TT 5: Superconductivity: Sample Preparation and Characterization

Time: Monday 9:30–12:30 Location: CHE/0089

TT 5.1 Mon 9:30 CHE/0089

Dielectric properties of NbN-films at the insulating side of the superconductor-insulator-transition — •Max Reinhart[1], Lea Pfaffinger[1], Sven Linzen[2], Evgenii Il'ichev[2], Alexander Weizel[1], and Christoph Strunk[1] — [1]Experimental and Applied Physics, Uni Regensburg, Germany — [2]Leibniz Institute of Photonic Technology, Jena, Germany

In 2D strongly disordered thin films the superconductor-insulator-transition (SIT) occurs [1]. The resistive behavior of the insulating side of this transition is well studied, as it has been observed in various materials [2,3]. For the imaginary part of the impedance the situation is less clear. To obtain information on the dielectric properties of 3nm thin NbN in the insulating regime at $R_{sq}(2\ \mathrm{K}) = 60\ \mathrm{k\Omega}$ we deposited interdigitated gold fingers as capacitor within an LC-circuit on SiOx and NbN. On SiOx, we obtained $C \approx 6$ pF. On insulating NbN, the measured capacitance was 6.6 pF. In the latter case the capacitance has a contribution, that depends non-monotonically on temperature, magnetic field and DC bias voltage.

[1] D.B. Haviland et al., Phys. Rev. Lett. 62 (1989) 2180
[2] V.F. Gantmakher and V.T. Dolgopolov, Phys. Usp. 180 (2010) 3
[3] N. G. Ebensperger, Dielectric properties on the insulating, side of the superconductor-insulator-transition [PhD thesis], Universität Stuttgart, 2021

TT 5.2 Mon 9:45 CHE/0089

Gap smearing and sub-gap states in disordered nitride superconductors — •Frederik Bolle[1], Yayi Lin[1], Heidemarie Krüger[2], Martin Dressel[1], and Marc Scheffler[1] — [1]1. Physikalisches Institut, Universität Stuttgart — [2]Leibniz IPHT, Jena

In recent years nitride-based superconductors have gathered a lot of attention due to their high critical temperatures, large kinetic inductances, and ease of manufacturing. According to the BCS theory, at temperatures far below the critical transition temperature, the superconducting s-wave state is characterized by a hard gap Δ and a coherence peak above the gap. In the case of substantial disorder, subgap states emerge and the coherence peak is suppressed.
We present the quasiparticle dynamics of ultra-thin NbN and MoN films with various levels of disorder, probed at energies comparable to the energy gap using THz spectroscopy ($0.2\,\mathrm{meV} - 10\,\mathrm{meV}$). To quantify the additional pair-breaking we employ the phenomenological Dynes model for the optical conductivity. We find in the case of NbN, a temperature-independent pair-breaking rate, which suggests magnetic impurities, while MoN shows a strongly temperature-dependent pair-breaking rate, which we attribute to inhomogeneities of the local gap function. The understanding of this excess quasiparticle density plays an important role for decoherence and loss mechanisms in quantum circuits at millikelvin temperatures.

TT 5.3 Mon 10:00 CHE/0089

Superconducting resonators from ultrathin NbN films — •meenakshi sharma[1], hrishikesh borah[1], surinder singh[2], sandeep singh[2], haolin jin[1], yejin lee[1], and uri vool[1] — [1]MPI CPFS, Dresden, Germany — [2]CSIR NPL, Delhi, India

We investigate superconducting microwave resonators fabricated from ultrathin niobium nitride (NbN) films with thicknesses down to 3 nm. Such films show extremely high kinetic inductance values of 298 pH per square, approaching the regime where disorder strongly influences superconductivity. However, they remain robust and exhibit a critical temperature of 7.8 K, making them suitable for high-impedance circuit applications. The resonators achieve internal quality factors of approximately 10^4-10^5, demonstrating that reliable device performance can be sustained even at such critical thicknesses. By monitoring the resonance frequency as a function of temperature, we probe the electrodynamic response of the ultrathin superconducting state. The superfluid density departs from the exponential temperature dependence expected for conventional BCS superconductors and instead follows a power-law behavior at low temperatures, indicating spatial inhomogeneity in the superconducting condensate. At millikelvin temperatures, dissipation is dominated by two-level systems, but the large kinetic inductance suppresses their influence on the resonance frequency, thereby enabling stable and reproducible devices. These results establish ultrathin NbN as both a practical platform for high-impedance quantum circuits and an accessible system for studying unconventional superconducting physics.

TT 5.4 Mon 10:15 CHE/0089

Tuning Superconductivity and Vortex Dynamics in NbRe Films via Grain-Size Control — •Zahra Makhdoumi Kakhaki[1], Francesco Avitabile[2], Abhishek Kumar[2], Francesco Colangelo[2], Carla Cirillo[3], Carmine Attanasio[2], and Oleksandr Dobrovolskiy[1] — [1]Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany — [2]Università degli Studi di Salerno, Italy — [3]CNR-SPIN, Università di Salerno, Italy

NbRe, a non-centrosymmetric superconductor with strong antisymmetric spin-orbit coupling and relatively high Tc, is of interest for superconducting spintronics and single-photon detectors. Yet, it poses a challenge: understanding how its order parameter evolves in thin films as crystallite size changes. Here, we induce a significant structural transformation in 20 nm-thick NbRe films through thermal annealing, increasing the average crystallite size from about 2 nm to approximately 8 nm across as-grown and annealed conditions [1]. We probe superconducting pairing via upper critical field measurements and quantify vortex dynamics through current-voltage curves under varying temperatures and magnetic fields. The annealed films exhibit discrete resistive states and traces of normal-conducting domains attributed to dissipative vortex motion and local overheating [2]. In addi- tion to spin-triplet correlations in NbRe-based hybrids [3], the annealed films show indications of two superconducting gaps.

[1] Makhdoumi Kakhaki et al., SUST 37 (2024) 125002
[2] Bezuglyj et al., PRB 99 (2019) 174518
[3] Colangelo et al., PRL (2025), arXiv:2510.08110

TT 5.5 Mon 10:30 CHE/0089

Superconductivity of $[(SnSe)_{1+\delta}]_m$[NbSe2] superlattices with varying $NbSe_2$ interlayer spacing — •Olivio Chiatti[1], Linus P. Stahlberg[1], Wieland G. Stoffel[1], Tom Herter-Lehmann[1], Willi Vallant[1], Alina Dietrich[1], Danielle Hamann[2], David C. Johnson[2], and Saskia F. Fischer[1,3] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — [2]Department of Chemistry and Materials Science Institute, University of Oregon, Eugene OR 97403, USA — [3]Center for the Science of Materials Berlin, Humboldt-Universität zu Berlin, 12489 Berlin, Germany

In layered superconductors the coupling betwee superconducting layers is crucial due to its strong impact on their properties [1]. We investigate the properties of $[(SnSe)_{1+\delta}]_m$[NbSe2] superlattices, which allow for nearly arbitrary stacking sequences due to the growth technique [2]. With this degree of freedom we study how coupling mechanisms enable the occurrence of superconductivity.
Temperature-dependent resistance measurements show superconductivity for $NbSe_2$ interlayer distances of 2.4 nm or smaller. This is explained by the interplay of grain boundaries, crossplane tunneling and proximity effect in the SnSe spacer layer. Additionally, current-voltage characteristics provide insights into the coupling mechanisms of 2D superconductors.

[1] Chiatti *et al.*, J. Phys.: Condens. Matter **35**, 215701 (2023)
[2] Grosse *et al.*, Sci. Rep. **6**, 33457 (2016)

TT 5.6 Mon 10:45 CHE/0089

Characterization and superconducting properties of $SrBi_2Se_4$ — •Max Brückner[1], Jule Kirschke[1], Ashiwini Balodhi[1], Cedric Schmitt[2], Lukas Gehrig[2], Kilian Strauss[2], Christoph Flathmann[3], Dina I. Fazlizhanova[4], Christian Liebscher[3], Ilya Eremin[5], Simon Moser[1,2], Andreas Kreyssig[1], and Anna E. Böhmer[1] — [1]Experimental Physics IV, Ruhr-University Bochum, Bochum — [2]Physikalisches Institut and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Würzburg — [3]Faculty of Physics and Astronomy, Ruhr-University Bochum, Bochum — [4]private — [5]Theoretical Physics III, Ruhr-University Bochum, Bochum

$SrBi_2Se_4$ is a newly discovered quasi-one-dimensional superconductor that offers a promising platform for exploring exotic superconductivity in low-dimensional systems. We present the growth of free-standing single crystals using a Bi-Se-rich self-flux method and characterize their structure and composition via x-ray diffraction, transmission electron

microscopy, and energy-dispersive x-ray spectroscopy. Heat-capacity and magnetization measurements confirm bulk superconductivity below $T_c = 2.9$ K, while magnetotransport reveals an anisotropic upper-critical field. Additionally, we present angle-resolved photoemission spectroscopy and density-functional theory calculations, that provide insight into the electronic structure and lay the groundwork for understanding possible unconventional superconductivity in $SrBi_2Se_4$.
We acknowledge funding from the European Research Council through Project 101040811, Distort-to-Grasp.

15 min. break

TT 5.7 Mon 11:15 CHE/0089

Structural transition and emergent bulk superconductivity in Te-doped $PtBi_2$ — •Soumen Ash[1,2], Kilian Srowik[1,2], Pablo Pedrazzini[1,3], Oksana E. Kvitnitskaya[1], Andrii Kuibarov[1], Susmita Changdar[1], Rui Lou[1], Alexander Fedorov[1], Swarnamayee Mishra[4], Alexander Mistonov[4], Saicharan Aswartham[1], Jochen Geck[4], Sergey Borisenko[1], Laura T. Corredor[1], and Bernd Büchner[1,4] — [1]Institute for Solid State Research, Leibniz IFW Dresden, 01069 Dresden, Germany — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany — [3]Lab. Bajas Temperaturas, Centro Atómico Bariloche, CNEA-CONICET, 8400 San Carlos de Bariloche, Argentina — [4]Institute of Solid State and Materials Physics, TU Dresden, 01062 Dresden, Germany

Noncentrosymmetric trigonal $PtBi_2$ has emerged as a topological system exhibiting signatures of unconventional surface superconductivity, while sub-Kelvin superconductivity, as revealed by resistivity measurements, makes it a promising platform for studying chemical-tuning effects. We have carried out Te doping at the Bi sites of $PtBi_2$ and grown plate-like crystals with nominal compositions of $PtBi_{2-x}Te_x$ (x = 0.02 - 0.05) using a stoichiometric-melt-growth method. Detailed structural, electrical transport, magnetic, thermodynamic, and spectroscopic studies reveal that doping of Te at Bi-sites results in a transition from noncentrosymmetric (space group: $P31m$) to centrosymmetric (space group: $P\bar{3}m1$) crystal structure and gives rise to a bulk superconductivity with comparatively higher $T_c \approx 2.4$ K.

TT 5.8 Mon 11:30 CHE/0089

High-pressure high-temperature synthesis of uranium-silver compounds — •Jordan Tierney[1], Julia-Maria Hübner[2], Ulrich Schwarz[1], Andreas Leithe-Jasper[1], Ulrich Burkhardt[1], Markus König[1], Anamaria Ghihor[1], Yurii Prots[1], and Eteri Svanidze[1] — [1]MPI CPfS, Dresden — [2]TU Dresden

Uranium-based quantum materials have recently entered a renaissance. Evidence of correlated topological states, spin-liquid behavior, hidden order phases, and spin-triplet superconductivity prove that these materials are exceptionally interesting. Because of their complex chemistry and fragile stability, many potentially fascinating uranium-based systems are currently entirely beyond the reach of conventional synthesis methods. In this talk, we will show how simultaneous high-pressure high-temperature synthesis, combined with micro-scale specimen isolation, can reach previously unattainable phases. We will discuss the uranium-silver system, in which no binary compounds have been previously reported; the two elements have appeared to be immiscible during conventional synthesis. By employing simultaneous high-pressure high-temperature synthesis instead, we have discovered several new materials. In particular, we were able to identify new magnetic and superconducting phases, with the detailed analysis of chemical and physical properties still currently underway. This proof-of-principle work shows that by implementing this methodology we can access high-purity materials and study their novel crystallographic arrangements and exotic quantum states. Supported by DFG grant number 553528746.

TT 5.9 Mon 11:45 CHE/0089

From superconductivity to unusual magnetic behaviour in noncentrosymmetric mercurides — •R. Nixon[1,2], N. Zaremba[1], S. Adegboyega[3], A. Leithe-Jasper[1], M. Krnel[1], Yu. Prots[1], L. Akselrud[1,4], M. Schmidt[1], U. Burkhardt[1], J. Sichelschmidt[1], L. Amidani[5,6], F. La Mattina[7], M. Shatruk[3], A. Shengelaya[8], M. Brando[1], Yu. Grin[1], and E. Svanidze[1] — [1]MPI CPfS, Dresden — [2]Uni. of St Andrews, UK — [3]Florida St. Uni., US — [4]Ivan Franko Lviv National Uni., Ukraine — [5]ESRF, Grenoble, France — [6]HZDR, Dresden — [7]Lab. for Transport at Nanoscale Interfaces, Duebendorf, Switzerland — [8]Ivane Javakhishvili Tbilisi State Uni., Georgia

Mercury and superconductivity are forever linked due to the discovery of zero resistivity (Onnes 1911), yet superconductivity in elemental Hg remains non-trivial (Tresca 2022). Here we examine superconductivity in noncentrosymmetric mercurides, $A_{11-x}Hg_{54+x}$, (A = Na, Ca, Sr). Due to their complexity, these structures were refined over many years (Tambornino 2015), the Ca and Sr adopt $A_{11-x}Hg_{54+x}$ (Tkachuk 2008), and Na forms a 3-fold superstructure, $Na_{11}Hg_{52}$ (Hoch 2012). Mercurides are often structurally characterised, but physical properties are rarely reported. We previously identified $Sr_{11-x}Hg_{54+x}$ to superconduct (Nixon 2024), motivated by growing interest of unconventional pairing in noncentrosymmetric superconductors (Bauer 2004), we extend to the Na and Ca analogues, also identified to superconduct (Nixon in prep.). Moving to rare-earths, we obtain the related $Eu_{11-x}Hg_{54+x}$ phase, however, multiple Eu sites give several magnetic phases (Nixon 2025). Research funded by DFG - No. 528628333.

TT 5.10 Mon 12:00 CHE/0089

Atomic scale imaging of the effect of chemical pressure in $Sr_{2-x}Ba_xRuO_4$ — •Siri A. Berge[1], Rebecca Bisset[1], Daniel Halliday[1], Carolina de Almeida Marques[1], Luke C. Rhodes[1], Alexander C. Komarek[2], Phil D. C. King[1], and Peter Wahl[1,3] — [1]SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, KY16 9SS, United Kingdom — [2]Max Planck Institute for Chemical Physics of Solids Nöthnitzer Strasse 40, Dresden 01187, Germany — [3]Physikalisches Institut, Universitat Bonn, Nussallee 12, 53115 Bonn, Germany

Tuning the electronic structure of layered perovskites is a powerful pathway to control their properties for future applications. Structural distortion in Sr_2RuO_4 affects the electronic structure, moving the van Hove singularity across the Fermi level, with significant consequences for physical properties such as superconductivity [1-2]. Here, we study the effect of chemical pressure by substitution with isovalent Ba atoms in $Sr_{2-x}Ba_xRuO_4$ for $x = 0$, 0.2, and 0.4 by Scanning Tunnelling Microscopy (STM). We report changes in the electronic structure with rotation of the surface RuO octahedra as well as surface inhomogeneity with regions of varying degrees of rotation. Our results highlight the connection between electronic and lattice degrees of freedom and demonstrate control of the electronic structure.
[1] C.A. Marques et al. Advanced Materials 33 (2021) 2100593
[2] J.B. Profe et al. Phys. Rev. Research 6 (2024) 043057

TT 5.11 Mon 12:15 CHE/0089

Multiple superconducting transitions in $Yb_{3+x}Co_4Sn_{13-x}$ — •Roman Gumeniuk[1], Meret Orlob[1], Volodymyr Levytskyi[1], Alexander A. Tsirlin[2], Bohdan Kundys[3], and Andreas Leithe-Jasper[4] — [1]Institut für Experimentelle Physik, TU Bergakademie Freiberg, 09596 Freiberg, Germany — [2]Felix-Bloch-Institut für Festkörperphysik, Universität Leipzig, 04103 Leipzig, Germany — [3]Université de Strasbourg, CNRS, Institut de Physique et Chimie des Matériaux, Strasbourg F-67000, France — [4]Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden, Germany

$Yb_{3+x}Co_4Sn_{13-x}$ is shown to posses homogeneity range within $0 \leq x \leq 0.5$. For all x a primitive cubic [space group $Pm\bar{3}n$, $a \approx 9.54$ Å] structure of strongly disordered $Sc_3Ir_4Si_{13+x}$ type is found. Despite showing no signatures of presence of additional phases, different pieces of the same stoichiometric $Yb_3Co_4Sn_{13}$ sample revealed multiple superconducting transitions of varying intensity at $T_c = 3.1(2)$ K and $T_c = 2.4(2)$ K in temperature dependence of specific heat. On the other hand, $Yb_{3.2}Co_4Sn_{12.8}$ is found to be a strongly coupled superconductor with single transition at $T_c = 2.4(2)$ K and enhanced critical magnetic field $B_{c2} = 4.79(9)$ T. To shed light on superconducting behaviors in both stannides diverse models were applied to describe $B_{c2}(T_c)$ and $c_{el}(T)$ dependencies. Both $Yb_{3+x}Co_4Sn_{13-x}$ ($x = 0, 0.2$) compounds reveal bosonic peaks in specific heat and thus, possible 'rattling' behavior. They are also metallic systems, some aspects of which are described by a free electron gas model [1].
[1] M. Orlob et al., Phys. Rev. B 112 (2025) 174513