PC5-1-INV

Critical-Current-by-Design

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We present a new paradigm, critical-current-by-design, that aims at predicting the optimal pinning landscape for maximum critical current in high temperautre superconducting (HTS) applications. This approach uses large scale time dependent Ginzburg-Landau simulations is to elucidate the vortex dynamics in complex pinning landscapes. On the experimental side, we use controlled particle irradiation to create defects of various morphologies in HTS coated conductors to enhance their critical current. We illustrate this new paradigm by predicting the critical current (J_c) and the non-additive pinning action of different defects in irradiated samples. An example of the latter is the recently discovered *reduction* of J_c at low fields in oxygen and copper irradiated HTS coated conductors which contain self-assembled BaZrO nanorods. In a new development, we discovered that off-angle irradiation can mitigate this issue. Furthermore, vortex creep studies in HTS coated conductors indicate that the J_c reduction could also be a consequence of faster creep in the presence of different vortex pinning sites. Another development is the discovery of double chain layer defects in HTS coated conductors, induced by high-energy, heavy-ion irradiation. These defects intersect the ion irradiation induced tracks and show a decrease in the oxygen and copper content at the interface, resulting in interfacial strain. These revelations directly demonstrate the extension of the electronic inhomogeneity following irradiation and the potential of strain-induced vortex pinning. We show that the combination of large scale TDGL simulations with bulk critical current and microstructural characterization provides the necessary ingredients for realizing the critical-current-by-design paradigm.

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PC5-2-INV

RESONANT SCATTERING STUDIES OF CHARGE ORDER IN QUANTUM SOLIDS

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The spontaneous self-arrangement of electrons into static and periodically modulated patterns, a phenomenon commonly termed as charge order or charge-density-wave, has recently resurfaced as a prominent, universal ingredient for the physics of copper oxide high-temperature superconductors. Its antagonist coexistence with superconductivity, together with a putative connection to a quantum critical point beyond optimal doping, are symptomatic of a very fundamental role played by this collective electronic state for the physics of cuprates.

Resonant x-ray scattering (RXS) has rapidly become the technique of choice for the study of charge order in momentum space [1], owing to its ability to directly identify a breaking of translational symmetry in the electronic density. We have used RXS in Bi-, Nd, and Y-based cuprates to detect charge-density-waves even in presence of short-ranged order [2-3], exploring a realm previously accessible only by STM. Using the information available from the full two-dimensional momentum space, we have taken this experimental methodology further to reveal the local (intra-unit-cell) symmetry in the charge distribution [4,5].

To conclude, I will discuss recent results and future perspectives concerning the study of the nanoscale (10-100 nm) texture of electronic orders using coherent soft x-ray scattering in scanning (RXS nanomapping) and imaging (ptychography and holography) mode.

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PC5-3-INV

Nematic Phase Transition at the Onset Temperature of Pseudogap in High-T_c Cuprates

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A long-standing controversial issue in the quest to understand the high transition temperature (T_c) superconductivity in cuprates is the nature of the enigmatic pseudogap sate of the phase diagram, where anomalous electronic states, including Fermi arc, charge density wave and *d*-wave superconductivity emerge. Especially important is whether the pseudogap state is a distinct thermodynamic phase characterized by any kinds of broken symmetries below the onset temperature T^*. Electronic nematicity, a four-fold (C_4) rotational symmetry breaking, has emerged as a key feature inside the pseudogap regime. Here we report torque-magnetometry measurements of anisotropic susceptibility within the CuO_2 planes in clean single crystals of $YBa_2Cu_3O_y$ (YBCO) and $HgBa_2CuO_{4+\delta}$ (Hg1201) with exceptionally high precision. In YBCO, the in-plane anisotropy of susceptibility displays a significant increase with a distinct kink at the pseudogap onset temperature T^*, showing a remarkable scaling behavior with respect to T/T^* in a wide doping range. Our systematic analysis reveals that the rotational symmetry breaking sets in at T^* in the limit where the effect of orthorhombicity is eliminated. These results provide thermodynamic evidence that the pseudogap onset is associated with a second-order nematic phase transition, which differs from the recently reported charge-density-wave transition that accompanies translational symmetry breaking.

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PC5-4-INV

Hidden Fermionic excitation at the origin of high-temperature superconductivity and pseudogap in cuprates

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The quasiparticle dynamics in a superconductor reflects its pairing mechanism. In fact, in conventional superconductors, studies on the quasiparticle dynamics played an essential role in establishing the phonon-mediated pairing mechanism [1]. We studied this dynamics for cuprate high-temperature superconductors, whose pairing mechanism is still unknown: We calculated the frequency-dependent properties of the two-dimensional Hubbard model, which is a standard model of cuprates, with an unbiased numerical method called cluster dynamical mean-field theory.

By scrutinizing the frequency-dependent structure of the electron self-energy, we found that
i) a hidden fermionic excitation, which appears as a pole in the self-energy, emerges directly from the Mott physics when carriers are doped to the parent Mott insulator,
ii) the hidden fermion enhances the superconductivity considerably through a hybridization to quasiparticles [Fig. (b)], and
iii) the same hidden fermion generates a pseudogap above the superconducting transition temperature as a hybridization gap [Fig. (a)].
We thus obtained a unified view on the Mott insulator, pseudogapped metal, and high-temperature superconductivity in cuprates.[2]

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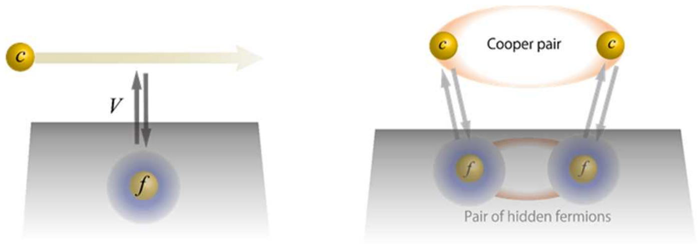

(a) $T>T_c$: Pseudogap state (b) $T<T_c$: Superconducting state
Figure: Hidden fermion (*f*) hybridizing with quasiparticles (*c*).

Keywords: cuprate superconductors, pseudogap, Hubbard model, hidden fermion

PC5-5-INV

Design of high-temperature topological superconductivity in curates and heavy fermions

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We propose topological superconductivity in strongly correlated d-wave superconductors. Although the gapless d-wave superconductors do not realize topological superconductivity, we find gapped topological superconducting states induced by spin-orbit coupling and electron correlation in recently-discovered two-dimensional heterostructures.

(1) 2D topological superconductivity in high-temperature cuprate supercoductors [1,2]
Search of gapped strong topological superconductivity has been one of the central subjects in the research field of topological science. We design the topological superconductivity based on familiar nodal d-wave superconductor heterostructures, such as high-Tc cuprates and heavy fermions [1]. Nonequilibrium topological superconductivity induced by circularly polarized laser-light is also proposed [2].

(2) Topological superconductivity in heavy fermion superlattices and reduction by electron correlation [3,4]
It is shown that the heavy fermion superlattice $CeCoIn_5/YbCoIn_5$ [5] realizes odd-parity superconductivity by spin-orbit coupling and it is a platform of topological crystalline superconductivity protected by mirror symmetry [3]. We also show the breakdown of topological classification by electron correlation, which can be experimentally realized by tuning the superlattice structure [4]. Material realization of similar odd-parity superconductivity in MoS_2 heterostructures is also proposed [6].

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Keywords: High-temperature cuprate superconductor, Heavy fermion superlattice, Topological superconductivity, Strong electron correlation

PC5-6

Electron backscatter diffraction analysis (EBSD) on superconducting nanowires

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Electrospun, superconducting nanowires are characterized concerning the grain orientation, their texture and the respective grain boundary misorientations by means of electron backscatter diffraction (EBSD) analysis. The individual nanowires in such electrospun, nonwoven nanowire networks of $Bi_2Sr_2CaCu_2O_x$ (Bi-2212) are polycrystalline, have diameters up to 250 nm and their grains are in the 20-50 nm range [1]. This requires a high spatial resolution for the analysis in the scanning electron microscope. However, the small diameter of the nanowires enables the application of the newly developed transmission EBSD (t-EBSD) technique without the preparation of TEM slices. Here, we present several EBSD mappings on Bi-2212 nanowires and compare their microstructure to those of filaments of the first generation tapes [2].

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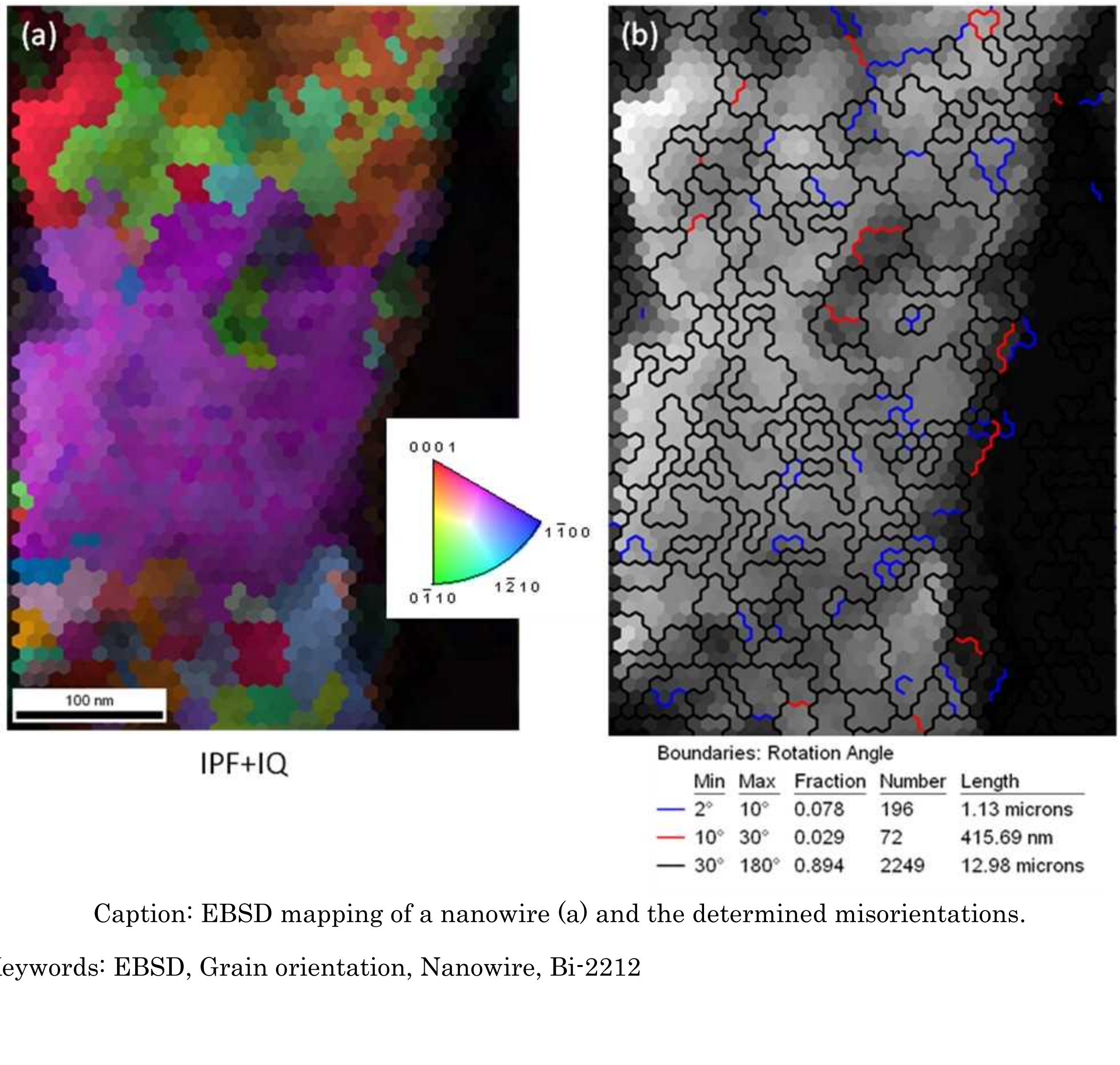

Caption: EBSD mapping of a nanowire (a) and the determined misorientations.

Keywords: EBSD, Grain orientation, Nanowire, Bi-2212

PC5-7

Study of oxygen exchange kinetics of $YBa_2Cu_3O_{7-\delta}$ films to achieve high carrier concentration

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YBCO films are of great technological interest as they show exceptional good superconducting properties. As in all cuprate SCs these properties are governed by its oxygen content. Understanding how to achieve optimal oxygen doping of the oxygen deficient triple perovskite YBCO structure is still an open, critical issue and its optimization a main goal of this work. The oxygenation kinetics is strongly influenced by microstructural and morphological features, which strongly differ depending on the growth technique. The kinetic effects comprises of molecular oxygen absorption, dissociation and atomic bulk diffusion.

We show that in-situ techniques as electrical conductivity relaxation (ECR) and high temperature environmental XRD (HTXRD) are very useful tools to analyze the oxygen exchange processes. We monitor the mechanisms of oxygen in- and excorporation in standard and nanocomposite CSD and PLD YBCO thin films during post annealings of grown films by changing between oxidizing and reducing $p(O_2)$ atmospheres. This analysis allows us to determine the dependence of the oxygenation rate of in- and out-diffusion (bulk and surface) on several processing parameters, as the O_2 partial pressure and temperature and obtain time constants and activation energies for each case. Our results demonstrate that the oxygenation of the thin films studied, is limited by surface reactions. Catalytic agents deposited on the surface, strongly accelerate the oxygen exchange and allow lower oxygenation temperatures, leading to higher oxygen contents. Understanding the oxygen exchange allows to properly engineer the carrier concentration to the overdoped regime, as monitored by Hall effect and XRD measurements. Therefore we can study the correlation between the doping level and the critical currents, with the aim to maximize the latter.

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Keywords: YBCO thin film, Oxygen exchange, Overdoping