TT 34: Superconductivity - Vortex Dynamics, Vortex Phases, Pinning

Time: Friday 10:15–13:00 Location: H19

TT 34.1 Fri 10:15 H19

Commensurability effects in Nb thin films with (quasi-)periodic pinning arrays — •Matthias Kemmler[1], Daniel Bothner[1], Albert Sterck[1], Michael Siegel[2], Reinhold Kleiner[1], and Dieter Koelle[1] — [1]Physikalisches Institut - Experimentalphysik II,Universität Tübingen, Auf der Morgenstelle 14, D-72076Tübingen — [2]IMS, Universität Karlsruhe,Hertzstr. 16, D-76187 Karlsruhe

We study experimentally the critical depinning current I_c versus applied magnetic field B in Nb thin films which contain 2D arrays of circular antidots placed on the nodes of a fivefold Penrose lattice.

For measurements of electric transport we use a highly sensitive liquid Helium-cooled dc SQUID amplifier. The sample temperature is controlled and stabilized close to the Nb transition temperature T_c via an optical, very low noise heating system.

Our experiments confirm essential features in the $I_c(B)$ patterns as predicted by Misko *et al.*[1] , close to the transition temperature T_c of the Nb films.

In order to find the arrangement of optimal pinning we compare the performance of Nb films containing quasiperiodic pinning arrays, triangular pinning arrays, randomly distributed antidots, or no antidots. Some of the results are published in [2].

[1] V.R. Misko, S.Savel'ev, F.Nori, Phys. Rev. Lett. 95 (2005) 177007

[2] M. Kemmler et al., Phys. Rev. Lett. 97 (2006) 147003

TT 34.2 Fri 10:30 H19

Vortex Structures in Tantalum, Vandium and Niobium — •Sebastian Mühlbauer[1], Peter Böni[1], Christian Pfleiderer[1], Robert Georgii[2], Edward Forgan[3], Charlotte Bowell[3], and Mark Laver[3] — [1]Physikdepartment E21, TU München, Garching — [2]Foschunsgneutronenquelle Heinz Maier-Leibnitz, Garching — [3]School of Physics and Astronomy, Birmingham (UK)

Small angle neutron scattering directly maps the fourier transform of the vortex lattice (VL) of type II superconductors and gives valuable informations on both the underlying fermi surface and the mechanism of the superconducting pairing. But the symmetry of the VL is also mainly influenced by pinning and impurity effects. Recent studies of the VL in the classical superconductors Tantalum, Vanadium and Niobium with field applied along the four-fold (100) axis will be presented. Four fold VL patterns, breaking the crystal symmetry have been identified in Niobium, which can be explained by non-local corrections in the Eilenberger model. Furthermore, recent polarised neutron studies of the VL in Niobium will be presented.

TT 34.3 Fri 10:45 H19

Effect of dc magnetic field on the microwave losses in MgB_2 thin films — •Alexander Zaitsev, Rudolf Schneider, Roland Hott, Thorsten Schwarz, and Jochen Geerk — Forschungszentrum Karlsruhe, Institut für Festkörperphysik, P.O.B. 3640, D-76021 Karlsruhe, Germany

The microwave surface impedance ($Z_s = R_s + iX_s$) of *in situ* MgB_2 thin films was measured as a function of temperature and parallel dc magnetic field at several frequencies between 5.7 GHz and 18.5 GHz using a dielectric resonator technique. The results are consistent with the expectations for a classical type-II superconductor and, consequently, quite different from those of the high-T_c cuprates. The films cooled in zero-field revealed a clear indication of the lower critical field, B_{c1}, with a small hysteresis around $B \leq B_{c1}$. In higher fields ($B > B_{c1}$) the losses followed the Coffey-Clem and Brandt model, including the frequency dependences, whereas high-T_c Y-Ba-Cu-O films did not show a reasonable agreement with this model. Both the relatively high values of $\Delta X_s/\Delta R_s$ ratio and their frequency dependence indicate a weak effect of the flux creep on the measured microwave loss in MgB_2 films. The temperature dependence of $\Delta X_s/\Delta R_s$ ratio can be described by a microscopic pinning model for BCS-superconductors.

TT 34.4 Fri 11:00 H19

Superconducting Transition Broadening in MgB_2 — •Anatolie Sidorenko[1], Vladimir Zdravkov[1], Andrej Sudru[1], Dimitriu Ghitsu[1], Thomas Koch[2], and Thomas Schimmel[2,3] — [1]Institute of Electronic Engineering and Industrial Technologies, ASM, MD-2028 Kishinev, Moldova — [2]nstitute of Nanotechnology, Forschungszentrum Karlsruhe D-76021 Karlsruhe, Germany — [3]Institute of Applied Physics, University of Karlsruhe D-76128 Karlsruhe, Germany

Superconducting properties of high-quality films of the first multiband superconductor, magnesium diboride, have been investigated. Two mechanisms with intrinsic origin of the superconducting transition broadening for MgB_2 were found. The dominating role of two-dimensional fluctuations in the vicinity of the critical temperature and thermally activated flux flow for the low parts of the superconducting transition are responsible for the resistivity of MgB_2 near the superconducting transition. The reasons for the observed extraordinary strong dependence of the activation energy of flux motion on the external magnetic field are discussed

TT 34.5 Fri 11:15 H19

Pinning and disorder effects of SiC and C additions in MgB_2 by magnetic relaxation and specific heat analysis — •C Senatore[1], R Lortz[1], SX Dou[2], and R Flükiger[1] — [1]DPMC and MaNEP, Universite de Geneve, Switzerland — [2]Institute for Superconductivity and Electronic Materials, University of Wollongong, Australia

The relatively high T_c and the reduced fabrication costs of MgB_2 render this material promising for industrial applications, especially in substitution to Nb_3Sn in the magnetic field range 9-12 T or in view of cryogen free devices, operating at 20 K. The addition of nanometric powders of SiC and C enhances both B_{irr} and J_c. However, the underlying physical mechanism is not completely understood. We have analyzed the effects of SiC and C doping on the superconducting properties of MgB_2 bulks by means of specific heat and magnetic relaxation measurements. Pinning in MgB_2 is governed by grain boundaries. To discriminate the influence of the additions on the pinning properties from the grain size effects, magnetic relaxation measurements have been performed on doped samples sintered at different temperatures. A series of binary MgB_2 has been used as reference. Doping introduces disorder into the superconductor and thus raises B_{c2}. In the case of $MgB_{1.9}C_{0.1}$, specific heat measurements show that the C substitution on the B sites modifies the low temperature shoulder related to the second gap. This effect is not visible in the samples doped with SiC. SiC leads to an inhomogeneous distribution of C as seen from the distribution of T_c determined from the calorimetric data.

TT 34.6 Fri 11:30 H19

MgB_2 - a self organised critical system — •Andreas Heinrich[1], Emmeram Stark[1], Monika Panhans[1], Bernd Stritzker[1], and Rudolf Schneider[2] — [1]Universität Augsburg, EPIV, 86135 Augsburg — [2]Forschungszentrum Karlsruhe, IFP, Karlsruhe

Systems like a sand hill or water droplets are treated in terms of a self organised critical system. Thereby several conditions apply for such a system: it should consist of many components, it should organise itself into a critical state, there should be an exceptional event - like an avalanche, this events should be invariant in time and scale, etc. Here we would like to present magneto optical investigations of flux penetration into MgB_2 thin films. Thereby one can differ between a homogeneous and an avalanche like flux penetration. We will show that especially the avalanche like flux penetration can be treated like a self organised critical system. In comparison with a sand hill we will demonstrate the avalanche or dendrite flux formation in MgB_2 exhibit all requirements mentioned above.

15 min. break

TT 34.7 Fri 12:00 H19

Vortex lattice in superconducting films of finite thickness — •Ernst Helmut Brandt — Max-Planck-Institut für Metallforschung, Stuttgart

Magnetic stray field, currents, self-energy, and interaction of vortices in superconductor films of any thickness are of interest for numerous applications. In the London limit of negligibly small vortex core, the general analytical solution for arbitrary arrangements of straight and curved vortex lines is given in [1]. For finite vortex core size, the

corresponding solution of Ginzburg-Landau theory is needed, which requires huge numerical effort. However, if the vortex lattice is ideally periodic in the film plane, the problem simplifies and an extension of a previous bulk method is possible, which includes the stray field energy outside the film. This calculation was performed for vortices oriented perpendicular to the film [2]. A similar computation is possible also for a periodic arrangement of arbitrarily tilted or curved vortex lines in a thick film.

[1] G. Carneiro and E. H. Brandt, Phys. Rev. B **61**, 6370 (2000).
[2] E. H. Brandt, Phys. Rev. B **71**, 014521, 1-12 (2005).

TT 34.8 Fri 12:15 H19

Vortex induced deformation of the superconductor crystal lattice — Pavel Lipavsky[1], •Klaus Morawetz[2,3], Jan Kolacek[4], and Ernst Helmut Brandt[5] — [1]Faculty of Mathematics and Physics, Charles University, Ke Karlovu 3, 12116 Prague 2, Czech Republic — [2]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [3]Max Planck Institute for the Physics of Complex Systems, Noethnitzer Str. 38, 01187 Dresden, Germany — [4]Institute of Physics, Academy of Sciences, Cukrovarnická 10, 16253 Prague 6, Czech Republic — [5]Max Planck Institute for Metals Research, D-70506 Stuttgart, Germany

The deformation of the superconductor crystal lattice caused by Abrikosov vortices is expressed as response of the elastic crystal lattice to electrostatic forces. It is shown that the lattice compression is linearly proportional to the electrostatic potential known as the Bernoulli potential, which is related to the kinetic energy of the supercurrents. Possible consequences of the crystal lattice deformation on the effective vortex mass are discussed. [cond-mat/0609669]

TT 34.9 Fri 12:30 H19

Structurally induced anisotropic formation of vortex avalanches — •J. Albrecht[1], H.-U. Habermeier[2], A. Matveev[3], D.V. Shantsev[4], Y.M. Galperin[4], and T.H. Johansen[4] — [1]MPI für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, Germany — [2]MPI für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart, Germany — [3]Chemistry Department, Lomonosov MSU, 119992 Moscow, Russia — [4]Department of Physics, University of Oslo, Blindern, 0316 Oslo, Norway

Anisotropic penetration of magnetic flux in MgB2 films grown on vicinal sapphire substrates is investigated using magneto-optical imaging. Regular penetration above 10 K proceeds more easily along the substrate surface steps, anisotropy of the critical current being 6 %. At lower temperatures the penetration occurs via abrupt dendritic avalanches that preferentially propagate perpendicular to the surface steps. This inverse anisotropy in the penetration pattern becomes dramatic very close to 10 K where all flux avalanches propagate in the strongest-pinning direction. The observed behavior is fully explained using a thermomagnetic model of the dendritic instability.

TT 34.10 Fri 12:45 H19

Critical currents in high-temperature superconductor/ferromagnet heterostructures — •Märit Djupmyr[1], Soltan Soltan[2,3], Hanns-Ulrich Habermeier[2], and Joachim Albrecht[1] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart — [2]Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart — [3]Physics Department, Faculty of Science, Helwan University, 11795 Cairo, Egypt

The critical current in bilayer structures consisting of high-temperature superconducting $YBa_2Cu_3O_{7-\delta}$(YBCO) and ferromagnetic $La_{2/3}Ca_{1/3}MnO_3$ thin films, is substantially influenced by the presence of the ferromagnetic layer at low temperatures. Using quantitative magneto-optics a detailed analysis of the temperature dependence of the critical currents is done in the range T=10-90 K, giving information about the mechanisms of flux line pinning. For YBCO thin films, different current limiting mechanisms have been found depending on temperature and microstructure. For temperatures above T=40 K thermal depinning of flux lines is most important for the YBCO thin films as for the bilayers. Below T=40 K, the granularity of the film plays an important role for the current transport in the YBCO thin film and the ferromagnetic layer strongly affects the critical current in the bilayer.