TT 20: SC: Fabrication and Characterization of Iron-Based and Other Superconductors

Time: Wednesday 9:30–13:00 Location: H19

TT 20.1 Wed 9:30 H19

Preparation and transport properties of FeSe thin films — •Martin Jourdan, Sebastian ten Haaf, and Janek Maletz — Institut für Physik, Johannes Gutenberg Universität Mainz, 55099 Mainz, Germany

Thin films of the presumably unconventional superconductor FeSe were prepared by molecular beam epitaxy (MBE). X-ray diffraction reveals epitaxial growth. The temperature dependent resistance of the samples depends crucially on the stoichiometry with variations in the order of 1% determining the observation or absence of superconductivity. The best samples show a critical temperature of 7K with a resistive transition width of 1K. Angular dependent measurements of the upper critical field reveal a pronounced anisotropy which is increasing with sample purity. Measurements of the Hall-effect in the normal conducting regime are related with sample stoichiometry as determined by energy dispersive x-ray spectroscopy (EDX) on thick films (thickness 600nm).

TT 20.2 Wed 9:45 H19

Metal-semiconductor transition and phase separation in superconducting $Fe_{1+y}Te_{1-x}Se_x$ single crystals — •Sahana Roessler[1], Dona Cherian[2], Sasidharan Harikrishnan[2], Handadi L Bhat[2], Suja Elizabeth[1], Frank Steglich[1], Steffen Wirth[1], and Liu Hao Tjeng[1] — [1]Max Planck Institute for Chemical Physics of Solids, Nöthnitzer Straße 40, 01187 Dresden, Germany — [2]Department of Physics, Indian Institute of Science, C V Raman Avenue, Bangalore - 560012, India

We have investigated the influence of excess Fe on the electrical transport and magnetism of $Fe_{1+y}Te_{1-x}Se_x$ (y = 0.26, 0.15, 0.12 and x =0.32, 0.34, 0.36, respectively) single crystals. All three samples exhibit superconducting transitions with critical temperatures T_c (onset) $\sim$ 15 K in the resistivity measurements. It has been inferred from the width of the superconducting transition and the magnitude of the lower critical field H_{c1}, that excess Fe occupying interstitial sites in the chalcogen planes suppresses superconductivity. Further, the temperature dependence of resistivity in the normal state changes from metallic to semiconducting behavior with increasing Fe. From the dc-magnetization, linear and non-linear response of the ac-susceptibility, we show that the superconducting state for these compositions is inhomogeneous. A possible origin of this phase separation is due to a magnetic coupling between Fe in the chalcogen planes with those in the Fe-square lattice.

TT 20.3 Wed 10:00 H19

Single crystal growth and physical characterization of iron-pnictides $Ca(Fe_{1-x}Co_x)_2As_2$ — •Luminita Harnagea, Surjeet Singh, Gerd Friemel, Norman Leps, Friedrich Roth, Mahmoud Abdel-Hafez, Ulrike Stockert, Sabine Wurmehl, Günter Behr, Christian Hess, Rüdiger Klingeler, Martin Knupfer, and Bernd Büchner — Leibniz Institute for Solid State Materials Research (IFW) Dresden, Germany

Single crystals of iron-pnictides $Ca(Fe_{1-x}Co_x)_2As_2$ ($0 \le x \le 0.2$) were grown from Sn-flux using the conventional high temperature solution growth technique. All the grown crystals were found to be phase-pure crystallizing in a tetragonal $ThCr_2Si_2$-type structure. In particular, no trace of Sn incorporation in the structure was detected. Upon Co doping, the c-crystallographic axis of the tetragonal unit cell decreases, while a-axis shows a less significant variation. Crystals were plate-like exhibiting lateral dimensions up to 15 mm and 0.5 mm thick. The details of crystal characterization, including the chemical composition, growth habits and morphology of the grown crystals are presented. Effects of Co-doping on the structural/magnetic transition of $CaFe_2As_2$ are discussed from optical spectroscopy and temperature dependent resistivity and susceptibility studies.

TT 20.4 Wed 10:15 H19

Phase diagram of $Ca(Fe_{1-x}Co_x)_2As_2$ — •Ulrike Stockert, Mahmoud Abdel-Hafez, Luminita Harnagea, Surjeet Singh, Norman Leps, Liran Wang, Gerd Friemel, Sabine Wurmehl, Günter Behr, Christian Hess, Rüdiger Klingeler, and Bernd Büchner — Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Germany

We report on magnetic and thermodynamic measurements on $Ca(Fe_{1-x}Co_x)_2As_2$ ($0 \le x \le 0.2$) single crystals grown from Sn-flux. Upon Co substitution, the first-order structural/magnetic phase transition of $CaFe_2As_2$ is split and shifted to lower temperatures. Simultaneously, superconductivity evolves at low T. The superconducting volume fraction depends sensitively on the Co content and reaches 100 % only above the optimum doping level of $x \sim 0.065$, as the magnetic and structural transitions are completely suppressed. We discuss the phase diagram of $Ca(Fe_{1-x}Co_x)_2As_2$ in consideration of recent investigations of $CaFe_2As_2$ under pressure, which revealed a sensitive pressure dependence of the structural/magnetic phase transitions and a T_c as high as 10 K at 3.5 kbar.

TT 20.5 Wed 10:30 H19

Single-crystal growth and characterization of ferro-pnictides $A(Fe,Co,Ni)_2As_2$ (A = Ba, Sr) and $(A_{1-x}K_x)Fe_2As_2$(A = Ba, Eu) — •S. Aswartham, S. Singh, G. Behr, N. Leps, G. Friemel, U. Stockert, S. Wurmehl, R. Klingeler, C. Hess, and B. Büchner — IFW Dresden, Helmholtzstraße 20, D-01069 Dresden, Germany

We employed a modified Bridgman and self-flux methods to grow single crystals of $A(Fe, Co, Ni)_2As_2$ (A = Ba, Sr) and $(A_{1-x}K_x)Fe_2As_2$(A = Ba, Eu) series, respectively. Using these techniques large single-crystals with dimensions up to 25 x 10 mm^2 and thickness up to 1 mm were grown. Susceptibility and resistivity of these crystals were studied. Narrow superconducting transition widths ($\approx$ 0.5 K) and large residual resistivity ratios ($\approx$ 7) indicate the high-quality of our single crystals. Here we present details of our crystal growth methods, structural characterizations and physical properties.

TT 20.6 Wed 10:45 H19

Crystal growth and physical characterization of $Ba(Fe_{1-x}Co_x)_2As_2$ — •C. Nacke[1], G. Behr[1], S. Singh[1], N. Leps[1], G. Friemel[1], U. Stockert[1], H.H. Klauss[2], S. Wurmehl[1], C. Hess[1], R. Klingeler[1], and B. Büchner[1] — [1]Leibniz Institute for Solid State and Material Research (IFW) Dresden, Germany — [2]TU Dresden, Institute for Solid State Physics, Germany

The vertical Bridgman technique was used to grow mm-size crystals of the $BaFe_2As_2$ compound and its Co-doped superconducting variants. With this technique the crystals were grown directly from a stoichiometric melt with the composition $Ba(Fe_{1-x}Co_x)_2As_2$. The resulting crystals were platelet-like and have lateral sizes up to 10 x 10 mm^2 and a thickness up to 1 mm. Analysis by X-ray diffraction and EDX confirm the correct Ba-122-phase. Measurements of magnetic susceptibility and electrical resistivity reveal superconducting properties of the Co-doped crystals. The suceptibility plots for the 10% Co-doping samples (x=0.1) show a sharp transition to superconductivity at T_c=23 K. This data are in good agreement with those from the resistivity. In particular, the zero-field μSR data show a pure Gaussian relaxation and confirm very high sample purity.

TT 20.7 Wed 11:00 H19

How Can We Raise T_c in $RO_{1-x}F_xFeAs$ Superconductors? — •Anke Köhler[1,2], Günter Behr[1], Marko Herrmann[1], and Wolfgang Hässler[1] — [1]IFW Dresden, PF 270116, 01171 Dresden — [2]Goethe-Universität Frankfurt am Main, Max-von-Laue-Str. 1, 60438 Frankfurt

By the discovery of $RO_{1-x}F_xFeAs$ (R = lanthanide) superconductors in the beginning of 2008, it was shown for the first time that a non-cuprate superconductor can reach a superconducting transition temperature T_c above 50 K. This offers new opportunities for the development of new high temperature superconductors. However, the superconductors with the highest T_c show the most difficulties in formation of the right phase. Problems are the incorporation of fluorine and the homogeneity of the samples. A further challenge is the structural instability for rare earth elements with small ion radius ($64 \le Z \le 71$). In our studies, several opportunities to overcome these difficulties are evaluated:

1. variation of the grain size of the initial powder
2. use of slightly non-stoichiometric initial composition
3. high-pressure synthesis

As a result, we raise the T_c of the material with a nominal composition $GdO_{1-x}F_xFeAs$ from 20 up to 40 K. In a $SmO_{0.9}F_{0.1}FeAs$-

compound could be observed superconductivity above 50 K after a small As-reduction at the surface of the sample. Measurements of the final composition and structure will animate the discussion about the requirements for realization of the superconducting state.

15 min. break

TT 20.8 Wed 11:30 H19

Magnetic phase diagram of iron pnictide thin films — •Silvia Haindl, Martin Kidszun, Fritz Kurth, Kazumasa Iida, Alexander Kauffmann, Nadezda Kozlova, Jens Freudenberger, Jens Hänisch, Konstantin Nenkov, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, Institute for Metallic Materials, PO - Box 270116, D-01171 Dresden

The new iron pnictide superconductors with transition temperatures up to 55 K and high upper critical fields are found to be candidates for multiband superconductivity as it has been suggested by theory and experiment. A serious investigation, however, is restricted to single crystals and epitaxial thin films. Latter offer a defined current path (two-dimensionality) and a higher voltage resolution in transport measurements. Epitaxial $LaFeAsO_{1-x}F_x$ and Co-doped $BaFe_2As_2$ thin films have been successfully grown by pulsed laser deposition (PLD). We have performed transport measurements in static fields up to 14 T and pulsed fields up to 42 T for different crystallographic directions. The upper critical field and its temperature dependent anisotropy are discussed in terms of a two gap superconductivity scenario. In addition, the vortex matter has been studied using a vibrating sample magnetometer (VSM).

TT 20.9 Wed 11:45 H19

Anisotropy and vortex matter of LaFeAs(O,F) — •Martin Kidszun, Silvia Haindl, Jens Hänisch, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, Institute for Metallic Materials, PO - Box 270116, D-01171 Dresden, Germany

The successful growth of epitaxial LaFeAs(O,F) thin films opens the way to study intrinsic properties of this novel superconductors. Exploring the magnetic phase diagram up to 42 T we were able to investigate the temperature dependence and anisotropy of the upper critical field as well as the irreversibility field in this iron oxypinictide. The anisotropy of the irreversibility field was determined using a combination of resistive measurements in high magnetic fields and critical current densitie measurements. A substantial report about the anisotropy and the vortex matter will be given in this conribution.

TT 20.10 Wed 12:00 H19

Dynamic studies on the influence of strain on superconducting properties using piezoelectric substrates — •Sascha Trommler, Ruben Hühne, Patrick Pahlke, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

It is known that the application of strain has a significant influence on the functional properties of superconducting materials. Typically, thin films are prepared on substrates with a different lattice misfit inducing a biaxial tensile or compressive strain to study this effect. Unfortunately, this approach is often restricted to very thin films. Furthermore, it is difficult to correlate strain and superconductivity directly, as the preparation conditions and the resulting microstructure may severely affect the superconducting properties. An alternative approach is the preparation of superconducting films on single crystalline piezoelectric substrates enabling a dynamical variation of the induced strain by applying an electric field on the substrate. This approach is used to study the strain dependence of superconducting properties in different materials. Therefore, thin epitaxial YBCO, $La_{1-x}Sr_xCuO_4$ and $BaFe_{2-x}Co_xAs_2$ films were prepared on piezoelectric (001) $Pb(Mg_{1/3}Nb_{2/3})_{0.72}Ti_{0.28}O_3$ substrates. Depending on the lattice parameter of these materials, additional buffer layers are required to achieve an epitaxial growth of the superconductor on these substrates. Finally, results on the influence of strain on superconducting properties like the transition temperature will be presented for these materials using dynamic investigations.

TT 20.11 Wed 12:15 H19

Preparation and Characterization of $Ho_xLu_{1-x}Ni_2B_2C$ Thin Films — •Tim Niemeier, Karolin Tscharntke, Ruben Hühne, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, PF 270116, D-01171 Dresden

On the basis of the epitaxial growth of rare earth nickel borocarbide films [1], mixed phase borocarbide thin films $Ho_xLu_{1-x}Ni_2B_2C$ were successfully prepared for the first time. Pulsed Laser deposition with two stoichiometric $LuNi_2B_2C$ and $HoNi_2B_2C$ alloy targets and variable pulse counts on both targets were used to produce thin films with different chemical compositions. Using x-ray diffraction, a homogeneous phase was detected in the films. Texture measurements revealed that for most of the compositions, a high in-plane order could be preserved in the films for slighty adapted deposition parameters. The superconductive transition temperatures in dependence of the composition are close to those known from mixed phase polycrystalline samples [2]. Finally, an outlook to the behaviour of the upper critical field in the composition series will be given. Additional details on the deposition and the epitaxial growth will be discussed on an additional poster.

[1] T. Niemeier *et al.*, J. Phys.: Conf. Ser. 150 (2009) 052185

[2] J. Freudenberger *et al.*: J. Magnetism and Magnetic Materials 187 (1998) Nr. 3, S. 309-317

TT 20.12 Wed 12:30 H19

Effect of Gallium Doping on Superconductivity in Germanium — •R. Skrotzki[1], T. Herrmannsdörfer[1], V. Heera[2], O. Ignatchik[1], M. Uhlarz[1], A. Mücklich[2], M. Posselt[2], H. Reuther[2], B. Schmidt[2], K.-H. Heinig[2], W. Skorupa[2], M. Voelskow[2], C. Wündisch[2], J. Fiedler[2], M. Helm[2], and J. Wosnitza[1] — [1]Hochfeld-Magnetlabor Dresden, Forschungszentrum Dresden-Rossendorf (FZD) — [2]Institut für Ionenstrahlphysik und Materialforschung, FZD

We report recent discoveries of superconductivity in Ga-doped germanium fabricated by ion implantation and subsequent flash-lamp or oven annealing. Tuning the preparation parameters allows for varying both charge-carrier and Ga concentration in the resulting roughly 100 nm thin nano- or single-crystalline layers. Transport measurements on systematically prepared samples reveal that besides a needed charge-carrier concentration of more than 0.4 atom%, superconductivity occurs to be sensitive on the implanted Ga content which may also be attributed to a change in the phonon properties. Onset transition temperatures up to 1.4 K have been found for almost 10 atom% Ga. Further, we observe in-plane critical fields exceeding 1 T and being close to the Pauli-Clogston limit. An exceptionally low Cooper-pair density of around 10^{15} cm^{-3} turns out the extreme type-II character of superconductivity. Finally, our work adds to our previous report [1] and may help to understand superconductivity in doped elemental semiconductors in general.

[1] T. Herrmannsdoerfer et. al., Phys. Rev. Lett. 102, 1027003 (2009)

TT 20.13 Wed 12:45 H19

YBCO nanowires grown by the alumina template method — •Michael R Koblischka[1], Anjela Koblischka-Veneva[2], Vassil Skumryev[3], and Uwe Hartmann[1] — [1]Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany — [2]Functional Materials, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany — [3]Institut Català de Recerca i Estudis Avançats (ICREA), Barcelona, Spain

$YBa_2Cu_3O_x$ (YBCO) nanowires are grown by the anodized alumina template method, starting from pre-sintered YBCO powder. As templates, we have employed commercially available alumina templates with pore diameters of 30 nm and 100 nm, and an overall thickness of 50 μm. An oxygen annealing step is required to obtain superconducting nanowires. Superconductivity with a transition temperature of 88 K is confirmed by means of magnetic susceptibility measurements. The resulting nanowires are analyzed in detail employing electron microscopy and atomic force microscopy. The separation of the nanowires of the templates is not yet established, but individual nanowires of up to 10 μm length could be separated from the template. In several cases, the template pores are not completely filled by the superconducting material, which implies that the observed length is similar to what could be expected from regular grain growth. Resistance measurements using cut pieces of the filled templates were carried out as a function of temperature. These pieces were covered with Au films on top and bottom in order to provide the electric contacts. The measurements confirmed the magnetically determined critical temperatures.