TT 1: Superconductivity - Fabrication and Characterization

Time: Monday 9:30–11:15 Location: H18

TT 1.1 Mon 9:30 H18

Critical state in current-carrying NbN thin-film structures — •Konstantin Ilin[1], Michael Siegel[1], Andreas Engel[2], Holger Bartolf[2], Andreas Schilling[2], Eugen Hollmann[3], Alexei Semenov[4], Andrey Smirnov[4], and Heinz-Wilhelm Hübers[4] — [1]Institute of Micro- and Nano-Electronic Systems, University of Karlsruhe, Germany — [2]Physics Institute, University of Zurich, Switzerland — [3]Research Centre Jülich, Germany — [4]DLR Institute of Planetary Research, Berlin, Germany

Superconducting NbN thin films are widely used for fabrication of detectors of electromagnetic radiation: single-photon detectors (SPD) and hot-electron mixers (HEM). While SPD is a meander line of width smaller than 100 nm, the key part of HEM is a few micrometers wide bridge with length of 200 - 300 nm. We report on a study of current-generated critical states in NbN bridges made from ultra-thin (< 10 nm) films. The films were deposited by reactive magnetron sputtering onto heated Si and sapphire substrates and patterned by electron-beam lithography and ion-milling to form bridges of width from 100 nm up to 10 μm. The critical current value of all bridges was measured in the temperature range from 2 K up to Tc. We observed significant variations of Ic(T) curves with the bridge widths. Sub-micrometer wide structures demonstrate almost standard dependencies of Ic on temperature, which can be described by the Ginzburg-Landau theory. Bridges of several micrometers in width show strongly non-monotonic Ic(T) dependencies. Mechanisms determining the current-carrying ability of the bridges made from ultra-thin NbN films will be discussed.

TT 1.2 Mon 9:45 H18

Optimization of superconducting/normal metal bi-layers for antenna structures of Hot-Electron Mixers — •Axel Stockhausen[1], Konstantin Ilin[1], Michael Siegel[1], Alexei Semenov[2], Andrey Smirnov[2], and Heinz-Wilhelm Huebers[2] — [1]Institute of Micro- and Nano-Electronic Systems, University of Karlsruhe, Karlsruhe, Germany — [2]DLR e.V. Institute of Planetary Research, Berlin-Adlershof, Germany

Hot-Electron Mixers operational in the THz frequency range are made from an ultra-thin (< 5 nm) NbN superconducting film, which is in direct contact with an antenna structure from a thick (about 300 nm) gold layer. Usually titanium or chromium in-situ deposited films are used as a buffer layer for the gold film. This leads to suppression of superconductivity in the ultra-thin NbN film due to the proximity effect and worsening of the device performance. To support the superconducting energy gap in the ultra-thin NbN film a buffer layer of superconducting material can be used instead of a normal metal. We report results on the development of deposition processes of superconducting Nb, NbN thin films, and Nb/Au and NbN/Au bi-layer structures. The superconducting films of Nb and NbN were deposited by magnetron or reactive magnetron sputtering of Nb target onto Si substrate kept at room temperature. In-situ Ar ion milling technique was used for pre-cleaning of the substrate surface before deposition. The dependencies of superconducting and normal state properties of the Nb and NbN films and multi-layer structures on deposition conditions will be presented and discussed.

TT 1.3 Mon 10:00 H18

Phase Slip in Thin Superconducting Wires — •Jonathan Eroms, Toeno van der Sar, Manohar Kumar, Ad Verbruggen, Kees Harmans, and Hans Mooij — Kavli Institute of Nanoscience, Delft University of Technology, P.O. Box 50 46, NL-2600GA Delft, The Netherlands

We experimentally investigate thermal and quantum phase slip in thin wires of amorphous NbSi. Quantum phase slip could ultimately be employed in a new type of superconducting qubit, but clear experimental evidence is scarce up to now. We focus on sputtered NbSi films with lithographically defined wires, since this will offer more flexibility for more complex devices. The sheet resistance, transition temperature and long-term stability of various film compositions and thicknesses were studied. The wires are fabricated with high-resolution e-beam lithography, using HSQ resist, a Leica EBPG 5000+ lithography tool and SF_6/He-based reactive ion etching. Line widths down to less than 15 nm are achievable. Transport in the wires was measured in a ^{3}He-cryostat, and also in a dilution refrigerator with extensive filtering. Wires with a normal state resistance per length of more than 35 Ω/nm deviate from the LAMH theory of thermally activated phase slip and show a saturation of the resistance at low temperature, which could point to quantum phase slip.

TT 1.4 Mon 10:15 H18

Masked ion-beam nano-patterning of high-T_c superconducting thin films — •Khurram Siraj[1], Johannes Pedarnig[1], Dieter Bäuerle[1], Herbert Richter[2], Wolfgang Lang[2], Renata Kolarova[3], Peter Bauer[3], Leopold Palmetshofer[4], and Christine Hasenfuss[4] — [1]Institut f. Angewandte Physik, Universität Linz, A-4040 Linz — [2]Institut f. Materialphysik, Universität Wien, A-1090 Wien — [3]Institut f. Experimentalphysik, Universität Linz, A-4040 Linz — [4]Institut f. Halbleiter- und Festkörperphysik, Universität Linz, A-4040 Linz

High-T_c superconducting (HTS) thin films are especially interesting for future nano-electronic devices. Masked ion-beam structuring (MIBS) is a promising technique to fabricate artificial HTS thin film nano-structures in a direct and single-step process.

Irradiation of vicinal $YBa_2Cu_3O_{7-d}$ (YBCO) thin films with light ions of low energy increases the normal state in-plane and out-of-plane resistivities and suppresses the critical temperature T_c without destroying the film crystal framework.

MIBS is employed for nano-structuring of YBCO thin films into lines, arrays and dots (size approx. 60 nm). Computer simulations (SRIM, MARLOWE) indicate that light-ion projection patterning can produce YBCO thin film nano-structures 10 nm in size.

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TT 1.5 Mon 10:30 H18

Effect of different carbon dopants on the superconducting properties of mechanically alloyed MgB_2 — •Marko Herrmann[1], Wolfgang Hässler[1], Christian Rodig[1], Margitta Schubert[1], Manfred Ritschel[2], Bernhard Holzapfel[1,3], and Ludwig Schultz[1,3] — [1]Institute of Metallic Materials, IFW Dresden, P.O. Box: 270116, D-01171 Dresden, Germany — [2]Institute for Solid State Research, IFW Dresden, P.O. Box: 270116, D-01171 Dresden, Germany — [3]Dresden University of Technology, Department of Physics, D-01062 Dresden, Germany

Doping with carbon both in its elemental state as well as present within carbon compounds is the method of choice for enhancing the superconducting properties of MgB_2. Precursor powders of carbon-doped MgB_2 were prepared by mechanical alloying. This preparation, successfully applied at ambient temperature, produced nanocrystalline, partially reacted powders. The high reactivity of the milled powders promotes the formation of MgB_2 at reduced temperatures around 600°C to 650°C. Compared to other in-situ preparation techniques, bulk samples of undoped mechanically alloyed MgB_2 show a high J_c of 1 x 10^6 A/cm^2 in self-field at 7.5 K and critical fields H_{c2} of 20 T. This can be explained by the high density of grain boundaries, which act as pinning centers and enhance the critical current density remarkably. A comparison of promising carbon dopants like carbon nanotubes and silicon carbide is presented. We show the influence of these dopants on the critical transition temperature, lattice parameter, critical field and critical current density of bulk and tape samples.

TT 1.6 Mon 10:45 H18

Correlation of Jc and microstructure in SiC added MgB_2 wires — •Balaji Birajdar[1], Nicola Peranio[1], Pavol Kováč[2], Wacek Pachla[3], and Oliver Eibl[1] — [1]Institut für Angewandte Physik, Universität Tübingen, Auf der Morgenstelle 10, D-72076 Tübingen, Germany — [2]Institute of Electrical Engineering, Dúbravska cesta 9, 842 39 Bratislava, Slovakia — [3]Institute of High Pressure Physics, Sokolowska 29/37, 01-142 Warsaw, Poland

Addition of SiC is known to enhance the critical current density (J_c) of MgB_2 wires. In this work, nano-crystalline SiC added MgB_2 wires are prepared by the powder-in-tube technique using different processing technologies. In ex-situ wires the powder is pre-reacted MgB_2+SiC and the annealing temperature is about 950 °C. In in-situ wires the

powder is Mg+2B+SiC and the annealing temperature is about 650 °C. The J_c's of the wires were found to differ by orders of magnitude. The best wires yielded a J_c of 10 000 A/cm^2 at B=9.7 T and T=4.2 K. Advanced electron microscopy techniques like EDX elemental mapping in SEM and TEM, and electron spectroscopic imaging (ESI) in TEM were used to study the microstructure of these wires on different length scales. The microstructure shows granularity (ex-situ samples) and incomplete phase formation (in-situ samples). Si is oxidised due to the high annealing temperature in ex-situ samples and forms Mg_2Si in in-situ prepared samples. C-doping of MgB_2 by dissolved SiC might play a role and would increase the B_{c2} and J_c. Measurement of the C-content by SEM-EDX in MgB_2 is inaccurate, the minimum detectable mass fraction of C in MgB_2 is about 1.7 at.%.

TT 1.7 Mon 11:00 H18

Evidence of superconductivity in $DyRh_4B_4$ **compound** —
•Anke Köhler[1], Günter Behr[1], Günter Fuchs[1], Konstantin Nenkov[1], and Laxmi Chand Gupta[1,2] — [1]IFW Dresden, P.O.Box 270116, D-01171 Dresden, Germany — [2]Guest Scientist

Several RRh_4B_4 (R = rare earth elements) are known to crystallize in *pt* (primitive tetragonal), *bct* (body-centered tetragonal) and the *or* (orthorhombic) structures. A number of them become superconducting. But so far, the Dysprosium compound is known to form only in the *pt*-structure and does not exhibit superconductivity. We examined the possibility of $DyRh_4B_4$ crytallizing in *bct*- or *or*-structures and exhibiting superconductivity. We synthesized polycrystalline samples containing Dy, Rh and B by arc-melting followed by an annealing process. The samples were characterized by electron EPMA and X-ray diffraction. Beside the desired $DyRh_4B_4$ composition we found a fraction of $DyRh_3B_2$ and a small amount of some other phases, which significantly got reduced by annealing. Unannealed and annealed samples contain a majority superconducting phase of the composition $DyRh_4B_4$, T_c = 4.4 K, as was shown by ac-susceptibility measurements. The as-grown samples also contain a ferromagnetic phase that is different from the superconducting one and vanishes nearly completely by annealing. In contrast, the superconducting volume fraction (≈ 50%) does not noticeably change by annealing or further melting. It seems to us that the superconducting phase is orthorhombic. Further work is in progress to check this.