TT 81: Superconductivity: Properties and Electronic Structure

Time: Thursday 9:30–13:15 Location: HSZ 201

TT 81.1 Thu 9:30 HSZ 201

Growth of superconducting $LaPd_1-xBi_2$ thin films by molecular beam epitaxy — •Reiner Retzlaff, Niklas van Elten, Jose Kurian, and Lambert Alff — Institute of Materials Science, TU Darmstadt, Germany

We have grown thin films of $LaPdBi_2$ by reactive molecular beam epitaxy on single crystal MgO substrates. Films were grown in a custom designed UHV chamber by the simultaneous evaporation of high purity La, Pd and Bi metals by e-beam evaporaters with in situ rate control. Single phase $LaPdBi_2$ films are stable in a small window of growth temperature. The films were characterised by RHEED, X-ray diffraction and electrical transport measurements. $LaPdBi_2$ films were epitaxial and c-axis oriented as evident from RHEED and XRD analysis. The Pd deficient $LaPdBi_2$ thin films showed superconductivity with a superconducting transition of about 3 K. To best of our knowledge this is the first report of the synthesis and superconductivity of $LaPdBi_2$.

TT 81.2 Thu 9:45 HSZ 201

Strain homogeneity in uniaxial stress and strain measurements — •Mark E. Barber[1], Clifford W. Hicks[1,2], Stephen D. Edkins[1], Daniel O. Brodsky[1], and Andrew P. Mackenzie[1,2] — [1]Scottish Universities Physics Alliance (SUPA), University of St. Andrews, St. Andrews, United Kingdom — [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Response to uniaxial distortion can be a powerful probe of the electronic properties of a solid. However, it is not a very commonly applied technique, chiefly because of the technical challenges of obtaining good strain homogeneity while applying significant pressures. In typical uniaxial pressure measurements, thin and wide samples are clamped between two anvils. We have carried out measurements on Sr_2RuO_4 using a different, easier technique: cutting the sample into a long, narrow bar, and securing its two ends with epoxy across a vice. We explain the details of this technique and by using finite element simulations present the guidelines (readily achievable in experiments) that need to be followed in order to achieve high strain homogeneity.

TT 81.3 Thu 10:00 HSZ 201

Large enhancement of the T_c of Sr_2RuO_4 under uni-axial strain — •Daniel O. Brodsky[1], Clifford W. Hicks[1,2], Edward A. Yelland[1], Alexandra S. Gibbs[1,3], Jan A. N. Bruin[1,4], Mark E. Barber[1], Stephen D. Edkins[1], Keigo Nishimura[5], Shingo Yonezawa[5], Yoshiteru Maeno[5], and Andrew P. Mackenzie[1,2] — [1]University of St Andrews, United Kingdom — [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [3]The University of Tokyo, Japan — [4]High Field Magnet Laboratory, Radboud University Nijmegen, Netherlands — [5]Kyoto University, Japan

We present AC magnetic susceptibility data taken on samples of the spin-triplet superconductor Sr_2RuO_4 under uni-axial strain. To do this, we built a probe that enables us to vary the strain applied to our samples continuously from compression to tension, whilst at cryogenic temperatures. We found that T_c changes dramatically with in-plane strain: strain along the crystallographic [100] direction leads to a strong strain-symmetric response of T_c, which is pushed up from 1.35 K to 1.9 K for 0.23% strain. Conversely, the response along the [110] direction is weak and mostly linear in strain. We discuss these results in the context of the predicted $p_x + ip_y$ topological order parameter.

TT 81.4 Thu 10:15 HSZ 201

The high-energy anomaly in ARPES spectra of cuprates– many body or matrix element effect? — •J. Fink[1], E.D.L. Rienks[2], M. Ärrälä[3], M. Lindroos[3], F. Roth[4], W. Tabis[5], G. Yu[5], and M. Greven[5] — [1]Leibnitz-Institute for Solid State and Materials Research, Dresden, Germany — [2]Helmholtz-Zentrum, Berlin, Germany — [3]Tempere University of Technology, Tempere, Finland — [4]Center for Free-Electron Laser Science, Hamburg, Germany — [5]University of Minnesota, Mineapolis, USA

We used angle-resolved and polarization-dependent photoemission spectroscopy (ARPES) and density functional theory calculations to study the high-energy anomaly (HEA) in the dispersion of $Nd_{2-x}Ce_xCuO_4$, $x = 0.123$. We have found that at particular photon energies the anomalous, waterfall-like dispersion gives way to a broad, continuous band. This suggests that the HEA is a matrix element effect: it arises due to a local suppression of the intensity of the broadened quasiparticle band. We confirm this interpretation experimentally, by showing that a waterfall appears when the matrix element is suppressed deliberately by changing the light polarization. Calculations of the matrix element using atomic wave functions and simulation of the ARPES intensity with one-step calculations provides further proof for this scenario. The possibility to detect the full quasiparticle dispersion further allows us to extract the mass enhancement and the scattering rates at high binding energies at the center and edge of the Brillouin zone.

TT 81.5 Thu 10:30 HSZ 201

Following doped charges in cuprate superconductors by ^{17}O and ^{63}Cu NMR — •Michael Jurkutat[1], Damian Rybicki[1], Grant Williams[2], Andreas Erb[3], and Jürgen Haase[1] — [1]Universität Leipzig, Faculty of Physics and Earth Sciences, 04103 Leipzig, Germany — [2]Victoria University, Wellington, New Zealand — [3]Walther Meissner Institute for Low Temperature Research, 85748 Garching, Germany

We report results of a ^{17}O and ^{63}Cu NMR investigation of aligned powder as well as single crystal samples of electron-doped cuprates $RE_{2-x}Ce_xCuO_4$(with RE=Pr,Nd and x=0.0,..,0.2), a hitherto hardly investigated field of high-T_C research. Employing a range of NMR techniques we show that doped electrons almost exclusively go to planar Cu, while leaving a considerable hole density at planar O largely unchanged. Our results are then compared with findings in hole-doped cuprates shedding new light on the local charge distribution within the CuO_2-plane.

TT 81.6 Thu 10:45 HSZ 201

Spin excitations of ferronematic order in underdoped cuprate superconductors — •Götz Seibold[1], Carlo Di Castro[2], Marco Grilli[2], and Jose Lorenzana[2] — [1]BTU Cottbus-Senftenberg, Germany — [2]University of Rome 'La Sapienza', Italy

The presence of an anisotropic hourglass shaped spectrum for magnetic excitations in underdoped cuprates is explained by a model in which topological defects of the antiferromagnet clump to producing domain wall segments with ferronematic order. This state does not invoke global charge order but breaks C4 rotational and inversion symmetry. The incommensurability of the low doping charge-disordered state is in good agreement with experiment and interpolates smoothly with the incommensurability of the stripe phase at higher doping. Within linear spin-wave theory the dynamic structure factor is in very good agreement with inelastic neutron scattering data and can account for the energy dependent anisotropy observed.

TT 81.7 Thu 11:00 HSZ 201

Tuning the performance of $YBa_2Cu_3O_{7-\delta}$ thin films by a local incorporation of gold nanoparticles — •Christian Katzer[1], Markus Westerhausen[1], Claudia Stahl[2], Joachim Albrecht[3], Evelyn Stilp[4], Andreas Suter[4], and Frank Schmidl[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, 07743 Jena — [2]Max-Planck-Institut für Intelligente Systeme, Heisenbergstraße 3, 70569 Stuttgart — [3]Hochschule Aalen, Beethovenstraße 1, 73430 Aalen — [4]Laboratory for Muonspin Spectroscopy, PSI, CH-5232 Villigen PSI, Switzerland

Many superconducting thin film applications require a spatially resolved current carrying capability due to different boundary conditions. On the one hand, the critical current density should be increased for high-current applications or in the antenna structures of sensor devices like gradiometers; on the other hand, the critical current of Josephson Junctions must not be too high to ensure a proper functionality. We report that a local incorporation of crystalline gold nanoparticles in $YBa_2Cu_3O_{7-\delta}$ thin films allows engineering the critical current landscape on the sub-micrometre scale. Meanwhile, as we will show the growth conditions of the YBCO are modified, resulting in less a-axis growth and an improved oxygen stoichiometry. Furthermore, we will present Muon Spin Spectroscopy measurements of the London-penetration depth which indicate a reduced defect density in YBCO thin films modified by Au particles.

[1] C. Katzer, et al., Supercond. Sci. Techn. 26, 125008 (2013)

[2] C. Katzer et al., New J. Phys. 15, 113029 (2013)

15 min. break.

TT 81.8 Thu 11:30 HSZ 201

Electrospun superconducting $La_{1.85}Sr_{0.15}CuO_4$ nanowires and nanoribbons — •XianLin Zeng[1], Michael R. Koblischka[1], Jennifer S. Atchinson[2], Volker Presser[2], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, Saarland University, Campus C 6 3, 66123 Saarbrücken, Germany — [2]INM – Institute of New Materials Saarbrücken, Campus D 2 2, 66123 Saarbrücken, Germany

The synthesis of high-temperature superconducting $La_{1.85}Sr_{0.15}CuO_4$ nanostructures via electrospinning and a subsequent calcination in air and oxygen is reported. Nanowire and nanoribbon structures are obtained in the experiments with a maximum $T_{c,onset}$ of 20 K. According to the morphological characterization via scanning electron microscopy (SEM) and transmission electron microscopy (TEM), the nanowires have average diameters of about 230 nm and the length spans more than 30 μm. The nanowires are polycrystalline with a mean grain size of about 110 nm and 30 nm as determined by TEM and X-ray analysis, respectively. The nanoribbons are about 0.5 to 1 μm wide but show a thickness of only 60 to 80 nm, which indicates that the ribbons have a monolayer crystal structure. A confirmation of the chemical phase and component ratio is given by X-ray diffraction and EDX measurements. Attempts are made to achieve a detailed understanding of the formation of nanowires and -ribbons. Furthermore, additional information concerning the symmetry breaking of two phonon modes is obtained via Raman spectra of the nanowires, confirming the previous results presented in [1].

[1] J. M. Li, X. L. Zeng, et al., Cryst. Eng. Comm. 13, 6964 (2011)

TT 81.9 Thu 11:45 HSZ 201

Magnetic characterization of bulk MgB_2 — Alex Wiederhold[1], •Michael R. Koblischka[1], Miryala Muralidhar[2], Masato Murakami[2], Thomas Hauet[3], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany — [2]Department of Materials Science and Engineering, Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-ku, Tokyo 135-8548, Japan — [3]Institute Jean Lamour, University of Lorraine, Vandœuvre-les-Nancy, France

A series of disk-shaped, bulk MgB_2 superconductors (sample diameter up to 4 cm) was prepared in order to improve the performance for superconducting super-magnets. Several samples were fabricated using a solid state reaction in pure Ar atmosphere from 750 to 950 °C to obtain the highest critical current density as well as large trapped field values. Microstructural observations obtained from scanning electron microscopy (SEM) and atomic force microscopy (AFM) indicated that the grain size is the crucial parameter to improve the critical currents as well as the trapped field values. The small samples cut from the large bulks were characterized by transport measurements ($R(T,B)$ and I/V characteristics) in magnetic fields up to 8 T and by magnetization loops measured by SQUID magnetometry. The pinning force analysis revealed a well developed scaling of the pinning force $F_p = j_c \times B$ data with $p = 0.65$, $q = 1.35$ and a peak at $h_0 = 0.32$, indicating pinning at normal conducting precipitates. Similar values are obtained in the literature for pure, small MgB_2 samples.

TT 81.10 Thu 12:00 HSZ 201

Effect of Coulomb Interactions on the Disorder-Driven Superconductor-Insulator Transition — Daniel Sherman[1,2], Uwe S. Pracht[1], Boris Gorshunov[1,3,4], Shachaf Poran[2], Nandini Trivedi[5], Pratap Raychaudhuri[6], Aviad Frydman[2], and •Martin Dressel[1] — [1]1. Phys. Inst., Universität Stuttgart, Germany — [2]Dept. Phys., Bar Ilan Univ., Israel — [3]Prokhorov Inst. Gen. Phys., RAS, Moscow, Russia — [4]Moscow Inst. Phys. Techn., Dolgoprudny, Russia — [5]Dept. Phys., Ohio State Univ., Columbus, OH, U.S.A. — [6]Tata Inst. Fund. Res., Mumbai, India

We have studied the evolution of the superconducting energy gap through the disorder-driven superconductor to insulator transition in InO and NbN films using two distinct experimental methods that allow us to test the influence of metallic screening on the electronic interactions. In the case of tunneling spectroscopy a metallic electrode is adjacent to the superconducting film thus screening Coulomb interactions. On the other hand terahertz spectroscopy is a contactless method which probes the sample without affecting the electron-electron interaction. In the presence of screening, a similar superconducting gap is detected on both sides of the superconductor-insulator transition, and at temperatures above and below T_c. Contactless measurements are able to identify the superconducting gap below but not above the critical temperature or in the insulating state. Our study reveals the importance of Coulomb interactions on the energy gap of disordered superconductors.

TT 81.11 Thu 12:15 HSZ 201

Superconducting gap of the noncentrosymmetric superconductor α-BiPd — •Zhixiang Sun[1], Mostafa Enayat[1], Darren Peets[1], Ana Maldonado[1], Andreas P. Schnyder[1], Alexander Yaresko[1], and Peter Wahl[1,2] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany — [2]SUPA, School of Physics and Astronomy, University of St. Andrews, North Haugh, St. Andrews, Fife, KY16 9SS, United Kingdom

In most known superconductors, inversion symmetry and Pauli exclusion ensure that the Cooper pair wave function can be separated into an orbital component that has either even or odd parity, and a spin component which is then either singlet or triplet, but this does not hold in general. In the absence of an inversion center in the crystal structure, parity is not a good quantum number, and the Cooper pairs will be some mixture of singlet and triplet. We report ultra-low temperature scanning tunneling microscopy/spectroscopy (ULT-STM/STS) measurements at temperatures down to 15 mK on the recently rediscovered non-centrosymmetric superconductor α-BiPd. Tunneling spectra show only a single superconducting gap with $\Delta(0) = 0.6$ meV, the temperature and magnetic field dependence of which are found to be well described by BCS theory and a single s-wave gap. Our results provide an upper limit for a possible triplet component in α-BiPd of 10 μ eV.

TT 81.12 Thu 12:30 HSZ 201

Suppression of superconductivity in a single layer of Pb on Si(111) by insertion of a single layer of Ag — •Hirofumi Oka[1], Augusto A. Leon Vanegas[1], Agnieszka Stepniak[1], Michael Caminale[1], Dirk Sander[1], and Jürgen Kirschner[1,2] — [1]MPI Halle — [2]MLU Halle-Wittenberg

A recent study indicates that even a single atomic layer of Pb on Si(111) is superconducting with a critical temperature of 1.83 K [1]. Here, we investigate effect of insertion of a single layer of Ag on superconductivity (SC) in a single layer of Pb on Si(111) using a ^{3}He-cooled STM with a vector magnetic field. Ag was deposited onto the clean 7×7-Si(111) surface held at 770 K, leading to a formation of a single layer of Ag on Si(111). Subsequently Pb atoms were evaporated at 300 K, followed by annealing at 560 K for 1 min. Our STM study reveals that the Pb/Ag/Si(111) surface has a well-ordered atomic structure. Most of the surface shows a stripe pattern indicative of a $\sqrt{3}\times\sqrt{7}$ structure and small areas show a $\sqrt{3} \times \sqrt{3}$ structure. STS measurements on the Pb/Ag/Si(111) surface show almost the same differential-conductance spectrum with temperature (0.38–6.0 K) or magnetic field (up to 3 T). We do not observe a SC gap in spectroscopy. Our results indicate that the insertion of a Ag layer suppresses SC in a single layer of Pb on Si(111). We speculate that the Ag insertion modifies the bonding situation between Pb and Si, which has been reported to play a crucial role for the SC of the single Pb layer on Si(111) [2].

[1] Zhang et al., Nat. Phys. 6, 104 (2010)
[2] Noffsinger and Cohen, Sol. State Comm. 151, 421 (2011)

TT 81.13 Thu 12:45 HSZ 201

Position-dependent tunneling spectroscopy from a superconducting Pb island towards a normal conducting single layer — •Agnieszka Stepniak[1], Augusto A. Leon Vanegas[1], Michael Caminale[1], Hirofumi Oka[1], Dirk Sander[1], and Jürgen Kirschner[1,2] — [1]Max-Planck-Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

Using scanning tunneling microscopy (STM) and spectroscopy (STS) we study the superconducting properties of Pb islands on a Ag monolayer on Si(111). We use a 3He-cooled STM with a vector magnetic field to characterize the structural and electronic properties of the Pb/Ag-Si system at the temperatures range of 0.38*4.0 K, in dependence of a magnetic field of up to 6 T along the sample normal. We find SC in Pb islands, where the transition temperature is 6 K in a 9 layer high Pb island. The interlayer of Ag suppresses superconductivity (SC) in single layer Pb surrounding the Pb islands. We exploit the spatial resolution of STM/STS to study the position dependent differential conductivity for a transition from a SC Pb island to the

surrounding non-superconducting Pb layer on Ag/Si, as a function of temperature and magnetic field. The quantitative analysis of the SC gap in spectroscopy identifies an exponential decay on which SC faints into the normal-metal region with a decay length of 5+/-1 nm at 1.8 K. This length is larger at lower temperature (10 nm at 0.4 K), and smaller at higher temperature (1 nm at 4 K). A magnetic field of up to 0.5 T along the sample normal does not change the decay length.

TT 81.14 Thu 13:00 HSZ 201

Search for superconductivity in differently treated graphite powders — •Pablo Esquinazi, Annette Setzer, Jose Carlos de Moraes Silva, and Winfried Böhlmann — Division of Superconductivity and Magnetism, University of Leipzig, Leipzig, Germany

Hints on the existence of superconductivity at high temperatures were reported recently in water-treated graphite powders [1], graphite TEM lamellae [2], as well as in graphite flakes embedded in alkanes [3]. There is evidence that interfaces between graphite Bernal structure could play a role in the measured response [2,4]. In this contribution we studied the magnetic response of high purity graphite powders treated with water, alkanes as well as with acids. Background independent as well as background dependent methods were used to check for pinned magnetic entities. Clear hysteresis in temperature (between zero-field cooled and field cooled) as well as in field were measured, which survives at very high temperatures. To compare the observed behavior with that expected from ferromagnetic particles, we have also measured ferromagnetic magnetite particles embedded in amorphous carbon. We discuss the obtained evidence in terms of triggered superconductivity and/or magnetic order.

[1] T. Scheike et al., Adv. Mater. 24, 5826 (2012)
[2] A. Ballestar et al., New J. Phys. 15, 023024 (2013)
[3] Y. Kawashima, AIP Advances 3, 052132 (2013)
[4] T. Scheike et al., Carbon 59, 140 (2013)