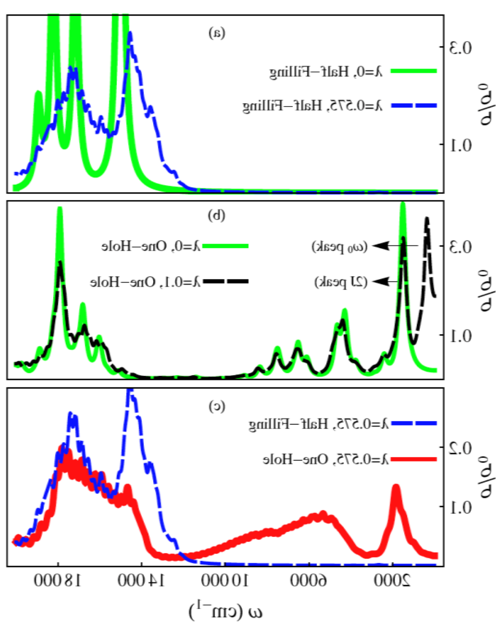
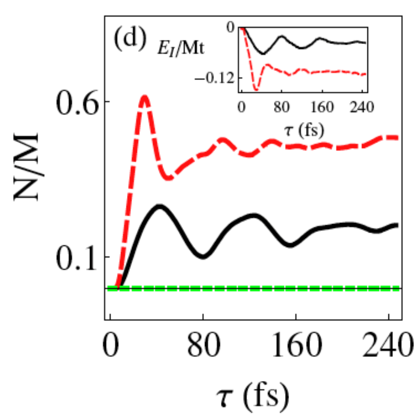
Physical Review Letters 109, 176402 (2012)

The paper shows that the calculated optical absorption of the 2D Hubbard-Holstein model at low doping reveals a three peak structure in agreement with experimental observations in many cuprates. We also address a very crucial problem in complex systems, as the high Tc superconductors are, where strongly interacting different degrees of freedom contribute to the system properties on very similar scale energies: Can ultrafast time dependent spectroscopy (pump and probe experiments) disantangle the different interactions by exploiting the fact that different interaction act on differet time scales? We show that this is possible and prove that, after an ultrashort pulse, phonon subsystem oscillate with a phonon period Tph=80 fs.



The decay time of the phonon oscillations is about 150–200 fs. We propose a criterion for observing these oscillations in high Tc compounds: the time span of the pump light pulse has to be shorter than the phonon oscillation period Tph. On the other hand we find that the time scale of magnetic excitations are much shorter (few fs).



2012

Direct Transition from Quantum Escape to a Phase Diffusion Regime in YBaCuO Biepitaxial Josephson Junctions

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Physical Review Letters 109, 050601 (2012)

The remarkable development of superconductive systems in the field of quantum information processing and the expertise gained on manipulating coherent entangled states and different coupling regimes with the environment have boosted research on several complementary aspects of coherence and dissipation. Because of their design scalability and their flexibility in controlling the level of damping, Josephson systems have proven to be a fantastic test bench for studying fundamental physics problems such as the quantum superposition of alive and dead states of Schrodinger's cat, the behavior of an artificial atom in cavity quantum electrodynamics experiments, or measurements of quantum coherence in macroscopic systems. Dissipation encodes the interaction of a quantum system with the environment and regulates the activation regimes of a Brownian particle. In this Letter, we demonstrate a direct transition from a running state, obtained following a quantum activation, to diffusive Brownian motion in YBaCuO Josephson Junctios (JJs) (Fig. 1). Multiple retrapping processes in subsequent potential wells characterize phase regimes where diffusive phenomena play a relevant role. The relevant parameters driving the occurrence of these phenomena are the operational temperature T, the damping factor Q, and the critical current Ic.

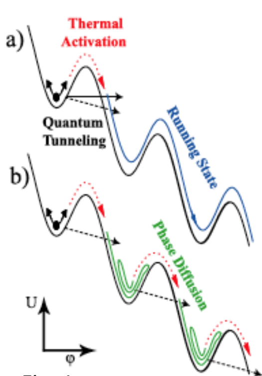

Fig. 1
(a) Thermal (red line) or quantum activated escape in the tilted periodic potential. Quantum escape is represented for both very low ideal (Q_>>1, continuous black line) and high (1<Q<5, dashed black line) levels of dissipation, respectively. (b) Diffusive motion due to multiple escapes and retrapping in subsequent potential wells.

The various operation scenarios for a JJ can be condensed in a phase diagram (see Fig. 2). By spanning the (EJ, kBT) parameter space it is possible to engineer all different regimes ranging from phase diffusion (PD) and thermal activation (TA) to macroscopic quantum tunneling (MQT). MQT takes place not only for low values of dissipation (Q_>>1), but also for intermediate levels of dissipation (1<Q<5). We explore a new region of this phase diagram, made available by the different ranges of Ic and of the standard deviation of the switching distribution offered by YBaCuO biepitaxial junctions when compared with most low temperature superconductor JJs. The moderately damped systems are particularly significant and promising to address and quantify interactions of a quantum system with the environment which is, apart from the its intrinsic interest for fundamental physics, a cornerstone for the development of whatever quantum hybrid technology.

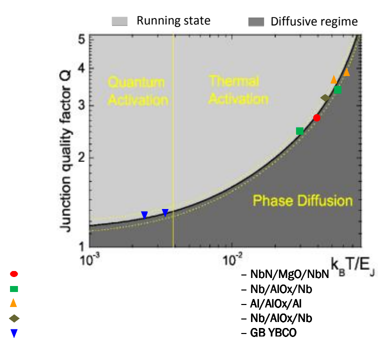

Fig 2: ($Q,k_BT/E_J$) phase diagram, showing the various activation regimes. The transition curve (black line) between the PD regime and the running state has been extrapolated through numerical simulations, the sideband curves (yellow lines) mark the uncertainty in our calculation and are due to the temperature step size. The symbols refer to various works reported in the literature in the last ten years. The proximity of experimental data to the simulations suggests the validity of such approach and the universal nature of the transition curve. This phase diagram constitutes a guideline for moderatey damped systems over a large range of junction materials, geometry and dissipation level.

2012

Long-Range Incommensurate Charge Fluctuations in $(Y,Nd)Ba_2Cu_3O_{6+x}$ competing with superconductivity

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Science 337, 821 (2012)

High temperature superconductivity remains one of the most fascinating, yet unsolved, puzzles of condensed matter physics. Since the discovery of superconducting cuprates, theorists have suggested the coexistence of several electronic orders. At the same time, recently, it has been shown that the typical excitations of antiferromagnetic and insulating parent compounds (magnons) survive in the superconducting state at the optimal doping even in the case of the most studied High Tc material, i.e. $Y_1Ba_2Cu_3O_7$ [Fig.1]. These results were interpreted as a possible hint of a "magnetic" origin of the attractive interaction necessary for the formation of the Cooper pairs at high temperatures. However, an estimation of the superconducting critical temperature deduced from the experimentally measured magnon-dispersion, yield values about two times higher than the experimental ones [1].

A possible reason of discrepancy was the simultaneous presence of competing electronic orders. However a direct, experimental, demonstration of the existence of such competing electronic phases remained elusive until now. Here, scientists of the Politecnico di Milano, of the Max-Planck Institute of Stuttgart and of the CNR-SPIN, found the first evidence of a charge density wave (CDW) in the high Tc family of $(Y,Nd)Ba_2Cu_3O_{6+x}$ cuprates [2]. By using the bulk sensitive resonant x-ray scattering, two-dimensional charge fluctuations with an incommensurate periodicity of ~3.2 lattice units have been identified in the copper-oxide planes of the superconducting (Y,Nd)Ba2Cu3O6+x, with hole concentrations between 0.09 to 0.12 per planar Cu ion. The intensity and the correlation length of the fluctuation signal increase strongly upon cooling down the sample to the superconducting transition temperature (Tc); however, the divergence of the charge correlations abruptly reverses its trend below Tc. In combination with earlier observations of a large gap in the spin excitation spectrum, these data indicate an incipient charge density wave instability that competes with superconductivity [3].

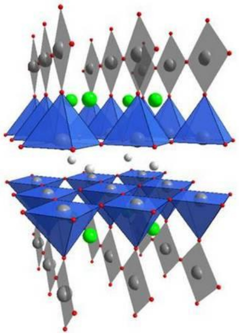

Fig. 1
The structure of $(YNd)_1Ba_2Cu_3O_7$ superconductor. Ghiringhelli, G. et al. Science 337, 821–825 (2012)

[1] M. Le Tacon, G. Ghiringhelli, J. Chaloupka, M.M. Sala, V. Hinkov, M.W. Haverkort, M. Minola, M. Bakr, K.J. Zhou, S. Blanco- Canosa, C. Monney, Y.T. Song, G.L. Sun, C.T. Lin, G.M. De Luca, M. Salluzzo, G. Khaliullin, T. Schmitt, L. Braicovich, and B. Keimer, Nature Physics 7, 725 (2011).
[2] G. Ghiringhelli, M. Le Tacon, M. Minola, S. Blanco-Canosa, C. Mazzoli, N.B. Brookes, G.M. De Luca, A. Fraňó, D.G. Hawthorn, F. He, T. Loew, M.M. Sala, D.C. Peets, M. salluzzo, E. Schierle, R. Sutarto, G.A. Sawatzky, E. Weschke, B. Keimer, and L. Braicovich, Science 337, 821 (2012).
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Highlights

2013

Graphene nanoribbon electrical decoupling from metallic substrates

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NANOSCALE 5, 291 (2013)

We address the structural and electronic properties of graphene nanoribbons (GNRs) covalently immobilized on a metallic substrate by means of an organic layer. The GNR–organic layer and organic layer–metal interfaces can be thought of as constituents of a nanodevice and have been accurately studied using large-scale density functional theory calculations. Our results demonstrate the possibility of combining nanopatterned metal–organic layer substrates with selected GNRs to obtain well ordered and stable structures while preserving the GNR energy band gap, an essential requirement for any switching nanodevice.

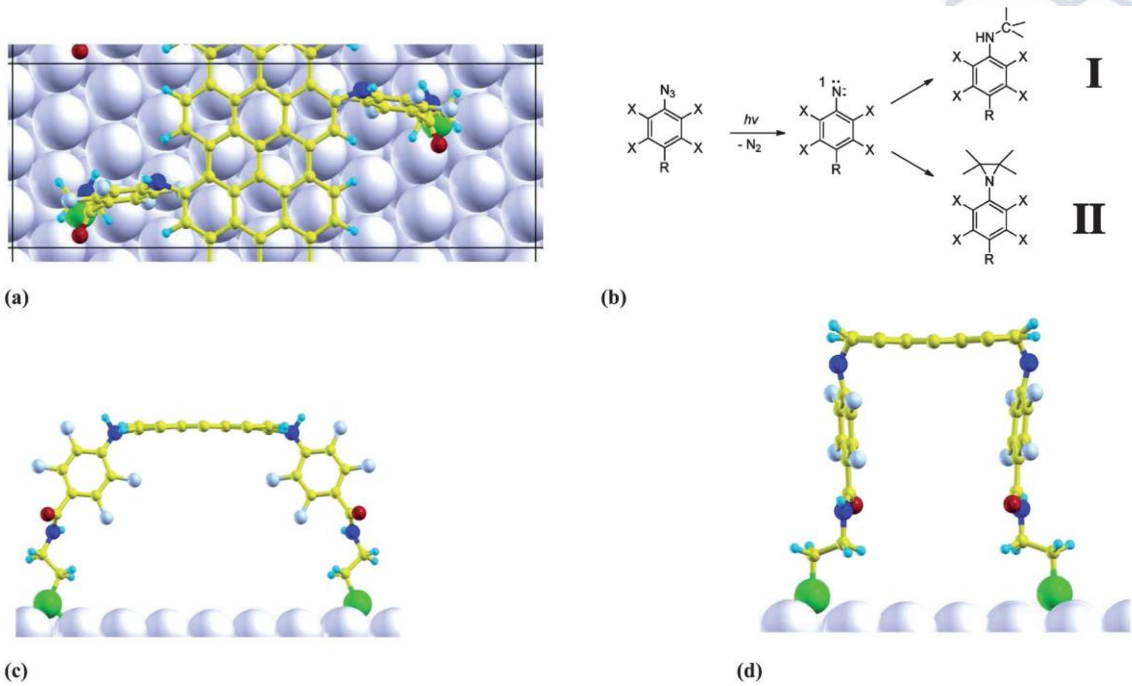

Fig.
(a) Top view of an armchair GNR covalently linked to the Au (111) surface through PFPA (the in-plane supercell is also represented). (b) Schematic view of the two possible PFPA–GNR link mechanisms (see text): insertion (I) and addition (II). The side views of the resulting Au–PFPA–GNR systems are given in (c) and (d), respective

Molecular Model for Light-Driven Spiral Mass Transport in Azopolymer Films

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PHYSICAL REVIEW LETTERS 110, 146102 (2013)

We described a detailed microscopic mechanism, that provides a first complete picture of the wavefront-sensitive light-induced mass transport phenomenon in azobenzene-contatining polymers. In fact, we have found the unexpected experimental observation of spiral-shaped relief patterns on the surface of an azopolymer that has been illuminated with a vortex laser beam, that is a beam having a helical wavefront. The spiral handedness of the polymer pattern is determined by the vortex one.

This result is quite surprising because the common understanding hitherto was that these surface patterns respond to the light intensity distribution and its gradients. The intensity pattern of a vortex beam is shaped as a "doughnut" and carries no information whatsoever about the vortex handedness.

We then introduced a model of the mass migration process based on anisotropic light-driven molecular diffusion. A key ingredient of our model is an enhanced molecular diffusion in proximity of the free polymer surface, which is essential for explaining, in particular, the recently observed spiral-shaped reliefs resulting from vortex-beam illumination.

Our model provides a realistic, although simplified, description of the light-induced mass-transport process at the molecular scale, illustrating the microscopic nature of the surface-enhanced diffusion term needed to explain the spiral relief patterns observed under vortex light illumination.

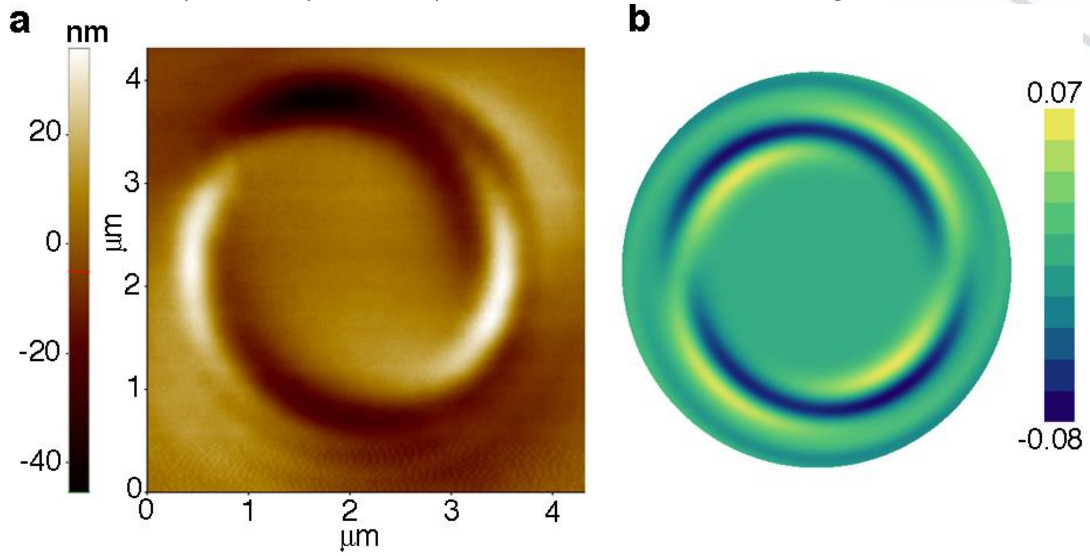

Figure – (a) Relief spiral patterns induced on the polymer by an impinging vortex light beam. (b) Pattern predicted by our model.

2013

Structural and Electronic Reconstructions at the $LaAlO_3/SrTiO_3$ Interface

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Advanced Materials vol.25, p. 2332 (2013)

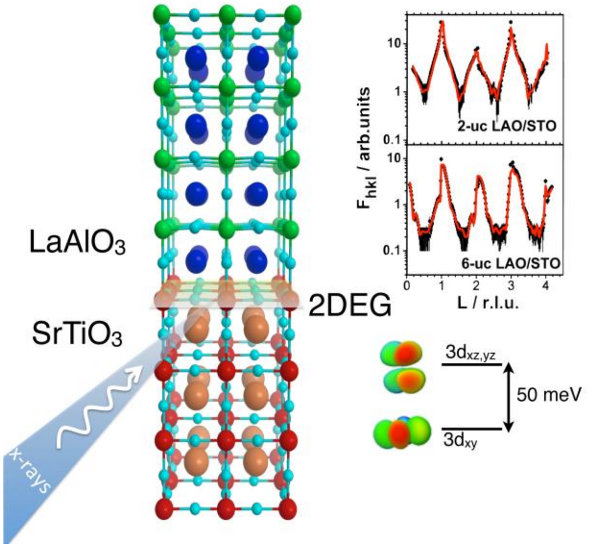

Fig.:
On the right x-rays from synchrotron source are absorbed or diffracted from the interfacial atoms belonging to $LaAlO_3$ (001) (La- blue Al- green and O cyan spheres) and $SrTiO_3$l (Sr- orange, Ti- red) crystals. On the left, upper panel, we show structural refinement from of crystal truncation rods measured by Grazing incidence x-ray diffraction in LAO/STO samples composed by 2uc and 6uc LAO films deposited on STO. On the left bottom panel, we show the inversion of energy levels, i.e. the crystal field splitting, as obtained by x-ray absorption spectroscopy and x.ray linear dichroism at the Ti- $L_{23,}$ edge

In 2004 Ohtomo and Hwang discovered that in some conditions the interface between two of the most popular band insulating oxides, $LaAlO_3$ and $SrTiO_3$, is conducting due to the formation of a high mobility 2D-electron gas (2DEG). The phenomenon is believed to be related to a polar character of $LaAlO_3$ (001) unit cell, which introduce an instability in the system.The so called 'polarization catastrophe' picture predicts, in particular, simultaneous electronic and structural reconstruction of the interface $SrTiO_3$ layers as consequence of the formation of a mobile 2DEG which eliminate the system instability.

Here, by using a combination of advanced x-ray synchrotron-based spectroscopic and structural measurements, we show that this phenomenon is linked to a structural and electronic reconstruction of the interface which precede the appearance of the 2DEG.

In particular, by using x-ray linear dichroism at the Ti-$L_{2,3}$ we find that the 3d splitting of Ti-states in LAO/STO bilayers is opposite to tha one of $SrTiO_3$. However, the phenomenon takes place at a LAO thickness below the critical value of 4uc necessary to get a conducting interface. By using grazing incidence x-ray diffraction we find that the orbital reconstruction takes place when one complete LAO layer is deposited on top of TiO2-terminated STO crystal, and is related to interfacial symmetry breaking, thus preceding the formation of the 2DEG.

Highlights

2013

Origin of Interface Magnetism in $BiMnO_3/SrTiO_3$ and $LaAlO_3/SrTiO_3$ Heterostructures

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Phys. Rev. Lett. 111, 087204 (2013)

Possible ferromagnetism induced in otherwise non-magnetic materials has been motivating intense research on diluted semiconductors and complex oxide heterostructures. Here we show that a confined magnetism is realized at the interface between $SrTiO_3$ and two insulating polar oxides, i.e. $BiMnO_3$ and $LaAlO_3$. By using polarization dependent x-ray absorption spectroscopy, we find in both cases that the magnetic order is stabilized by a negative exchange interaction between the electrons transferred at the interface and localized magnetic moments. These local magnetic moments are associated to Ti^{3+} ions at the interface itself, for $LaAlO_3/SrTiO_3$, and to Mn^{3+} ions in the overlayer, for $BiMnO_3/SrTiO_3$. In $LaAlO_3/SrTiO_3$ magnetism is quenched by annealing in oxygen, suggesting a decisive role of oxygen vacancies. These results provide a unified picture of magnetism in titanate interfaces and help reconciling two conflicting phenomena such as ferromagnetism and superconductivity, both observed in $LaAlO_3/SrTiO_3$.

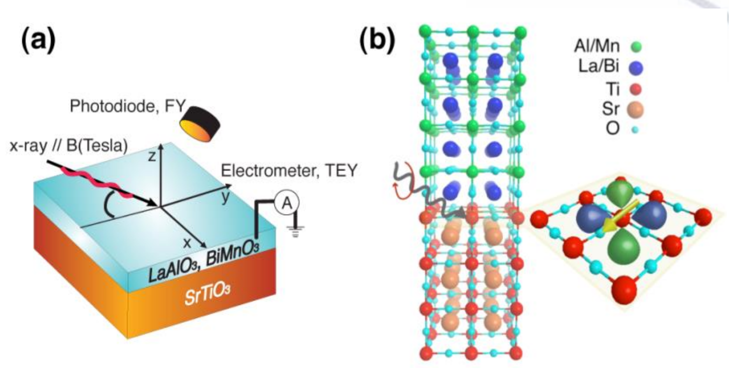

Fig.
Linear and circular dichroism in the XAS of SrTiO3 interfaces. (a) Schematics of the experimental setup: by absorption of a photon (zigzag red arrow) of appropriate energy and known polarization, a Ti or Mn 2p electron is promoted to the 3d states. The external magnetic field B is always parallel to the beam direction and the sample can be oriented at normal (0) or 70 incidence. (b) The crystal struc- ture of an ideal 4 unit cell polar insulating oxide film ($LaAlO_3$ or $BiMnO_3$) deposited on TiO_2 terminated SrTiO3 single crystal, and a pictorial view of the outcomes of Ti $L_{2,3}$ XMCD and XLD, which provide insight on the symmetry and occupation of lowest-lying 3d states (Ti-3dxy orbitals in the picture), and on the consequent magnetic moments (yellow arrow).

2013

Deep Ultraviolet Plasmon Resonance in Aluminum Nanoparticle Arrays

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ACS Nano 7, 5834-5841 (2013)

The localized surface plasmon resonance (LSPR) is a resonant oscillation of the free-electron gas within a metallic nanoparticle (NP), induced by an external electromagnetic (EM) field. The LSPR is instrumental in fabricating devices for sub-wavelength light routing or ultra sensitive molecuar detectors. So far, however, most of the research on plasmonics has been performed employing Au or Ag-based systems, thus limiting the LSPR range to the visible regime.

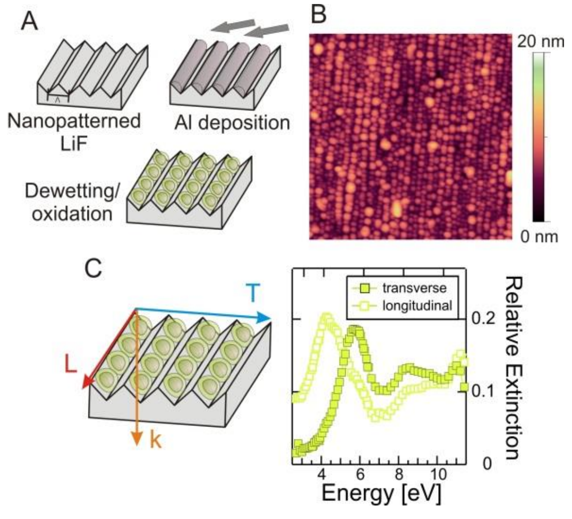

Fig.1: A: schematic representation of the Al NP array fabrication procedure. B: AFM image of an ultradense array of Al NPs. C: optical geometry for extinction measurements. Extinction spectra measured in longitudinal and transverse optical geometry.

In our work, we demonstrate a new upper energy limit for DUV plasmonics in ultradense ($>10^{11}$ particles/cm^2) arrays of Al/Al_2O_3 core-shell NPs. The Al NPs were produced by bottom-up approaches (Fig.1A) depositing Al on a self-organized insulating surface and dewetting it to form arrays of disconnected Al/Al_2O_3 core/shell NPs (Fig.1B).

The optical extinction of the Al NP arrays as a function of photon energy, measured with the electric-field either parallel (longitudinal) or perpendicular (transverse) to the Al-NP "chains" (Fig. 2C) shows peaks corresponding to the excitation of LSPR that reach the strikingly-high energy of 5.8 eV, the highest ever observed in optically-excited metallic NPs.

The achievement of a high-energy plasmonic response in Al NPs, and the ease of fabrication of these NPS in ultradense arrays is a milestone for DUV plasmonics, and a promising achievement for future applications in plasmon-enhanced DUV optical spectroscopy.

2013

Programmable Mechanical Resonances in MEMS by Localized Joule Heating of Phase Change Materials

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Advanced Materials 25, 6430-6435 (2013)

Dynamical control of mechanical resonance in MEMS and NEMS is a challenging task, usually achieved by external electrical fields or by modulating internal stress by thermal expansion. However, these solutions show some drawbacks and in particular they lack of memory effects . We report a material-based approach exploiting the phase transition of VO_2. Above 68°C VO_2 shows a sharp drop of resistivity by more than four orders of magnitude, accompanied by a monoclinic to rutile crystallographic phase change. This phase transition is hysteretic, showing a width of about 4°C and can be tuned by chemical doping or growth conditions.

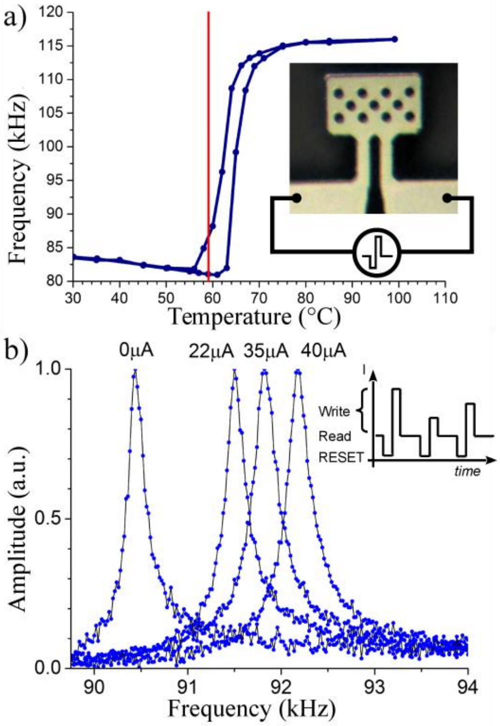

Fig.: a) Temperature dependence of the first flexural mode of the (unbiased) VO_2 microcantilever. b) Mechanical resonances of the microcantilever measured within the hysteretic windows (59 °C) and 15 μA constant read current bias upon a series of erase (0 μA)/write (22-35-40 μA) pulses (inset).

In thin films this phase transition is characterized by percolation between nanoscale-size domains, allowing the selection of intermediate physical states. Applying a current bias to a VO_2/TiO_2 free-standing mechanical microresonator we are able to control the formation of metallic (rutile) nanodomains by localized Joule heating. The local phase change modifies the interfacial stress between the two layers with a consequent shift of the mechanical resonance frequency proportional to the number of the rutile (metallic) domains. We are able to drive the monoclinic/rutile domains ratio by current pulses, thus selecting the resonance frequency of the microcantilever. The number of rutile domains is determined by the amplitude of the electrical pulse. A constant current bias maintains the “written” state after the pulse end, while the state is simply erased by a current pulse of zero amplitude. The key point of this approach is the mixing between VO_2 peculiar properties, low thermal coupling of free-standing devices and current biasing, which allows stable and reproducible selection of the different mechanical states.

2013

Interface reconstruction in superconducting $CaCuO_2/SrTiO_3$ superlattices: A hard x-ray photoelectron spectroscopy study

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Physical Review B 87, 155145 (2013)

We report on the electronic reconstruction behind the hole doping mechanism in superconducting (SC) artificial superlattices (SLs) based on insulating $CaCuO_2$ (CCO) and $SrTiO_3$ (STO) blocks. Hard x-ray photoelectron spectroscopy (HAXPES) shows that the diverging built-in electrostatic potential arising at the polar/nonpolar CCO/STO interface is suppressed. However, the valence band alignment (Fig.2(d)), calculated by the HAXPES core-level shifts, prevents any electronic reconstruction by direct charge transfer between CCO and STO bands.

A simplified mechanism for the suppression of the electrostatic potential can be based on a purely ionic mechanism, as shown in Fig. 1(b).

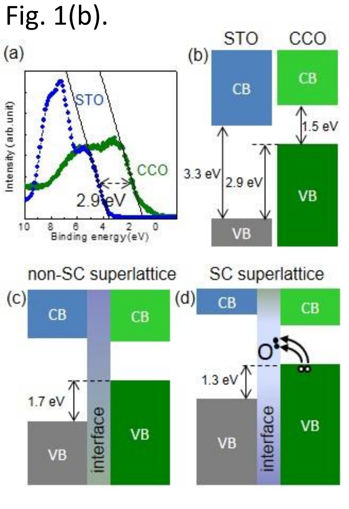

Fig.2 (a) Valence-band spectra for the CCO and the STO. (b)–(d) Schematic diagram of the valence and conducting bands: (b) uncoupled CCO and STO, (c) non-SC SL and (d) SC SL.

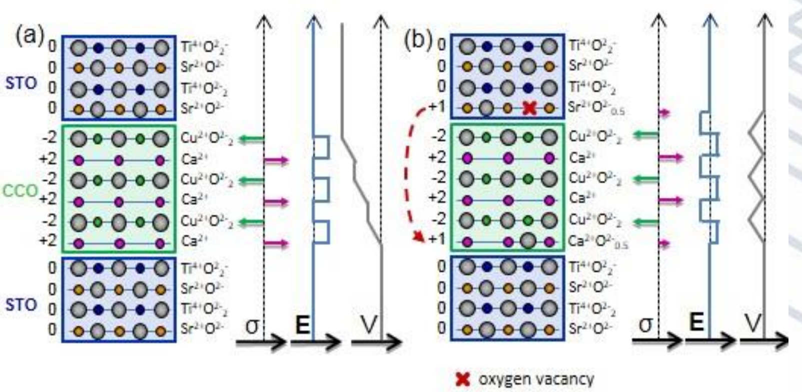

Fig.1 Sketch of CCO/STO SLs. (a) Unreconstructed interfaces with the diverging electrostatic potential. (b) Reconstructed interfaces by oxygen redistribution in the alkaline-earth metal interface planes.

The oxygen compositional roughening, resulting from the proposed model, is supported by the presence of additional peaks and doublets in all the measured HAXPES core-level spectra.

Furthermore, by using highly oxidizing growth conditions, the oxygen coordination in the reconstructed interfaces may be increased by excess oxygen introduced at the interfaces. The charge neutrality is preserved by leaving two holes in the valence band of CCO for each extra oxygen ion, as shown in Fig. 2(d), thus making the cuprate block superconducting.

2013

s-wave pairing in the optimally doped $LaO_{0.5}F_{0.5}BiS_2$ superconductor

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PHYSICAL REVIEW B 88, 180509(R) (2013)

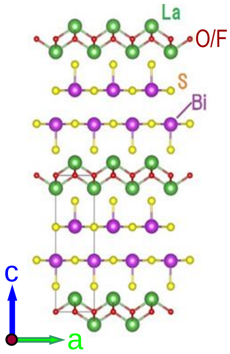
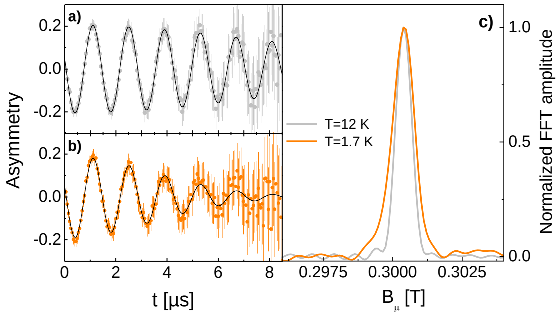


Fig.1: *Crystal structure of $LaO_{0.5}F_{0.5}BiS_2$; the solid line indicates the unit cell. (Y. Mizuguchi et al. J. Phys. Soc. Jpn. 81, 114725 (2012)).*

We report on the magnetic and superconducting properties of the layered compound $LaO_{0.5}F_{0.5}BiS_2$ (Fig.1) by means of zero- and transverse-field (ZF/TF) muon-spin spectroscopy (μSR). These measurements were performed by using both the General-Purpose Spectrometer (GPS) and the Low-Temperature Facility (LTF) on the πM3 beamline of the Swiss Muon Source at the Paul Scherrer Institute, Villigen, Switzerland.

Contrary to previous results on iron-based superconductors, measurements in zero field demonstrate the absence of magnetically ordered phases. TF-μSR measurements were performed by field cooling the sample in the mixed state ($H_{C1}<H_{ext}<H_{C2}$) . In Fig. 2 we show the TF muon-spin precession recorded below and above the superconducting critical temperature (~10 K) and the corresponding local field distribution *P(B)* at muon implantation sites.

The measurement of the muon spin relaxation rate σ_{SC} give access to the superfluid density n_S whose temperature behavior shows a marked s-wave character, with $2\Delta/k_BT_c$ very near to the value expected for a phonon-mediated pairing, with possibly an anisotropic gap. The high value of the Ginzburg-Landau parameter, $\kappa(0)$ ~ 85, places this compound in the extreme type-II superconductor family. Finally, the in-plane magnetic penetration depth λ_{ab}(1.7 K)=484 ± 3 nm indicates a very dilute superfluid density, typical of systems with an almost 2D character.



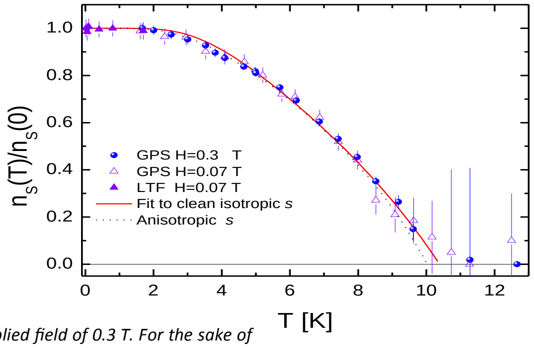


Fig. 2: *TF-μSR asymmetry data collected above (a) and below (b) Tc at an applied field of 0.3 T. For the sake of clarity the time-dependent asymmetry is represented in a 40-MHz rotating frame. (c) FFT real amplitude of the data shown in (a) and (b).*

2013

Hough Transform of Special Classes of Curves

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SIAM Journal on Imaging Sciences 6 (1), 391-412 (2013)

The Hough transform is a standard pattern recognition technique introduced between the 1960s and the 1970s for the detection of straight lines, circles, and ellipses in images. In the present paper we show that the Hough transform can be effectively applied for the automatic recognition of specific classes of curves whose algebraic forms are known but are significantly more complicated than straight lines or conics. For a large variety of these algebraic curves, we have proved a duality-type correspondence between the image and the parameter spaces by showing that each curve in the image space is transformed into a curve in the parameter space in such a way that all curves meet in one and only one point. This point uniquely identifies the original curve to be detected. Then we have implemented a numerical algorithm that realizes the recognition in a robust and automatic way.

We believe that this pattern recognition procedure may have applications in several domains of applied science, like in the processing of high resolution images from astronomical satellites (Fig. 1) and in medical imaging. Indeed, a specific work in progress involving this technique is concerned with the automatic description of the human skeleton districts for applications in oncology and neurology (Fig. 2).

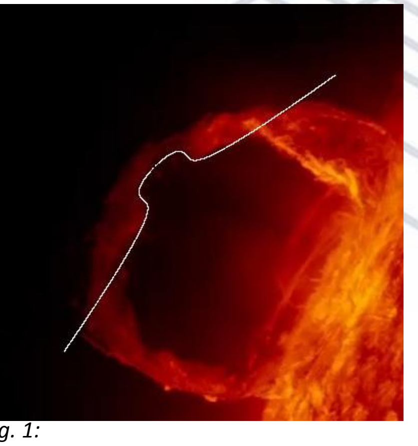

Fig. 1:
Detection of an elliptic curve in an Extreme Ultra-Violet (EUV) image recorded by the NASA SDO/AIA telescope in the 304 Å channel.

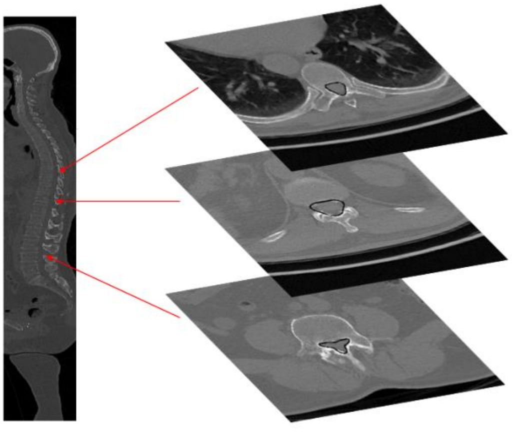

Fig. 2:
A possible application of the pattern recognition method illustrated in the paper: detection of the spinal canal in clinical X-ray tomography images.

2013

Nonlinear current-voltage characteristics due to quantum tunneling of phase slips in superconducting Nb nanowire networks

M. Trezza[1], C. Cirillo[1], P. Sabatino[1], G. Carapella[1], S.L. Prischepa[2], and C. Attanasio[1]

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[2]Belarusian State University of Informatics and Radioelectronics, Minsk, Belarus

Applied Physics Letters 103, 252601 (2013)

Superconductivity in 1D nanowires involves fundamental phenomena such as macroscopic quantum tunneling and quantum phase transitions. These systems can find applications in classical and possibly quantum information-processing devices, or they can be used as interconnects in electronic nanostructured devices. Quantum fluctuations of the superconducting order parameter were consistently revealed from both R(T) and V(I) measurements in superconducting Nb nanowire networks, consisting of about 30 interconnected wires, patterned on porous Silicon templates, a nanofabrication approach which can produce samples with physical properties resembling those of single nanowires. Indeed, Quantum Phase Slips (QPS) phenomenon is the dominant contribution to the transport properties of the system. All the data were coherently reproduced in the framework of theoretical models elaborated to describe QPS processes. The analyzed system, obtained starting from a robust and macroscopically large substrate, reveals fascinating quantum effects and shows high values of the critical current density. This last occurrence makes the system of potential use as 1D interconnection in complex nanodevices.

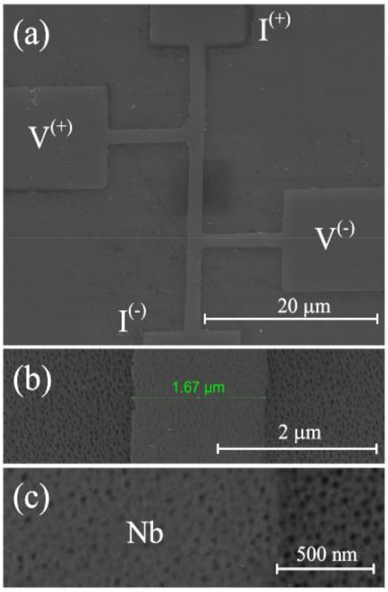

Fig. 1: FE-SEM images of the sample consisting of (a) a pair of current-carrying Nb electrodes, which contact the (L=30 µm, W=1.67 µm) nanoporous Nb film and a pair of voltage pads 10 µm apart, realized using EBL.. (b) Middle portion of the Nb film. (c) Zooming-in of the nanoporous Nb film edge. The average pore diameter and interpore distance are a=15 nm and d=50 nm, respectively.

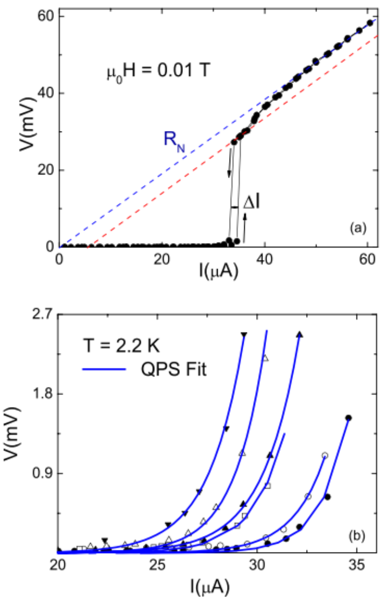

Fig. 2: (a) V(I) curve at T=2.2 K. The red (blue) line shows the resistance due to the single PS entering the sample (the normal-state resistance, R_N). (b) Nonlinear V(I) characteristics at different fields (0.01, 0.025, 0.05, 0.06, 0.08, 0.12 T, from right to left). Blue lines are the QPS fits to the data.

2013

Time-Resolved Optical Response of All-Oxide $YBa_2Cu_3O_7/La_{0.7}Sr_{0.3}MnO_3$ Proximitized Bilayers

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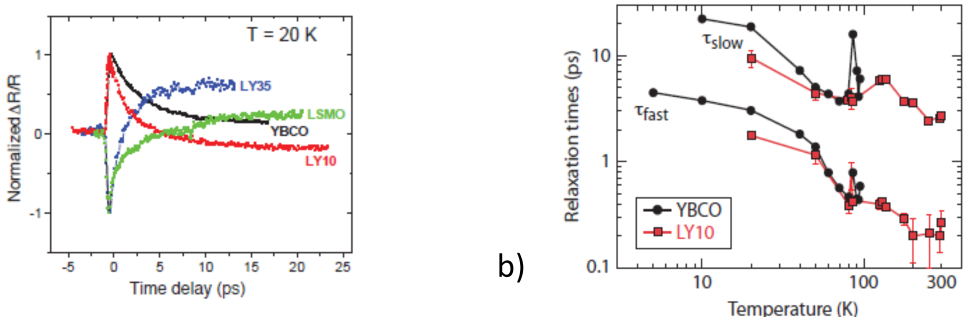
Phys. Rev. B vol. 87, 134514 (2013)

We present femtosecond pump–probe spectroscopy studies of time-resolved optical reflectivity of all-oxide, $YBa_2Cu_3O_7/La_{0.7}Sr_{0.3}Mn_{O3}$(YBCO/LSMO) superconductor/ferromagnet (*S*/*F*) bilayers consisting of a 100-nm-thick YBCO base layer and either 10-nm or 35-nm LSMO cap thickness, in the temperature range from 4 K to room temperature. At temperatures far below the YBCO superconducting transition T_C, samples with a 10-nm *F* overlayer show a photoresponse that is similar to, but faster than, pure-YBCO, 100-nm-thick reference samples, while close to T_C and above (up to 160 K), we observe a signature of both the electronic and spin response that cannot be interpreted as an incoherent sum of contributions from the two layers. The photoresponse of the *S*/*F* structures with the 35-nm LSMO layer always follows that of the pure LSMO. In all cases, the YBCO/LSMO nonequilibrium dynamics can be modeled using a generalized multi-temperature model, which is a superposition of the dynamics of the three-temperature models used to describe the superconductor and ferromagnet subsystems, respectively. The long-term of the photoresponse signal can be well fitted with the two characteristic relaxation times. Finally, the LSMO/YBCO bilayers with 10-nm-thick LSMO caps were characterized by quasiparticle relaxation times substantially shorter than those of the pure YBCO, making them interesting for possible applications of *S*/*F* bilayers in the field of ultrafast superconducting optoelectronics.



a) b)

a) Normalized Δ*R/R* transients versus time delay measured at 20 K for our LY10 and LY35 bilayers, as well as the pure YBCO and LSMO reference samples. b) Characteristic fast and slow relaxation times (τ_{fast} and τ_{slow}) extracted from the experimental Δ*R*/*R*(*t*) plots for our LY10 and pure YBCO samples as a function of temperature.

2013

Spin-orbital coupling in a triplet superconductor—ferromagnet junction

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[2] Max-Planck-Institut fur Festkorperforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany
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Physical Review Letters 111, 097003 (2013)

We predict a novel form of interaction between spin and orbital degrees in a spin-triplet superconductor (TSC)- ferromagnet (FM) heterostructure (see Fig. a). In such a system the orientation of the FM moment relative to the TSC vector order parameter is a crucial variable that controls the main physical properties. In addition to the pair breaking, spin-flip reflection processes at the interface with the FM scatter the triplet Cooper pairs between the spin up and down condensates, setting up an effective Josephson-like coupling between them. The pair-breaking and spin Josephson coupling both make significant contributions to the free energy of a TSC-FM junction through the proximity effect, the interface electronic reconstruction, and the variation of the TSC gap. Although these contributions depend upon the direction of the FM's exchange field, the two effects do not necessarily act constructively. For a single-component p-wave TSC, we find that the variation of the gap controls the orientation of the FM's moment via the change in condensation energy. The stable configuration is either parallel or perpendicular to the TSC vector order parameter, depending on the alignment of the TSC gap with respect to the interface, thus evidencing a unique form of spin-orbital coupling. The competing orbital components of the chiral p_x+ip_y state generate a non unique behavior and a first-order transition from the perpendicular to the parallel configuration as the FM exchange field is increased (see Fig. b). When the interface is imperfect the scenario is different and other processes can play a relevant role in setting the magnetic profile.

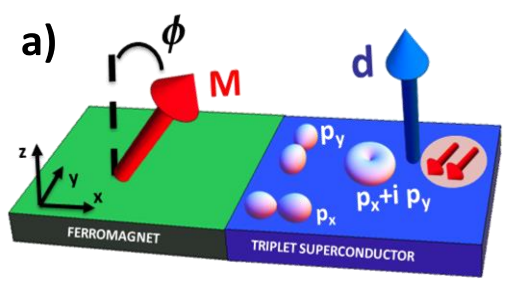

Fig. a) Schematic diagram of the two-dimensional TSC-FM junction. The magnetization M of the FM can form an angle Φ with respect to the d-vector of the TSC. We study TSC states with p_x, p_y and p_x+ip_y orbital symmetry.

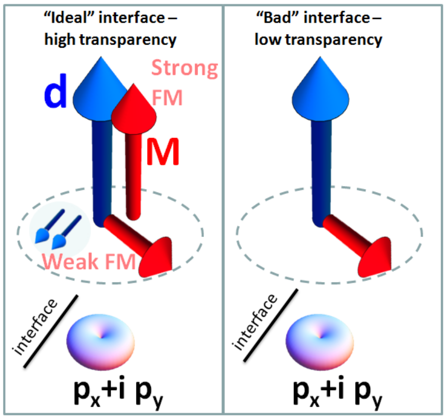

Fig. b) Sketch of the most favorable ferromagnetic orientation in the case of a chiral spin-triplet superconductor.

2013

Persistent Photoconductivity in 2D Electron Gases at Different Oxide Interfaces

Emiliano Di Gennaro[1,2], Umberto Scotti di Uccio[1,2], Carmela Aruta[1], Claudia Cantoni[3], Alessandro Gadaleta[4], Andrew R. Lupini[3], Davide Maccariello[2], Daniele Marré[4], Ilaria Pallecchi[4], Domenico Paparo[1], Paolo Perna[2], Muhammad Riaz[2], and Fabio Miletto Granozio[1]

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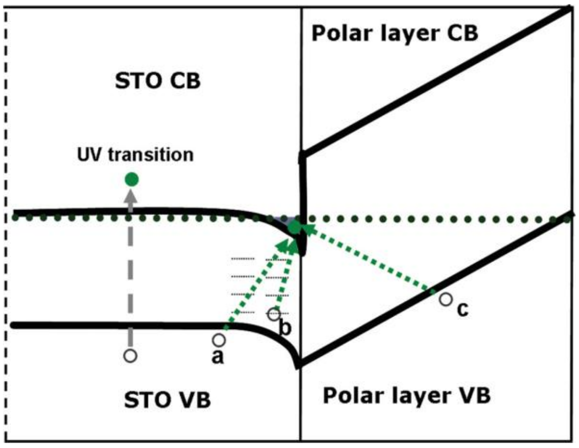
[4] Physics Department, University of Genova, Genova (Italy)

Advanced Optical Materials 1, 834 (2013)

The transport characterization in the dark and under light irradiation of three different interfaces — $LaAlO_3/SrTiO_3$, $LaGaO_3/SrTiO_3$, and the novel $NdGaO_3/SrTiO_3$ heterostructure — is reported. All of them share a perovskite structure, an insulating nature of the single building blocks, a polar/non-polar character, and a critical thickness of four unit cells for the onset of conductivity.



Sketch of the band structure of a polar/non-polar interfaces where the band bending is depicted as expected within an ER scenario and localized states possibly due to oxygen vacancies or intermixing are also considered in the gap. The bending of the STO band is emphasized for clarity. The possible mechanisms (a), (b) and (c) described in the text for the promotion of carriers at the interface into the STO CB by sub-gap photons are sketched. A standard inter-band transition induced by above-gap UV light is also shown.

The interface structure and charge confi nement in $NdGaO_3/SrTiO_3$ are probed by atomic-scale-resolved electron energy loss spectroscopy showing that, similarly to $LaAlO_3$ /$SrTiO_3$, extra electronic charge confi ned in a sheet of about 1.5 nm in thickness is present at the $NdGaO_3/SrTiO_3$ interface. Electric transport
measurements performed in the dark and under radiation show remarkable similarities and provide evidence that the persistent perturbation induced by light is an intrinsic peculiar property of the three investigated oxide-based polar/non-polar interfaces. This sets a framework for understanding the previous contrasting results found in the literature about photoconductivity in $LaAlO_3$ /$SrTiO_3$ and highlights the connection between the origin of persistent photoconductivity and the origin of conductivity itself. An improved understanding of the photoinduced metastable electron–hole pairs might allow light to be shed directly on the complex physics of this system and on the recently proposed perspectives of oxide interfaces for solar energy conversion.

2013

Stepwise behaviour of magnetization temperature dependence in iron nanoparticle assembled films.

V. Iannotti[1], S. Amoruso[1], G. Ausanio[1], R. Bruzzese[1], L. Lanotte[1], A. C. Barone[2], G. Margaris[3], K.N. Trohidou[3], D. Fiorani[4]

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[2] CNR-ISTEC, Via Granarolo 64, Faenza (RA), Italy
[3] IAMPPNM, Department of Materials Science, NCSR ‘Demokritos’, Aghia Paraskevi, Athens, Greece
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Nanotechnology 24, 165706 (2013)

An unusual stepwise behaviour was observed in the temperature dependence of zero field cooled (ZFC) magnetization in iron nanoparticle (NP) dense films, produced by ultrashort pulsed laser deposition. This result is striking because nanostructured magnetic materials produced by other techniques typically show a ZFC magnetization increasing monotonously with the temperature. We have interpreted this behaviour by means of phenomenological modeling and Monte Carlo simulations addressing the peculiar morphology of the nanostructure. Key elements are: 1) competition between Zeeman, intracluster anisotropy and intercluster exchange energy densities; 2) slow change of the anisotropy and exchange energy density with temperature; 3) quasi two-dimensionality of the system. This finding allows conceiving nanostructured materials very sensitive to the local magnetic field gradient, with potential applications in, e.g, sensor devices, nanoscope tips and magnetic read heads.

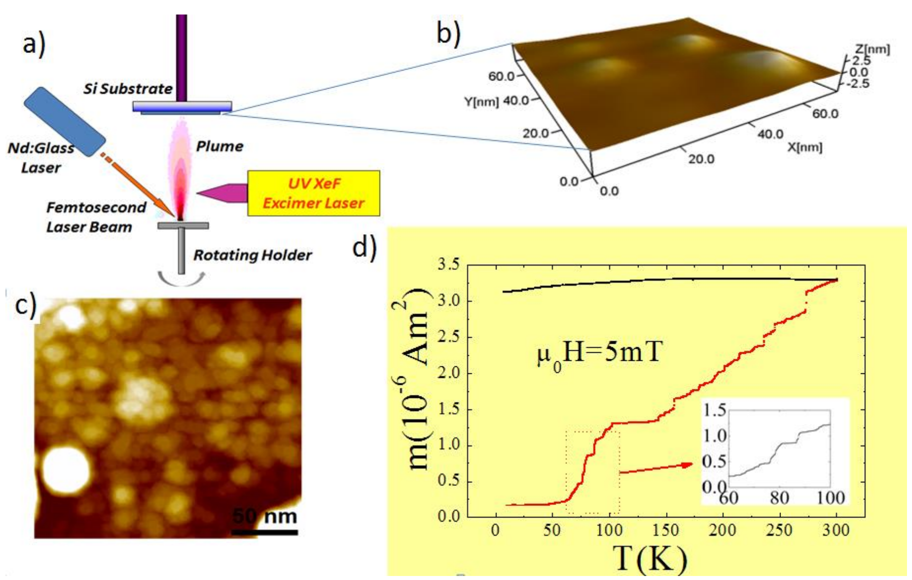

Fig. a): Sketch of the experimental setup: the NPs median size and size dispersion is controlled by irradiating the NPs in-flight with ns UV pulses. Fig. b): Typical AFM image of isolated Fe NPs. Fig. c): HRSEM image of Fe NPs assembly. Fig. d): Stepwise behaviour of the ZFC magnetization curve.

2013

Electric Control of the Giant Rashba effect in bulk GeTe

D. Di Sante [1,2], P. Barone[1], R. Bertacco[3], S. Picozzi[1]

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[2] Physics Department, University of L'Aquila, L'Aquila (Italy)
[3] LNESS - Dip. Fisica, Politecnico di Milano (Italy)

Advanced Materials 25, 509-513 (2013)

Relativistic effects are increasingly seen as key ingredients in the burgeoning field of spintronics. Among them, the Rashba effect, in which the spin degeneracy is removed as a consequence of spin-orbit interaction in noncentrosymmetric structures, plays a leading role. While the Rashba effect is commonly associated to two dimensional systems and interfaces, recent reports suggest that a sizeable Rashba splitting might also occur in bulk materials, such as BiTeI. In our work we establish, for the first time, a link between Rashba physics and the field of ferroelectricity in single-phase materials, by predicting from first-principles a giant Rashba effect in bulk GeTe, a narrow gap ferroelectric semiconductor.

We focus on the dependence of the spin splitting amplitude on the ferroelectric polarization, which makes the spin polarization of the current fl owing in GeTe to be controllable and switchable by an electric field. In particular, we demonstrate that a full reversal of the spin polarization, i.e., of the Rashba parameter, can be achieved upon reversal of the ferroelectric polarization. Noteworthy, the hysteretic nature of ferroelectricity provides a unique way to exploit the Rashba effect in novel spintronics devices with non volatile logic functions associated with the remanent ferroelectric states. As an example, the design of a spin FET employing a bulk GeTe channel is also discussed.

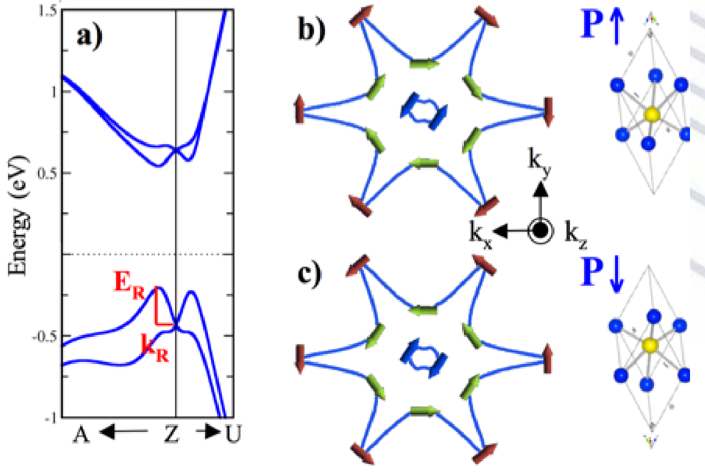

Fig.: a) Zoom of the density-functional band structure in the Brillouin Zone plane A-Z-U perpendicular to polarization P for bands close to the Fermi level. The Rashba parameters E_R and k_R are highlighted. b) Isoenergy cuts at an energy of -0.47 eV around Z in the A-Z-U plane. The spin-expectation values for holes are shown by arrows for polarization direction parallel to [111] (see sketch on the right for GeTe atomic arrangement); c) same as panel b) but for opposite polarization direction: the spin texture is reversed.

2013

Carrier-number fluctuations in the 2-dimensional electron gas at the $LaAlO_3/SrTiO_3$ interface

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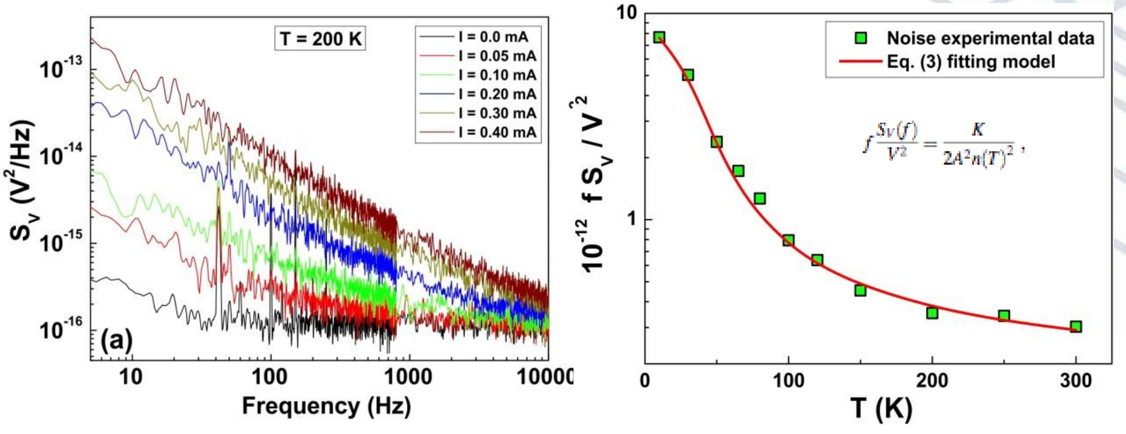
[1]Dipartimento di Fisica “E. R. Caianiello” and CNR-SPIN Salerno, Universitàdi Salerno, I-84084 Fisciano, Salerno, Italy. [2]CNR-SPIN Napoli and Dipartimento di Fisica, Universitàdi Napoli “Federico II,” I-80126 Napoli, Italy.
[3]CNR-SPIN Genova and Dipartimento di Fisica, Università di Genova, I-16152 Genova, Italy

APPLIED PHYSICS LETTERS 103, 231601 (2013)

The voltage-spectral density $S_V(f)$ of the 2-dimensional electron gas formed at the interface of $LaAlO_3/SrTiO_3$ has been thoroughly investigated. The low-frequency component has a clear 1/f behavior with a quadratic bias current dependence, attributed to resistance fluctuations. However, its temperature dependence is inconsistent with the classical Hooge model, based on carrier-mobility fluctuations. The experimental results are, instead, explained in terms of carrier-number fluctuations, due to an excitation-trapping mechanism of the 2-dimensional electron gas.



(Left) Voltage spectral traces at 200 K and for different bias currents.(Right) Normalized noise level fS_V/V^2 vs. T (dots). Red solid curve is the fitting function given in the inset.

The experimental findings support the existence of a thermally activated mechanism which promotes charge carriers from a narrow, underlying band (attributed to polarons or to Anderson-localized states), to the conduction band. The low-frequency Flicker noise spectra have pure 1/f dependence, with a I^2 scaling, allowing the attribution of the noise to resistance fluctuations. The noise level dependence on temperature cannot be consistently explained in terms of the classical Hooge picture. It is, instead, shown that a model based on the fluctuation of the carrier number describes correctly the experimental observations.

Events

2012

__Apr. 27-28__, Napoli

Meeting to remember the human and scientific figure of Antonio Barone that is universally considered not only the founder of the Superconductivity School in the Napoli area, but also as the "grande maestro" and one of the most representative physicists in Italy.

__Mar. 20-22__, Vietri sul Mare (Sa)

MAMA ProTheo Workshop
Multifunctional Advanced Materials: Probe and Theory

The aim of the workshop was to join together leading scientists involved in advanced probes and modelling of multifunctional complex materials, in order to address their fundamental aspects and novel functionalities. The joint expertise guarantees a stimulating environment to achieve the identification of future challenges and strategies about the tailoring of specific physical phenomena and the potential impact of multifunctional materials.

__Jun. 02-05__, Catania

International Conference
Frontiers in Statistical Physics and Complex Systems

The conference, organized by the Universities of Naples (Seconda Università e Federico II), Messina e Catania and supported by the CNR - Department of Materials and Devices, was in honor of prof. Antonio Coniglio on the occasion of his 70° birthday. The conference was attended by physicists of great international prestige in the field of Statistical Mechanics and Complex Systems, as prof. Eugene Stanley from the Boston University and prof. Giorgio Parisi from La Sapienza Rome University.

__Jun. 20-22__, Parma

SINFO Workshop

Surfaces, Interfaces and Functionalization Processes in Organic Compounds and Applications

The workshop aimed at providing scientists from the CNR - Department of Materials and Devices with a forum to share the latest information and ideas on the fundamental properties of organic semiconductor and small molecule overlayers as well as their future applications and implementation into working devices.

Events

2012

***Sep. 17-21**, Napoli*

XCVIII Congresso Nazionale SIF

Società Italiana di Fisica - Sezione di Fisica della Materia

Dedicated to the teaching of the properties of matter around us in order to understand its microscopic mechanisms and to learn how to control their properties in order to create materials and devices of practical use in many fields

***Oct. 22-24**, Ischia (NA)*

MAMA Hybrids Workshop

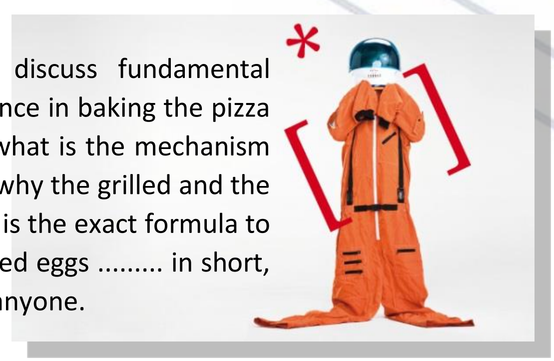
Multifunctional Hybrids And Organics

The aim of the workshop was to gather together leading scientists in the field of fabrication, characterization, and modelling of multifunctional hybrids and organics, in order to address their fundamental aspects and novel functionalities also emerging from the coupling of different materials and phenomena. Indeed this research is moved forward by the continuous developments in the fabrication techniques, which make possible the reliable realization of complex heterostructures consisting of layers only a few nanometers thick coupled through high quality contacts.

***Oct. 27**, Genova*

Science Festival - Andrei Varlamov Conference

Scienziati in Pizzeria



Physicists and chemists meet in pizzeria to discuss fundamental questions about the Universe: what is the difference in baking the pizza in the wood-fired oven or in the electrical one, what is the mechanism by which the heat is transferred in a microwave, why the grilled and the boiled meat have so many different flavors, what is the exact formula to determine the cooking time of spaghetti and boiled eggs .... in short, all matter of great importance in the universe of anyone.

***Nov. 21-22**, Roma*

CNR-DSFTM training

Gestione Documentale e Protocollo

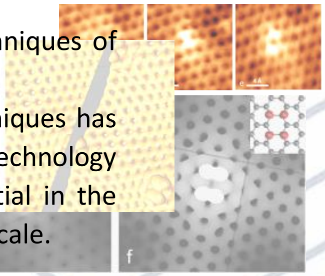
The training course addressed to the administrative staff of the CNR whit the following topics: the document management and the dematerialization of administrative procedures. These activities present priority interest in the Public Administrations as a result of the new regulatory provisions.

Events

2012

***Dec. 13-14**, Genova*

CNR-DSFTM training - *Tecniche di microscopia innovative e a risoluzione atomica*



The course provided participants with an update on the advanced techniques of electron microscopy and stylus, and strong field in continuous evolution.
The opportunity to organize two training days dedicated to these techniques has highlighted the very importan role that they assume in the science and technology of materials science because of their versatile use and of their potential in the investigation and handling innovative materials and devices at the nano-scale.

2013

***Feb. 20-24**, Napoli*

MAGNET
Annual Conference on Magnetism

The conference – promoted by the Italian Magnetism Society (AIMagn) and organized by the Physics Department, University of Naples Federico II, in cooperation with CNR-SPIN U.O.S. Napoli – aimed at presenting and discussing recent achievements in both fundamental and applied magnetism, putting together researchers from Universities, Research Institutions and companies working in this field.

***Apr. 06-09**, Sestri Levante. (Ge)*

Les Journées des Actinides

This conference is a traditional forum for informal discussion encompassing numerous different aspects related to the chemistry and physics of the actinides. It regularly brings together experts from all the fields involved, emphasizing exchanges and lively discussions on current issues in actinide science and stimulating new collaborative projects. Moreover, a strong emphasis is given on presentations of on-going research projects by young scientists and PhD students.

May 20-23, *Sorrento (NA)*

Last MAMA Workshop

Trend

MAMA Trend was the last and most important event organised within the MAMA project. It collected a large interest from the scientific community and a wide number of participants.

The aim was to organize a lively conference focused on the latest breakthroughs in the highly dynamic research field of novel (multi)functional materials.

The conference is structured in 4 plenary sessions, and 4 Symposia. Each day consisted of one plenary session and two Symposia that ran in parallel. One afternoon was devoted to the poster session.

Topics:

Symposium 1	Unconventional superconductivity: materials, pairing mechanisms and physical properties
Symposium 2	Dielectrics, ferroelectrics and multiferroics
Symposium 3	Spin, charge and orbital ordering, phase transitions and quantum critical behaviour in correlated electron systems
Symposium 4	Emerging phenomena at surfaces and interfaces in correlated electron systems

Jul. 09, *Roma*

Conference "*Tutto il Mondo in un Atomo - Potenza e stranezza del mondo quantistico*"

Series of meetings on the occasion of 100 years of Bohr's atomic model and the 90th birthday of CNR

Serge Haroche, Nobel Prize for Physics 2012 attended the Conference *Potenza e stranezza del mondo quantistico*

Sep. 09-13, *Genova*

ESAS Summer School

New Trends with Superconducting Quantum Detectors

The ESAS Summer School is a satellite event of the European cOnference Eucas 2013. The school aims to provide an up to date scientific and technological review of the superconductivity applied to the wide fields of the electronics, devices, and detectors

Events

2013

Oct. 06-11, *Ischia*

International Conference On Laser Ablation

COLA - 2013

The COLA conference brings together hundreds of scientists from all over the world providing a global, interdisciplinary forum covering topics in a wide range of scientific research areas, from basic science to applications and technology. The conference focuses on a variety of arguments which have their core in laser-materials interactions.

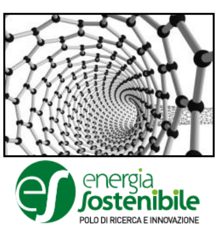
The conference continues the tradition initiated at the 1991 Conference in Oak Ridge (USA) and 1993 Conference in Knoxwille (USA), and strengthened at successive biannual meetings in Strasbourg (France, 1995), Monterey (USA, 1997), Göttingen (Germany, 1999), Tsukuba (Japan, 2001), Crete (Greece, 2003), Banff (Canada, 2005), Tenerife (Spain, 2007), Singapore (2009), and Playa del Carmen (Mexico, 2011).

Topics: Fundamentals of Laser-Material Interactions – Laser Materials Processing – Laser-based analytical methods – Pulsed Laser Ablation and Deposition – Laser Applications – Lasers in Nanoscience/ Nanotechnology – Ultrafast phenomena and phase transformations – Laser interactions with organics and bio-materials – New trends in photoexcitations

Oct. 18, *Genova*

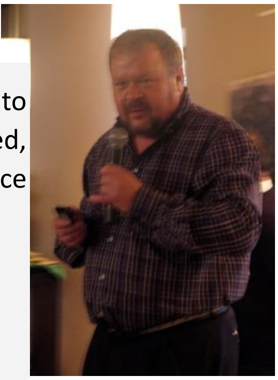
Workshop

the Graphene material: from scientific discovery to industrial innovation



The focus of the conference is the Graphene and its startling properties which are at the origin of numerous applications promising implications in many industrial sectors. The objective of the meeting is to know the latest news from research on Graphene and some of its first industrial applications.

Oct. 28, *Genova* Science Festival - Andrei Varlamov Conferences



In the year of its tenth anniversary, the Festival of Science decided to choose the “beauty” as main topic: among the many events scheduled, Andrei Varlamov presented 4 conferences with the aim of making science accessible to all and leading away the audience of all ages:

Il lato oscuro dell’Universo

La Fisica in viaggio

Le tempeste spaziali

Visioni e illusioni

Events

2013

Italia del futurO

An innovative exhibition on some of the most significant Italian scientific and technological excellence. Italy of the future' has been on tour in some of the Italian Cultural Institutes from all over the world:

Tokyo, April 17 – May 17
San Francisco, July 12 – August 23
Los Angeles, September 4 – October 1
Budapest, November 27 2013 – January 10 2014

11th European Conference on Applied Superconductivity

September 15-19 2013 - Genova, Italy — Eucas 2013

www.eucas2013.org

EUCAS is the European Conference on Applied Superconductivity that takes place every two years in a different European venue, and attracts scientists working in the field of superconductivity and industrial researchers dealing with the industrial applications, coming from all over the world.

EUCAS is principally aimed at bringing out the most recent scientific developments in the investigation of superconducting materials, and at fostering discussion on new potential applications of superconductivity and on technology transfer to industry. EUCAS is therefore a prestigious event from both the scientific and technological point of view, because it hosts the presentation of products, services, techniques and know-how, which are innovative and highly relevant to the advancement of scientific research and industrial productivity in the superconductivity field.

The choice of Genoa as the 2013 location is of particular significance, given its scientific and industrial vocation for superconductivity issues. In Genoa, in fact, are based many companies operating in this area of excellence, both in industry (such as ASG Superconductors, Columbus Superconductors, and Paramed), and in the research field (the SPIN Institute of CNR, the University of Genoa, with the Departments of Physics and Chemistry, and the local branch of INFN). All of them are represented in the organizing committee of EUCAS 2013.

Conference chair:

Carlo Ferdeghini and Marina Putti

Topics and program co-chair:

Materials – G. Balestrino

Wires, Tapes and Conductors – G. Grasso

Electronics – S. Pagano

Large scale applications – P. Fabbricatore

Some numbers:

Participants	9
Exhibitors	90 (33) companies
Staff	46

1.055 total participants from 40 different Countries

Plenary	7
Invited talks	23
Oral talks	203
Posters	550
Chairs	125

Closing cerimony

Nobel laureate Alexander Muller meets a young SPIN researcher

Social event at Villa Croce

Pubblications

Publications

2012

1. M. Trezza, S.L. Prischepa, C. Cirillo, C. Attanasio
   1D superconductivity in porous Nb ultrathin films
   PHYSICA C: SUPERCONDUCTIVITY Volume: 479 Issue: Pages: 167-169

2. M. Vignolo, G. Romano, A. Martinelli, C. Bernini, and A. S. Siri
   A Novel Process to Produce Amorphous Nanosized Boron Useful for MgB_2 Synthesis
   IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY Volume: 22 Issue: 4 #: 6200606

3. J. N. Gonçalves, A. Stroppa, J. G. Correia, T. Butz, S. Picozzi, A. S. Fenta, and V. S. Amaral
   Ab initio study of the relation between electric polarization and electric field gradients in ferroelectrics
   PHYSICAL REVIEW B Volume: 86 Issue: 3 #: 035145

4. R. Pastore, M. Pica Ciamarra, and A. Coniglio
   Absence of 'fragility' and mechanical response of jammed granular materials
   GRANULAR MATTER Volume: 14 Issue: 2 Pages: 253-258

5. S. Picozzi and A. Stroppa
   Advances in ab-initio theory of multiferroics materials and mechanisms: modelling and understanding
   THE EUROPEAN PHYSICAL JOURNAL B Volume: 85 Issue: 7 Pages: 240(22)

6. P. Lucignano, A. Mezzacapo, F. Tafuri, and A. Tagliacozzo
   Advantages of using high-temperature cuprate superconductor heterostructures in the search for Majorana fermions
   PHYSICAL REVIEW B Volume: 86 Issue: 14 #: 144513

7. S. De Martino and S. De Siena
   Allometry and growth: A unified view
   Physica A Volume: 391 Issue: 18 Pages: 4302-4307

8. F.V. Di Girolamo, M. Barra, F. Chiarella, S. Lettieri, M. Salluzzo, and A. Cassinese
   Ambipolar transport and charge transfer at the interface between sexithiophene and N,N-bis(n-octyl)-dicyanoperylenediimide films
   Phys. Rev. B Volume: 85 Issue: 12 Pages: 125310(10)

9. S. Allavena, M. Piana, F. Benvenuto, and A.M. Massone
   An interpolation/extrapolation approach to X-ray imaging of solar flares
   Inverse problems and imaging Volume: 6 Issue: 2 Pages: 147-162

10. C. Mirri, F. M. Vitucci, P. Di Pietro, S. Lupi, R. Fittipaldi, V. Granata, A. Vecchione, U. Schade, and P. Calvani
    Anisotropic optical conductivity of $Sr_4Ru_3O_{10}$
    Phys. Rev. B Volume: 85 Issue: 23 Pages: 235124 (7)

11. S. G. Sharapov and A. A. Varlamov
    Anomalous growth of thermoelectric power in gapped graphene
    Phys. Rev. B Volume: 86 Issue: 3 Pages: 035430 (5)

12. R. Ciancio, A. Vittadini, A. Selloni, C. Aruta, U. Scotti di Uccio, G. Rossi, and E. Carlino
    Atomic structure and crystallographic shear planes in epitaxial TiO_2 anatase thin films
    Microscopie Società Italiana Scienze Microscopiche (SISM) Volume: IX n.2 Issue: 18 Pages: 50-56

13. A. Andreone, G. Abbate, E. Di Gennaro, and P.R. Thankamani
    Bandgap isotropy in photonic quasicrystals with low-index contrast
    Proceedings of SPIE Volume 8423 Metamaterials VII Pages: 842307 (7)

14. A. Carella, F. Borbone, A. Roviello, G. Roviello, A. Tuzi, A. Kravinsky, R. Shikler, G. Cantele, and D. Ninno
    Benzodifuroxazinones, a new class of heteroacene molecules for possible applications in organic electronics: Synthesis, electronic properties and crystal structure
    Dyes and Pigments Volume 95 Issue 1 Pages 116–125

15. V. Bisogni, M. Moretti Sala, A. Bendounan, N. B. Brookes, G. Ghiringhelli, and L. Braicovich
    Bimagnon studies in cuprates with resonant inelastic x-ray scattering at the O K edge. II. Doping effect in $La_{2-x}Sr_xCuO_4$
    Phys. Rev. B Volume: 85 Issue: 21 Pages: 214528 (6)

Publications

2012

16. V. Bisogni, L. Simonelli, L. J. P. Ament, F. Forte, M. Moretti Sala, M. Minola, S. Huotari, J. van den Brink, G. Ghiringhelli, N. B. Brookes, and L. Braicovich
Bimagnon studies in cuprates with resonant inelastic x-ray scattering at the O K edge. I. Assessment on La_2CuO_4 and comparison with the excitation at Cu L-3 and Cu K edges
Phys. Rev. B Volume: 85 Issue: 21 Pages: 214527 (9)

17. C. A. Perroni and V. Cataudella
Bipolaron formation in organic semiconductors at the interface with dielectric gates
Europhysics letters Volume: 98 Issue: 4 Pages: 47004 (5)

18. V. Cataudella, R. Citro, G. De Filippis, and C. A. Perroni
Bond Stretching Phonon Softening of Underdoped Copper-Oxide Superconductors
Journal of superconductivity and novel magnetism Volume: 25 Issue: 5 Pages: 1303-1306

19. M. D. Lee, S. Rist, and J. Ruostekoski
Bragg spectroscopic interferometer and quantum measurement-induced correlations in atomic Bose-Einstein condensates
New journal of physics Volume: 14 Pages: 73057(13)

20. M. Barra, D. Viggiano, R. Di Capua, F. Di Girolamo, F. Santoro, M. Taglialatela, and A. Cassinese
Cell viability studies and operation in cellular culture medium of n-type organic field-effect transistors
Journal of applied physics Volume: 111 Issue: 3 Pages: 34702(8)

21. A. Ambrosio, F. Borbone, A. Carella, R. Centore, S. Fusco, H. G. Kuball, P. Maddalena, C. Romano, A. Roviello, and M. Stolte
Cis-trans isomerization and optical laser writing in new heterocycle based azo-polyurethane
Optical materials Volume: 34 Issue: 4 Pages: 728(5)

22. F. Carillo, G.M. De Luca, D. Montemurro, G. Papari, M. Salluzzo, D. Stornaiuolo, F. Tafuri, and F. Beltram
Coherent transport in extremely underdoped $Nd_{1.2}Ba_{1.8}Cu_3O_z$ nanostructures
New journal of physics Volume: 14 Pages: 083025 (9)

23. C. Autieri, M. Cuoco, and C. Noce
Collective properties of eutectic ruthenates: Role of nanometric inclusions
Phys. Rev. B Volume: 85 Issue: 7 Pages: 75126 (9)

24. M. Calandra, C. Attaccalite, G. Profeta, and F. Mauri
Comment on "Electronic Structure of Superconducting KC_8 and Nonsuperconducting LiC_6 Graphite Intercalation Compounds: Evidence for a Graphene-Sheet-Driven Superconducting State''
Physical review letters Volume: 108 Issue: 14 Pages: 149701 (2)

25. C. Artini, G. Costa, M. Carnasciali, and R. Masini
Comparative study and properties of $RuSr_2Gd_{1.4}Ce_{0.6}Cu_2O_{10-\delta}$ ruthenocuprate samples by different preparation methods
Materials science & engineering. B, Solid-state materials for advanced technology Volume: 177 Issue: 1 Pages: 112-116 –

26. V. D'Ambrosio, E. Nagali, S. P. Walborn, L. Aolita, S. Slussarenko, L. Marrucci, and F. Sciarrino
Complete experimental toolbox for alignment-free quantum communication
Nature communications Volume: 3 Pages: 961-968

27. M. Barbieri, M. Chotalia, J. Fraser, L. M. Lavitas, J. Dostie, A. Pombo, and M. Nicodemi
Complexity of chromatin folding is captured by the strings and binders switch model
Proceedings of the National Academy of Sciences of the United States of America Volume: 109 Issue: 40 Pages: 16173- 16178

28. G. Carapella, P. Sabatino, and G. Costabile
Considerable asymmetry of the critical current in a niobium thin strip of plano-convex section
Journal of applied physics Volume: 111 Issue: 5 Pages: 053912(7)

Publications

2012

29. G. Grimaldi, A. Leo, A. Nigro, A. V. Silhanek, N. Verellen, V. V. Moshchalkov, M. V. Milosevic, A. Casaburi, R. Cristiano, and S. Pace
Controlling flux flow dissipation by changing flux pinning in superconducting films
Applied physics letters Volume: 100 Issue: 20 Pages: 202601(4)

30. A Galdi, P Orgiani, L Maritato, and L Méchin
Correlation between structural properties and resistivity critical behavior in $SrRuO_3$ thin films
Journal of physics. Condensed matter Volume: 24 Issue: 43 Pages: 435603(6)

31. C. Aruta, S. Amoruso, G. Ausanio, R. Bruzzese, E. Di Gennaro, M. Lanzano, F. Miletto Granozio, M. Riaz, A. Sambri, U. Scotti di Uccio, and X. Wang
Critical influence of target-to-substrate distance on conductive properties of $LaGaO_3/SrTiO_3$ interfaces deposited at $10^{(-1)}$ mbar oxygen pressure
Applied physics letters Volume: 101 Issue: 3 Pages: 031602(5)

32. P. De Marco, F. Bisti, F. Fioriti, M. Passacantando, C. Bittencourt, S. Lettieri, A. Ambrosio, P. Maddalena, S. Prezioso, S. Santucci, and L. Ottaviano
Crystal phase dependent photoluminescence of 6,13-pentacenequinone
Journal of applied physics Volume: 112 Issue: 1 Pages: 013512(4)

33. A. Provino, Y. Mudryk, D. Paudyal, V. Smetana, P. Manfrinetti, V. K. Pecharsky , K. A. Gschneidner, Jr, and J. D. Corbett
Crystal structure of $Tb_5Ni_2In_4$ and $Y_5Ni_2In_4$, and magnetic properties of $Dy_5Ni_2In_4$
Journal of applied physics Volume: 111 Issue: 7 Pages: 3673432(3)

34. J. Guo, A. G. Emslie, E. P. Kontar, F. Benvenuto, A. M. Massone and M. Piana
Determination of the acceleration region size in a loop-structured solar flare
Astronomy & astrophysics Volume: 543 Pages: A53(7)

35. L. Longobardi, D. Massarotti, D. Stornaiuolo, L. Galletti, G. Rotoli, F. Lombardi, and F. Tafuri
Direct Transition from Quantum Escape to a Phase Diffusion Regime in YBaCuO Biepitaxial Josephson Junctions
Physical review letters Volume: 109 Issue: 6 Pages: 821-825

36. D. Petti , A. Stroppa , S. Picozzi , S. Brivio , M. Cantoni , and R. Bertacco
Effect of Au proximity on the LSMO surface: An ab initio study
Journal of magnetism and magnetic materials Volume: 324 Issue: 17 Pages: 2659- 2663

37. S. Attaf, M.F. Mosbah, R. Fittipaldi , D. Zola , S. Pace , and A. Vecchione
Effect of double substitution on structural and magnetic properties of $Y_{1-x}Ca_xBa_2(Cu_{1-y}Mg_y)_{(3)}O_{7-delta}$
Physica C, Superconductivity Volume: 477 Pages: 36-42

38. R. De Renzi , P. Bonfa , M. Mazzani, S. Sanna, G. Prandoz, P. Carretta, R. Khasanov, A. Amato, H. Luetkens, M. Bendele, F. Bernardini, S. Massidda, A. Palenzona, M. Tropeano and M. Vignolo
Effect of external pressure on the magnetic properties of LnFeAsO (Ln = La, Ce, Pr, Sm)
Superconductor science and technology Volume: 25 Issue: 8 Pages: 84009(9)

39. A. Iadecola, B. Joseph, L. Simonelli, L. Maugeri, M. Fratini, A. Martinelli, A. Palenzona, M. Putti, and N. L. Saini
Effect of Ru substitution on atomic displacements in the layered $SmFe_{1-x}Ru_xAsO_{0.8}5F_{0.15}$ superconductor
Phys. Rev. B Volume: 85 Issue: 21 Pages: 214530 (5)

40. D. Daghero, M. Tortello, G.A. Ummarino, V.A. Stepanov, F. Bernardini, M. Tropeano, M. Putti, and R.S. Gonnelli
Effects of isoelectronic Ru substitution at the Fe site on the energy gaps of optimally F-doped SmFeAsO
Superconductor science and technology Volume: 25 Pages: 84012 (11)

41. G. Ausanio, V. Iannotti, S. Amoruso, X. Wang, C. Aruta, M. Arzeo, R. Fittipaldi, A. Vecchione, R. Bruzzese, and L. Lanotte
Effects of substrate temperature on nanoparticle-assembled Fe films produced by ultrafast pulsed laser deposition
Applied surface science Volume: 258 Issue: 23 Pages: 9337-9341

42. A. Ciattoni and E. Spinozzi
Efficient second-harmonic generation in micrometer-thick slabs with indefinite permittivity
Physical review A Volume: 85 Issue: 4 Pages: 043806(10) – Published: 4 April 2012
Applied physics letters Volume: 100 Issue: 20 Pages: 202601(4)

2012

43. F. Romeo, R. Citro, D. Ferraro, and M. Sassetti
Electrical switching and interferometry of massive Dirac particles in topological insulator constrictions
Physical review B Volume: 86 Issue: 16 Pages: 165418 (9)

44. L. Baldassarre, A. Perucchi, P. Postorino, S. Lupi, C. Marini, L. Malavasi, J. Jiang, J. D. Weiss, E. E. Hellstrom, I. Pallecchi, and P. Dore
Electrodynamics of $BaFe_2As_2$ from infrared measurements under pressure
Physical review B Volume: 85 Issue: 17 Pages: 174522 (6)

45. C. Cantoni, J. Gazquez, F. Miletto Granozio, M. P. Oxley, M. Varela, A. R. Lupini, S. J. Pennycook, C. Aruta, U. Scotti di Uccio, P. Perna, and D. Maccariello
Electron Transfer and Ionic Displacements as the Origin of the 2D Electron Gas at the LAO/STO Interface: Direct Measurements with Atomic-Column Spatial Resolution
Advanced materials Volume: 24 Issue: 29 Pages: 3952- 3957

46. A. Galdi, C. Aruta, P. Orgiani, C. Adamo, V. Bisogni, N. B. Brookes, G. Ghiringhelli, D. G. Schlom, P. Thakur, and L. Maritato
Electronic band redistribution probed by oxygen absorption spectra of $(SrMnO_3)_{(n)}(LaMnO_3)_{(2n)}$ superlattices
Physical review B Volume: 85 Pages: 125129 (5)

47. H. Yamaoka, P. Thunström, N. Tsujii, I. Jarrige, K. Shimada, M. Arita, H. Iwasawa, H. Hayashi, J. Jiang, H. Namatame, M. Taniguchi, N. Hiraoka, H. Ishii, K.-D. Tsuei, M. Giovannini, and E. Bauer
Electronic structure and the valence state of Yb_2Pd_2Sn and $YbPd_2Sn$ studied by photoelectron and resonant x-ray emission spectroscopies
Physical review B Volume: 86 Issue: 8 Pages: 85137 (7)

48. G. Torre, N. Pinamonti, A. Gordon Emslie, J. Guo, A. M. Massone, and M. Piana
Empirical determination of the energy loss rate of accelerated electrons in a well-observed solar flare
The Astrophysical journal Volume: 751 Issue: 2 Pages: 129 (7)

49. F. Tafuri, D. Stornaiuolo, P. Lucignano, L. Galletti, L. Longobardi, D. Massarotti, D. Montemurro, G. Papari, A. Barone, and A. Tagliacozzo
Energy scales in YBaCuO grain boundary biepitaxial Josephson junctions
Physica C, Superconductivity Volume: 479 Pages: 74-78

50. E. A. Ilyina, J. M. Hernàndez, A. García-Santiago, C. Cirillo, and C. Attanasio
Enhancement of the superconducting critical temperature in Nb/Py/Nb trilayers
Physica C, Superconductivity Volume: 479 Pages: 170-172

51. A. Braggio, D. Ferraro, M. Carrega, N. Magnoli, and M. Sassetti
Environmental induced renormalization effects in quantum Hall edge states due to 1/f noise and dissipation
New journal of physics Volume: 14 Pages: 93032 (14)

52. D. Massarotti, L. Longobardi, L. Galletti, D. Stornaiuolo, D. Montemurro, G. Pepe, G. Rotoli, A. Barone, and F. Tafuri
Escape dynamics in moderately damped Josephson junctions
Low temperature physics Volume: 38 Issue: 4 Pages: 263-272

P. Orgiani, A. Yu. Petrov, R. Ciancio, A. Galdi, L. Maritato, and B. A. Davidson
53. **Evidence of direct correlation between out-of-plane lattice parameter and metal-insulator transition temperature in oxygen-depleted manganite thin films**
Applied physics letters Volume: 100 Issue: 4 Pages: 042404(3)

54. C. Schlueter, P. Orgiani, T.-L. Lee, A. Yu. Petrov, A. Galdi, B. A. Davidson, J. Zegenhagen, and C. Aruta
Evidence of electronic band redistribution in $La_{0.65}Sr_{0.35}MnO_{3-\delta}$ by hard x-ray photoelectron spectroscopy
Physical review B Volume: 86 Pages: 155102 (7)

55. G. Ambrosone , D.K. Basa , U. Coscia , and M. Passacantando
Evolution of structural and optical properties of nanostructured silicon carbon films deposited by plasma enhanced chemical vapour deposition
Thin solid films Volume: 720 Issue: 15 Pages: 4875- 4879

Publications

2012

56. M. Iavarone, R. Di Capua, X. Zhang, M. Golalikhani, S. A. Moore, and G. Karapetrov
Evolution of the charge density wave state in Cu_xTiSe_2
Physical review B Volume: 85 Issue: 15 Pages: 155103(6)

57. D. Buono , G. Nocerino , A. Porzio and S. Solimeno
Experimental analysis of decoherence in continuous-variable bipartite systems
Physical review A Volume: 86 Issue: 4 Pages: 042308 (12)

58. F. Giubileo, A. Di Bartolomeo, M. Sarno, C. Altavilla, S. Santandrea, P. Ciambelli and A. M. Cucolo
Field emission properties of as-grown multiwalled carbon nanotube films
Carbon Volume: 50 Pages: 163-169

59. N. R. D'Amico, G. Cantele, and D. Ninno
First principles calculations of the band offset at $SrTiO_3$-TiO_2 interfaces
Applied physics letters Volume: 101 Issue: 14 Pages: 141606 (4)

60. N. R. D'Amico, G. Cantele, and D. Ninno
First-Principles Calculations of Clean and Defected ZnO Surfaces
Journal of physical chemistry C Volume: 116 Issue: 40 Pages: 21391- 21400

61. R. Bureau, S. Brand, R. C. Ball, and M. Nicodemi
Flow regimes of a fluid driven granular suspension
Granular matter Volume: 14 Issue: 2 Pages: 175-178

62. K. Buchkov, K. Nenkov, A. Zaleski, E. Nazarova, and M. Polichetti
Fundamental and 3rd harmonic AC magnetic susceptibility of over-doped polycrystalline $Y_{1-x}Ca_xBa_2Cu_3O_{7-delta}$ (x=0.025 and x=0.20) samples
Physica C Superconductivity Volume: 473 Pages 48–56

63. M. Polichetti, D. Zola, J.-L. Luo, G.-F. Chen, Z. Li, N.-L. Wang, C. Noce and S. Pace
Grain geometry effect on the magnetic properties of a granular iron-based superconductor $LaFeAsO_{1-x}F_x$
Superconductor science and technology Volume: 25 Issue: 2 Pages: 025010(8)

64. G. Papari , F. Carillo , D. Stornaiuolo , L. Longobardi , F.Beltram and F. Tafuri
High critical current density and scaling of phase-slip processes in YBaCuO nanowires
Superconductor science and technology Volume: 25 Issue: 3 Pages: 35011 (5)

65. C. Marini, D. Chermisi, M. Lavagnini, D. Di Castro, C. Petrillo, L. Degiorgi, S. Scandolo, and P. Postorino
High-pressure phases of crystalline tellurium: A combined Raman and ab initio study
Physical review B Volume: 86 Issue: 6 Pages: 64103 (5)

66. E. Cappelluti and G. Profeta
Hopping-resolved electron-phonon coupling in bilayer grapheme
Physical review B Volume: 85 Issue: 20 Pages: 205436 (9)

67. G. Guarnaccia and C. Noce
Hubbard model with spin-orbit coupling: Lattice gauge theory approach
Physical review B Volume: 86 Issue: 6 Pages: 064409 (7)

68. A. V. Silhanek, A. Leo, G. Grimaldi, G. R. Berdiyorov, M. V. Milosevic, A. Nigro, S. Pace, N. Verellen, W. Gillijns, V. Metlushko, B. Ilic, X. Zhu, and V. V. Moshchalkov
Influence of artificial pinning on vortex lattice instability in superconducting films
New journal of physics Volume: 14 Issue: 5 Pages: 53006 (11)

69. I. A. Grimaldi , M. Barra, A. De Girolamo Del Mauro, F. Loffredo, A. Cassinese, F. Villani, and C. Minarini
Inkjet printed perylene diimide based OTFTs: Effect of the solvent mixture and the printing parameters on film morphology
Synthetic metals Volume: 161 Issue: 23-24 Pages: 2393-2396

70. A. Ambrosio, C. Aramo, R. Battiston, P. Castrucci, M. Cilmo, M. De Crescenzi, E. Fiandrini, V. Grossi, F. Guarino, P. Maddalena, E. Nappi, M. Passacantando, G. Pignatel, S. Santucci, M. Scarselli, A. Tinti, A. Valentini and M. Ambrosio
Innovative carbon nanotube-silicon large area photodetector
Journal of instrumentation Volume: 7 Pages: 8013(11)

Publications

2012

71. C. A. Perroni and V. Cataudella
Interplay between electron-phonon coupling and disorder strength on the transport properties of organic semiconductors
Physical review B Volume: 85 Issue: 15 Pages: 155205 (5)

72. E. Diez-Jimenez, J. Luis Perez-Diaz, F. Canepa, and C. Ferdeghini
Invariance of the magnetization axis under spin reorientation transitions in polycrystalline magnets of $Nd_2Fe_{14}B$
Journal of applied physics Volume: 112 Issue: 6 Pages: 63918 (4)

73. E. Orignac, R. Citro, S. De Palo, and M. L. Chiofalo
Light scattering in inhomogeneous Tomonaga-Luttinger liquids
Physical review A Volume: 85 Pages: 013634- 013642

74. A. Ambrosio, L. Marrucci, F. Borbone, A. Roviello and P. Maddalena
Light-induced spiral mass transport in azo-polymer films under vortex-beam illumination
Nature communications Volume: 3 Pages: 989 (9)

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