

## TT 36 Superconductivity - Vortex Dynamics, Vortex Phases, Pinning

Zeit: Mittwoch 10:00–13:00

Raum: TU H2053

TT 36.1 Mi 10:00 TU H2053

**Vortex Pinning and Magnetization Reversal Observed in Real Space by Magnetic Force Microscopy** — ●ALEXANDER SCHWARZ<sup>1</sup>, MARCUS LIEBMANN<sup>2</sup>, UNG HWAN PI<sup>3</sup>, and ROLAND WIESENDANGER<sup>1</sup> — <sup>1</sup>IAP, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — <sup>2</sup>Department of Mechanical Engineering, Yale University, 15 Prospect Street, New Haven, CT06511, USA — <sup>3</sup>ETRI, Gajeong dong Yuseong gu, Daejeon 305-350, South Korea

Vortex pinning mechanisms are important for an understanding of the magnetic properties of high temperature superconductors. Since magnetic force microscopy is able to image individual vortices and the surface topography in the same sample area, it is an ideal tool to study trapping characteristics of defects. In this study, we investigate a  $\text{Bi}_2\text{SrCa}_2\text{Cu}_2\text{O}_{8+\delta}$  plate-like single crystal with artificial  $c$ -axis columnar defects and intrinsic line defects. The later can be identified as either stacking fault dislocations or surface steps. Columnar defects typically trap only one quantum flux. In regions where only columnar defects are present the vortex density follows the transversal Bean model. On the other hand, stacking fault dislocations can accommodate large numbers of vortices and exhibit an anisotropic pinning behavior, i.e., strong transversal, but weak longitudinal pinning [1]. As a result, they impede vortex propagation during magnetization reversal perpendicular to their orientation and strongly alter the flux distribution in their vicinity. Finally, surface steps apparently do not act as pinning centers at all.

[1] U. H. Pi *et al.*, Phys. Rev. B **69**, 094518 (2004).

TT 36.2 Mi 10:15 TU H2053

**On the imaging of the flux-line lattice of a type-II superconductor by soft x-ray absorption microscopy** — ●MANFRED FÄHNLE<sup>1</sup>, JOACHIM ALBRECHT<sup>1</sup>, THOMAS EIMÜLLER<sup>1</sup>, PETER FISCHER<sup>1,2</sup>, EBERHARD GÖRING<sup>1</sup>, DANIEL STELAUF<sup>1</sup>, and GISELA SCHÜTZ<sup>1</sup> — <sup>1</sup>Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany — <sup>2</sup>Center for X-ray Optics, E. O. Lawrence Berkeley National Laboratory, MS-400, 1 Cyclotron Road, Berkeley, CA 94720 U.S.A.

A new method is proposed for the imaging of the flux-line lattice of a type-II superconductor by soft x-ray absorption microscopy. The method is based on the fact that in the core of a flux-line with linear extension  $2\xi$  ( $\xi$  = coherence length) the quasiparticle density of states is different from the one of the surrounding superconducting matrix. Like the scanning tunneling microscopy, the x-ray absorption microscopy therefore is sensitive to the spatial variation of the superconducting order parameter which is quite strong across the sample even for fields considerably larger than  $H_{c1}$ , whereas other imaging techniques are sensitive to the spatial variation of the magnetic field which becomes very small for large fields. The new technique has the potential to image in real space static and dynamical properties of the flux-line lattice at arbitrary magnetic fields and with single-flux-line resolution. Based on an estimate of the expected contrast it is shown that the new method is very demanding but probably realizable in the foreseeable future.

TT 36.3 Mi 10:30 TU H2053

**Dendrite Propagation Velocity in Type-II Superconductors** — ●BERND-UWE RUNGE<sup>1</sup>, BJÖRN BIEHLER<sup>1</sup>, ROMAN MINTS<sup>2</sup>, and PAUL LEIDERER<sup>1</sup> — <sup>1</sup>University of Konstanz, Germany — <sup>2</sup>Tel-Aviv University, Israel

We use the Faraday effect in combination with ultra-short fs-laser pulses to investigate the flux dynamics in type-II superconductors upon sudden heating. Under certain conditions a dendritic instability develops in those systems. The penetration velocity is measured using a pump-probe technique. A theory is proposed explaining the observed velocities. The theory is based on experimental observations and treats the dendrite as a moving flux jump instability. We can explain the observed “fast” and the well distinct “slow” regimes of flux penetration [1].

[1] U. Bolz *et al.*, Europhys. Lett. **64**(4) 517 (2003)

TT 36.4 Mi 10:45 TU H2053

**Vortex Matching due to Periodic Pinning Center Arrays produced by Micellar Techniques** — ●J. EISENMENGER, M. OETTINGER, C. PFAHLER, C. DIETRICH, F. WEIGL, B. KOSLOWSKI, A. PLETTL, H.-G. BOYEN, A. ETHIRAJAN, and P. ZIEMANN — Abteilung Festkörperphysik, Universität Ulm, 89069 Ulm

It has been demonstrated that pinning centers can lead to an enhanced stability of a vortex lattice, if this lattice matches a regular array of pinning centers without disturbing its preferred triangular order. Less explored are these phenomena at  $T \ll T_c$  where effective pinning centers should exhibit sizes in the nm-range, which are difficult to achieve with conventional lithography methods. To produce triangular arrays of pinning centers we use metal-salt loaded inverse micelles of diblock-copolymers. The metal islands are prepared by immersion of the sample into a solution of diblock-copolymer micelles in toluene which were loaded with a defined amount of metal precursor. Subsequent plasma-etching removes the polymer and reduces the precursor salt to metal islands with a size of about 10 nm. Such supported metal nano particles can be used in different ways to produce pinning centers in superconductors. One approach is overgrowing the metal islands directly with a superconducting (SC) layer, producing pinning centers by locally changed SC properties. In a second approach, nano particles serve as etching masks to pattern arrays of nano columns into the surface of the substrate. These columns are used to locally influence the SC properties of a thin film grown on top. A third possibility is pressing a sample with nano columns into a SC film leading to an array of antidots.

TT 36.5 Mi 11:00 TU H2053

**AFM-Analyse von schmelztextuiertem  $\text{YBa}_2\text{Cu}_3\text{O}_x$  mit nanoskaligen Einschlüssen** — ●MICHAEL R. KOBLISCHKA<sup>1</sup>, MARC WINTER<sup>1</sup>, UWE HARTMANN<sup>1</sup>, ANJELA KOBLISCHKA-VENEVA<sup>2</sup>, N. HARI BABU<sup>3</sup> und DAVID CARDWELL<sup>3</sup> — <sup>1</sup>FR Experimentalphysik, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken — <sup>2</sup>Institut für Funktionswerkstoffe, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken — <sup>3</sup>IRC in Superconductivity, University of Cambridge, Madingley Road, Cambridge, U.K.

$\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  (YBCO) ist immer noch der am besten geeignete Hochtemperatur-Supraleiter (HTSL) für Anwendungen, allerdings wäre eine grössere Stromdichte wünschenswert. Um dieses Ziel zu erreichen, wurde bislang hauptsächlich versucht, die Grösse der beim Wachstumsprozess entstehenden  $\text{Y}_2\text{BaCuO}_5$ -Partikel zu verringern. Diese sind jedoch bislang für effektive Pinningzentren zu gross und ausserdem nicht ideal verteilt. Mit Hilfe der Nanotechnologie besteht jedoch die Möglichkeit, gezielt nicht-reaktive Nanopartikel in die HTSL-Proben einzubringen. Kürzlich gelang es, YBCO-Proben mit  $\text{Y}_2\text{Ba}_4\text{CuMO}_x$ -Partikeln ( $M = \text{Zr}, \text{Nb}$ ) herzustellen, in denen die Nanopartikel Grössen zwischen 10 und 50 nm aufweisen. Mit Hilfe von AFM-Messungen untersuchen wir die Verteilung dieser Partikel und deren Grössenverteilung, und die Wechselwirkung zwischen diesen Partikeln und der umgebenden supraleitenden Matrix. Ausserdem wurden die lokalen Stromdichten mit Hilfe magneto-optischer Untersuchungen bestimmt.

Diese Arbeit wird unterstützt durch EFFORT und DAAD-PPP.

TT 36.6 Mi 11:15 TU H2053

**Artificial modulation and anisotropy of flux pinning force in  $R123$  composite films** — ●CHUANBING CAI, JENS HAENISCH, THOMAS GEMMING, and BERNHARD HOLZAPFEL — IFW Dresden, D-01171 Dresden, Germany

Artificial flux pinning centers in  $R123$  films has emerged much significant for both fundamental understanding and practical applications (especially for coated conductors). Using PLD technique, we prepared two types of composite films: i) superlattices consisting of three  $R123$ :  $n \times (\text{Gd}123_d/\text{Nd}123_d/\text{Eu}123_d)$ , and ii) multilayer of  $R123/\text{Y}_2\text{O}_3$ :  $n \times (\text{Y}123_{d1}/\text{Y}2\text{O}_{d2})$ . They possess the potential of artificial flux pinning centers due to epitaxial strain fields and second phase additions, respectively. We show the tailorable flux pinning forces and their anisotropy by angular dependences of the transport critical current density. It is revealed that the strongest modulation of flux pinning takes place at field direction parallel to  $c$  while it is hardly variable at field direction perpendicular to  $c$ .

Pause

TT 36.7 Mi 11:45 TU H2053

**Nanostrukturierte Flußhaftzentren in Hoch- $T_c$  Supraleitern** — ●M. WINTER<sup>1</sup>, M. R. KOBLISCHKA<sup>1</sup>, A. HU<sup>2</sup>, M. MURALIDHAR<sup>2</sup>, U. HARTMANN<sup>1</sup> und M. MURAKAMI<sup>3</sup> — <sup>1</sup>FR Experimentalphysik, Universität des Saarlandes, Postfach 151150, D-66041 Saarbrücken — <sup>2</sup>SRL/ISTEC, 1-10-13 Shinonome, Koto-ku, Tokyo 135-0062, Japan — <sup>3</sup>Department of Materials Science and Engineering, Shibaura Institute of Technology, Shibaura 3-9-14, Minato-ku, Tokyo 108-8548, Japan

Die ideale Größe für Haftzentren in Supraleitern liegt bei der doppelten Kohärenzlänge, z.B. 4,5 nm in der *ab*-Ebene von  $\text{YBa}_2\text{Cu}_3\text{O}_x$  (YBCO). Nichtleitende Einschlüsse, wie (SE)211-Partikel ( $\text{Y}_2\text{BaCuO}_5$ ) mit typischen Größen von einigen hundert Nanometern bis hin zu Mikrometern wirken nur bei niedrigen Magnetfeldern als effektive Flußhaftzentren. Um hohe kritische Stromstärken auch bei hohen Feldern zu erreichen, müssen nanometergroße, nicht-supraleitende Strukturen innerhalb des gesamten Volumens des Supraleiters vorhanden sein. Wir haben schmelztexturierte  $(\text{Nd}_{0.33}\text{Eu}_{0.28}\text{Gd}_{0.38})\text{Ba}_2\text{Cu}_3\text{O}_x$ ,  $(\text{Nd}_{0.33}\text{Eu}_{0.38}\text{Gd}_{0.28})\text{Ba}_2\text{Cu}_3\text{O}_x$ - (NEG),  $(\text{Sm}_{0.33}\text{Eu}_{0.33}\text{Gd}_{0.33})\text{Ba}_2\text{Cu}_3\text{O}_x$ - (SEG) und  $\text{SmBa}_2\text{Cu}_3\text{O}_x$ - (SmBCO) Proben mit Rasterkraft- und Rastertunnel-Mikroskopie an Luft untersucht. Im Vergleich zu YBCO-Kristallen zeigen die SEG und NEG-Kristalle regelmäßige Streifen- und Kreuzstrukturen, etwa eine Größenordnung größer als die Kohärenzlänge. Es handelt sich dabei um periodische Variationen der chemischen Zusammensetzung, die zu örtlich unterschiedlichen supraleitenden Eigenschaften führt, so daß gewisse Phasen bei hohen Strömen oder hohen Feldern normalleitend werden und als Flußhaftzentren wirken können.

TT 36.8 Mi 12:00 TU H2053

**Charge density distributions induced by flux creep in superconducting YBCO films** — ●VOLKER BORN and CHRISTIAN JOOSS — Institut für Materialphysik, Friedrich-Hund-Platz 1, 37077 Göttingen

A moving vortex in a superconductor represents an electric dipole where the induced charge is distributed over its spatial magnetic extension. On mesoscopic length scales of  $\approx 1\mu\text{m}$  (averaging over the spatial structure of individual vortices) all dipoles cancel, if ensembles of vortices move homogeneously. However, a mesoscopic charge density distribution arises if gradients of the vortex velocity perpendicular to their direction of motion exist. An excellent tool to study these charge densities is time and space resolved magneto-optics with spatial resolutions down to  $\approx 1\mu\text{m}$ . Here, we report on charge densities being induced into superconducting  $\text{YBa}_2\text{Cu}_3\text{O}_7$  thin films by thermally activated flux creep in constant external magnetic fields. We discuss briefly our method how to obtain the total electric field, the polarisation distribution and the charge density distribution. The main focus is directed to the vortex motion at current domain boundaries, grain boundaries and circular defects which builds up complex patterns of charge density distributions.

TT 36.9 Mi 12:15 TU H2053

**Investigation of the  $j_c(T)$ -behavior to answer the question of pinning in  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  thin-films** — ●SEBASTIAN BRÜCK<sup>1</sup> and JOACHIM ALBRECHT<sup>1,2</sup> — <sup>1</sup>Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, D-70569 Stuttgart, Germany — <sup>2</sup>Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany

Thin films of the high-temperature superconductor  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  (YBCO) grown on  $\text{SrTiO}_3$  (STO) substrates which partly experience a moderate nanostructuring of the surface, show an imposing increase of the critical current density where the surface is treated. The magneto-optical imaging technique joint by a numerical inversion scheme is used to obtain the current density distribution in such films with high spatial resolution enabling one to directly compare  $j_c$  in different parts of the sample. It will be shown that a detailed investigation of the temperature behavior of  $j_c$ , taking into account the distinctions between untreated and structured part, can provide deeper insights into the actual pinning scenario. By comparing the experimental results with theoretical models, evidence is found for the important role of intergranular low-angle grain boundaries for the increase of  $j_c$  as well as for the pinning scenario in general.

TT 36.10 Mi 12:30 TU H2053

**Origin of the Resistive Transitions Broadening in Superconducting MgB2 Films** — ●A. S. SIDORENKO<sup>1,2,3</sup>, V. I. ZDRAVKOV<sup>2,3</sup>, E. NOLD<sup>4</sup>, TH. KOCH<sup>5</sup>, TH. SCHIMMEL<sup>1,5</sup>, S. HORN<sup>2</sup>, C. MÜLLER<sup>2</sup>, A. WIXFORTH<sup>2</sup>, and R. TIDECKS<sup>2</sup> — <sup>1</sup>Institute of Applied Physics, Universität Karlsruhe, D-76128 Karlsruhe — <sup>2</sup>Institut für Physik, Universität Augsburg, D-86159 Augsburg — <sup>3</sup>Institute of Applied Physics, MD-2028 Kishinev, Moldova — <sup>4</sup>Institute of Materials Research I, Forschungszentrum Karlsruhe, D-76021 Karlsruhe — <sup>5</sup>Institute of Nanotechnology, Forschungszentrum Karlsruhe, D-76021 Karlsruhe

The discovery of superconductivity in MgB2, the material with hexagonal layered crystal structure, raised questions about its transport properties. The crystal structure of MgB2 and the band structure calculations suggest that the quasi-two-dimensional (2D) boron planes are mainly responsible for the charge transport. Therefore the superconducting properties of MgB2 are expected to reflect this 2D character. On the other hand, the layered structure should also influence the magnetic flux penetration and flux motion in the presence of an external magnetic field. In particular, thermally activated vortex creep processes (TAFF) play a crucial role in the resistive transitions broadening for MgB2 as well as for artificial multilayered systems. In the present work we report about experimental studies of the origin of resistive transitions broadening for MgB2 thin films.

TT 36.11 Mi 12:45 TU H2053

**Flux-lattice melting in two-dimensional disordered superconductors** — ●THOMAS NATTERMANN<sup>1</sup> und LI MAI SUAN<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik der Universität zu Köln, Zùlpicher Str. 77, 50937 Köln — <sup>2</sup>Institute of Physics, Polish Academy of Sciences,

The flux line lattice melting transition in two-dimensional pure and disordered superconductors is studied by a Monte Carlo simulation using the lowest Landau level approximation and quasi-periodic boundary condition on a plane. The position of the melting line was determined from the diffraction pattern of the superconducting order parameter. In the clean case we confirmed the results from earlier studies which show the existence of a quasi-long range ordered vortex lattice at low temperatures. Adding frozen disorder to the system the melting transition line is shifted to slightly lower fields. The correlations of the order parameter for translational long range order of the vortex positions seem to decay slightly faster than a power law (in agreement with the theory of Carpentier and Le Doussal) although a simple power law decay cannot be excluded. The corresponding positional glass correlation function decays as a power law establishing the existence of a quasi-long range ordered positional glass formed by the vortices. The correlation function characterizing a phase coherent vortex glass decays however exponentially ruling out the possible existence of a phase coherent vortex glass phase.