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NOTA BENE:

As announced in the Feb. 15 issue, we will discontinue the free hard-copy version of the *High-T_c Update* newsletter beginning May 1, 1999, due to lack of funds. We will e-mail our current hard-copy subscribers a PDF version of the newsletter that looks, for all practical purposes, exactly like the hard copy. You will just need to print out the paper version at your end. This enables us to continue to offer you up-to-date reliable information on current superconductivity research and at the same time alleviate our financial difficulties for a while. (If you are aware of any funding opportunities that you believe may benefit *High-T_c Update,* please contact the editor! We certainly depend on you, our subscribers, for help.)

If you have not already done so, please fill out and send the form on page 13 informing us of your e-mail address so that we can start conversion of the hard-copy subscription list to an e-mail recipient list. You can also send us this information by e-mail to mitra@ameslab.gov. We would appreciate a prompt response by March 1 (March 15 for foreign subscribers).

Coated Conductors

New approaches leading to the possibility of fabricating biaxially textured $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* on metallic substrates are currently under development in many laboratories around the world. Such coated conductors offer prospects for operation at the high temperatures (77 K) and high magnetic fields (several tesla) required for economical operation of motors, generators, and other large-scale equipment in commercial applications. One approach, based on rolling-assisted, biaxially textured substrates (RABiTS), starts with a sharply biaxially textured nickel tape. There must be an epitaxial buffer layer on top of the *Ni,* not only to protect the superconductor from *Ni* contamination, but also to provide an appropriate biaxially oriented, lattice-matched substrate for the subsequent epitaxial growth of *YBCO*. To date, according to preprints by Q. He et al. (Oak Ridge) and D. F. Lee et al. (Oak Ridge), the preferred buffer layers in the RABiTS technique have been the combination of CeO_2 and *YSZ* (yttria-stabilized zirconia). *YBCO* films with self-field critical current densities J_c above 10^6 A/cm^2 at 77 K have been deposited on the architectures $CeO_2/YSZ/CeO_2/Ni$ and $YSZ/CeO_2/Ni$.

A preprint by D. F. Lee et al. (Oak Ridge) reports that high-quality *YBCO* films have been grown on Yb_2O_3 buffer layers. A 350 nm *YBCO* film grown on $Yb_2O_3/YSZ/CeO_2/Ni$ by pulsed-laser deposition (PLD) was found to have a zero-resistance T_c = 90 K with a transition width of 1 K and a self-field transport $J_c = 1.2 \times 10^6$ A/cm^2 at 77 K, which compares favorably with the best *YBCO* films on the $YSZ/CeO_2/Ni$ architecture. A *YBCO* film grown on $Yb_2O_3/CeO_2/Ni$, however, was found to have a self-field J_c(77K) of only 0.6×10^6 A/cm^2, and the authors blamed this low value of J_c on the crack-prone CeO_2 layer. The authors next replaced the CeO_2 by Y_2O_3, deposited *YBCO* films on crack-free substrates of $Yb_2O_3/Y_2O_3/Ni$, and achieved self-field J_c(77K) as high as 1.8×10^6 A/cm^2. The authors emphasize that the use of Y_2O_3 as the first layer on *Ni* eliminates the cracking problem that plagues the RABiTS process when CeO_2 is used.

As pointed out in a preprint by Q. He et al. (Oak Ridge), insulating buffer layers have the disadvantage that there is no alternative current path in the event of a local microcrack in the superconductor or a transient to a nonsuperconducting state. All the commercially available superconducting composites, such as *NbTi* or Nb_3Sn in a *Cu* matrix or *Bi-2223* in a *Ag* matrix, provide parallel current paths through normal metal to provide electrical and thermal stability. The authors report that they have grown electrically conductive $LaNiO_3$ films on textured *Ni* substrates by sputter deposition in a reducing gas ambient, and that the *$LaNiO_3$* films may be able to serve as an appropriate buffer layer for *YBCO*. Although crack formation has been a problem with commonly used buffer layers such as *CeO_2*, no cracks were observed in the *$LaNiO_3$* films, either as deposited or after high-temperature annealing in low oxygen pressure at 750°C and 850°C. The authors also report that highly textured *YBCO* films have been grown on the *$LaNiO_3$*-buffered *Ni* substrate by PLD. To date, however, the *YBCO* T_c values are only in the range 75-80 K, evidently because of *Ni* contamination either from *Ni* diffusion through the thin buffer layer or by direct chemical reaction between the growing *YBCO* and the *$LaNiO_3$*. The authors stress that *$LaNiO_3$* is potentially an excellent candidate for conductive buffer layers because of its low resistivity, crack-free morphology, and structural compatibility with high-T_c superconductors or other perovskite-related materials of importance for electronic device applications.

Vortices

A preprint by Y. Yuzhelevski and G. Jung (Ben Gurion University of the Negev) reports results using a new technique of creating artificial pinning structures in thin superconducting *$YBa_2Cu_3O_{7-\delta}$* films. The authors demonstrated that a pre-recorded magnetic tape applied to the surface of a thin-film superconducting specimen that is subsequently cooled in the tape's spatially inhomogeneous magnetic field affects the vortex system in a way that is equivalent to changes introduced by artificially introduced pinning sites. The lowest available spatial periodicity of the tape's magnetic field was about 3 μm. The authors found that the application of the magnetic tape can increase the critical current of the strip, introduce commensurability effects in the sample's magnetoresistance, and promote coherent flow of vortices in short and wide macrobridges.

Vortex pinning in *Nb* thin films with rectangular submicron magnetic *Ni* dot arrays (e.g., 625 nm × 400 nm) has been studied by J. I. Martín (Madrid) et al. From magnetotransport measurements at different magnetic fields, the authors found two pinning regimes. At low fields, the pinning force from the dots is strong enough to distort the vortex lattice into a rectangular configuration that matches the dot array. As the field is increased, the elastic energy associated with the lattice is enhanced so that the rectangular distortion becomes unstable, and the vortex lattice becomes square. The crossover field between the two regimes depends on the asymmetry factor of the *Ni* dot array.

The dynamics of vortices in planar pinning centers with thermal fluctuations have been studied by Y. Mawatari (ETL) using a Fokker-Planck equation. The author also investigated the anisotropic behavior of the current-voltage characteristics. Because of the guided motion of vortices in planar pinning centers, both the longitudinal electric field $E_{||}$ (parallel to the current density **J**) and the transverse electric field $E_{\perp}$ (perpendicular to **J**) depend strongly on the direction of **J**. When a driving force due to the current is tilted away from the pinning planes, the direction of vortex motion depends on both the magnitude of **J** and the pinning strength, and both $E_{||}$ and $E_{\perp}$ have a nonmonotonic J dependence.

The applicability of the theory of self-organized criticality (SOC) to the process of magnetic relaxation in type-II superconductors is considered theoretically by R. Prozorov (Illinois-Urbana) and D. Giller (Bar-Ilan). The authors find that the driving parameter for self-organization of vortices is the energy barrier for flux creep and not the current density. The authors also calculate the power spectrum of the magnetic noise due to vortex avalanches and predict that it varies with time during relaxation.

Using a sensitive torque magnetometer, H.-H. Wen (Beijing) et al. have measured the current-voltage (I-V) or E-J characteristics for a ring-shaped *$Tl_2Ba_2CaCu_2O_{8+\delta}$ (Tl-2212)* thin film at temperatures between 4.2 K and 70 K in magnetic fields up to 6 T. The authors find low-field behavior they attribute to 3D elastic vortex motion and high-field behavior they attribute to 2D plastic motion. They also find a feature they attribute to a crossover between different collective-pinning regimes.

A preprint by M. C. Marchetti (Syracuse) and D. R. Nelson (Harvard) points out that patterned irradiation of cuprate superconductors with columnar defects allows for a new generation of experiments that can probe the properties of vortex liquids by confining them to controlled geometries. The authors show that an analysis of such experiments combining an inhomogeneous Bose-glass scaling theory with the hydrodynamic description of viscous flow of vortex liquids can be used to infer the critical behavior near the Bose-glass transition. The authors predict the shear viscosity to diverge as $|T-T_{BG}|^{-z}$ at the Bose-glass transition, with the dynamical critical exponent $z \approx 6$.

The Berry phase produced by the adiabatic motion of a vortex in an s-wave BCS superconductor is examined in a preprint by A. Tanaka (Teikyo University of Science and Technology) and M. Machida (JAERI). The authors find results that contradict earlier claims that the only possible hydrodynamic transverse force exerted on a vortex is a Magnus force proportional to the superfluid electron density.

A study of the vortex structure and its field dependence within the framework of the quasi-classical Eilenberger theory has been carried out by M. Ichioka et al. (Okayama) to explore differences between $d_{x^2-y^2}$- and s-wave pairing. The authors find that $d_{x^2-y^2}$-wave pairing introduces a fourfold-symmetric structure around each vortex core. With increasing field, this structure becomes increasingly important to the vortex-lattice structure. The authors predict effects in the form factor of the internal field, which may be detected by small-angle neutron scattering or via the resonance lineshape of μSR and NMR experiments. Authors also study the induced s- and d_{xy}-wave components around the vortex in $d_{x^2-y^2}$-wave superconductors.

Theory

A preprint by A. V. Balatsky (Los Alamos) and P. Bourges (Saclay) points out that Δq, the half width at half maximum in momentum space of the normal (out-of-resonance) peak in the imaginary part of the low-energy antiferromagnetic spin susceptibility Imχ(**q**,ω) measured in $YBa_2Cu_3O_{6+x}$ via inelastic neutron scattering is proportional to the superconducting transition temperature T_c for a wide range of oxygen doping. The linear relation can be expressed as $k_BT_c = hv^*\Delta q$, where hv* = 35 meV Å. This relation is similar to the linear relation between the incommensurate peak splitting and T_c in $La_{2-x}Sr_xCuO_4$, as first noted by K. Yamada et al. [*Phys. Rev. B* **57**, 6165 (1998)]. The authors note that the velocity v* is smaller than either the Fermi velocity or the spin-wave velocity of the parent compound and remains the same for a wide doping range, and they suggest that this velocity indicates the existence of some new mode in these materials and that this mode is closely related to the formation of the superconducting state.

Possible pure and mixed-symmetry phases of the superconducting order parameter have been studied by Ch. Jurecka and E. Schachinger (Graz) for a two-dimensional system of orthorhombic symmetry, which is assumed to be representative of the CuO_2 planes typical for high-T_c superconductors. The study, based on the BCS theory of anisotropic superconductors, reveals that an (s+d)-symmetric order parameter is the stable solution for most of the available parameter space. The authors also found a small pocket in which an [s + i(s+d)]-symmetric order parameter is the stable solution.

Using the memory-function method in terms of the Hubbard operators, G. Jackeli and N. M. Plakida (JINR-Dubna) have calculated the dynamical charge susceptibility and optical conductivity for the planar t-J model. The density fluctuation spectrum consists of a damped sound-like mode for small wave vectors and a broad high-energy peak for large momenta. The authors assert that their results are in good agreement with both exact diagonalization studies and experimental results in copper oxides.

The effects near T_c of thermally fluctuating Cooper pairs on the specific heat C_p, in-plane paraconductivity $\Delta\sigma_{ab}$, and fluctuation-induced diamagnetism $\Delta\chi_{ab}$ have been calculated by M. V. Ramallo and F. Vidal (Santiago de Compostela) using a model of bilayered superconductors with two superconducting layers and two tunneling couplings per unit cell. The calculations were performed using a generalization of the Lawrence-Doniach Ginzburg-Landau functional and assuming Gaussian fluctuations. The authors found that their approach was able to explain, simultaneously and quantitatively, the fluctuation contributions to C_p, σ_{ab}, and χ_{ab} in $YBa_2Cu_3O_{7-\delta}$ crystals in the reduced temperature region $2 \times 10^{-2} \leq |T-T_c|/T_c \leq 10^{-1}$.

Some results of electronic Raman scattering in superconducting cuprates concerning the position of the superconductivity-induced pair-breaking peaks are analyzed theoretically in a preprint by T. Strohm et al. (MPI-Stuttgart). The authors also compare the predicted low-frequency behavior with experimental results in $YBa_2Cu_3O_{7-\delta}$ *(Y-123)*, $Y_{0.8}Ca_{0.2}Ba_2Cu_3O_{7-\delta}$, and $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)*.

Using a Boltzmann-equation approach, J.-X. Li (Taipei) et al. have examined the effect of Fermi-surface destruction on the transport properties of underdoped cuprates. The authors calculated the temperature dependence of the dc resistivity, inverse Hall angle, and Hall coefficient using the nearly antiferromagnetic Fermi-liquid model. The authors found that the experimental data are better described by the cold-spot model; i.e., the main contribution to transport comes from cold spots on the Fermi surface near the Brillouin-zone diagonals.

Various anomalies in the cuprates are explained by T. Kasuya (Tohoku) in terms of magnetic polaron condensation. In the author's view, the mechanism for high-T_c superconductivity is Bose condensation of paired magnetic polarons.

A complete topological classification of solutions of the Ginzburg-Landau equations for which the order parameter $\psi_i(\mathbf{r})$ is a three-dimensional (i = 1,2,3) vector has been carried out by A. Knigavko (National Chiao Tung University) et al. In weak magnetic fields, the authors find a new class of solutions carrying two units of magnetic flux, $2\phi_0$. These solutions, called magnetic skyrmions, do not have singular cores like Abrikosov vortices. They also repel each other as 1/r at separations much larger than the magnetic penetration depth, and hence they form a relatively robust triangular lattice. The authors suggest that skyrmion lattices may occur in the superconductors UPt_3, Sr_2RuO_4, and $Sr_2YRu_{1-x}Cu_xO_6$.

The results of a theoretical model for the effects of a rough surface on a d-wave superconductor are presented in two preprints by A. A. Golubov (Twente) and M. Yu. Kupriyanov (Moscow State). The authors derived the boundary conditions on the Eilenberger functions for the general case of arbitrary strength of electron scattering by an impurity layer covering the surface, and applied them to study the crossover from specular to diffusive surface scattering. The authors also calculated the low-temperature differential conductance of an N/I/D (normal-metal/insulator/d-wave superconductor) tunnel junction and the Josephson supercurrent in a D/I/D tunnel junction for arbitrary surface roughness.

The tunneling spectroscopy of ferromagnet/superconductor (F/S) junctions has been studied theoretically by I. Zutic (Maryland) and O. T. Valls (Minnesota). The authors considered both d- and s-wave superconductors, as well as mixed states of the d + is form, and took into account the effects of spin polarization, Fermi wavevector mismatch (FWM) between the F and S regions, interfacial resistance, and Andreev reflection at the F/S interface. The authors present numerical results for the differential conductance G for a wide range of values of the relevant parameters, and they find that many features appear, depending upon the pairing state and other conditions. The authors note that in the presence of FWM, spin polarization can enhance Andreev reflection and give rise to a zero-bias conductance peak for an s-wave superconductor.

Resonant transmission of normal electrons through Andreev states in ferromagnets has been studied by A. Kadigrobov (Göteborg and Kharkov) et al. The authors predict giant oscillations in the differential conductance G in S/F/S heterostructures of the Andreev interferometer type, in which the ferromagnet (F) part is separated from superconducting (S) reservoirs of normal electrons with potential barriers (beam splitters) of low transparency. The predicted effect is due to the resonant transmission of normal electrons through Andreev levels when the voltage V applied to the ferromagnet is close to $2h_0/e$, where h_0 is the spin-dependent part of the electron energy. The authors suggest that this phenomenon not only provides a convenient tool for Andreev level spectroscopy but also enables applications, such as a double-gate ferromagnet transistor and a superconducting transistor AND logic element.

$RBa_2Cu_3O_{7-\delta}$

An extensive nuclear-magnetic-resonance (NMR) and nuclear-quadrupole-resonance (NQR) study of the normal state ($T > T_c$) of an $YBa_{1.93}Sr_{0.07}Cu_3O_{6.92}$ single crystal (T_c = 90 K) has been carried out by T. Auler (São Carlos) et al. The authors interpret the ^{63}Cu and ^{89}Y NMR data using a model for the imaginary part of the dynamical electron spin susceptibility $\chi''(\mathbf{q},\omega)$ that is consistent with inelastic neutron scattering (INS) experiments carried out on the same sample; the **q** dependence is assumed to be Gaussian (commensurate), with a short and temperature-independent coherence length ξ. This model enables the authors to perform a quantitative analysis of the planar copper spin-lattice and spin-spin relaxation rates, which provides evidence that a spin pseudogap starts to open at $T^* \approx 130$ K, confirming the INS results. The authors' main conclusion is that, in order to explain the yttrium and planar oxygen relaxation coherently with the INS results and the widely accepted one-band picture, the characteristic energy Γ_0 of the spin dynamics near **q** = 0 must be strongly T-dependent; otherwise the one-band description is not feasible.

The dependence of the superconducting transition temperature $T_c(P)$ of strongly underdoped $YBa_2Cu_3O_{6.41}$ [T_c(1 bar) ≈ 14 K] upon hydrostatic pressure P up to 7 GPa has been measured by V. G. Tissen (Washington and Chernogolovka) et al. via ac susceptibility in a diamond-anvil cell filled with dense helium as the pressure medium. The authors found that $T_c(P)$ depends markedly on the temperature-pressure history because of the importance of relaxation processes in the oxygen sublattice. The relaxation time τ was found to increase exponentially with pressure, corresponding to an activation volume of 4.2 cm^3/mole. The intrinsic $T_c(P)$ dependence (that devoid of relaxation effects) was determined: T_c initially increases with pressure, passes through a maximum near 17 K at 2 GPa, and falls below 1.6 K above 7 GPa.

As reported by H. Suematsu (Tokyo Tech) et al., a novel melt-growth technique, i.e., melt growth under varied oxygen pressure (MG-VOP) in which the oxygen partial pressure is increased to solidify the initial melt, has been used to prepare melt-textured bulk samples of the *Y-Ba-Cu-O* system. The resulting samples consisted of two phases: superconducting $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* and nonsuperconducting Y_2BaCuO_5 *(Y-211).* The critical current density J_c(65K) reached as high as 40 kA/cm^2 in a magnetic field of H_a = 3 T and exhibited a peak in J_c vs H_a. The authors used transmission electron microscopy (TEM) to determine that samples with higher twin-boundary density possessed higher J_c values at the peak in the J_c vs H_a characteristics, while fine *Y-211* particles were likely to contribute to the J_c value only at low magnetic fields.

The dependence of the irreversibility field H_{irr} on the concentration and distribution of holes throughout the crystal in superconducting cuprates of the *Cu-1212:P (123)* structure has been investigated by T. Nakane (Tokyo Tech) et al. The authors used a series of samples of $Cu(Ba_{0.8}Sr_{0.2})_2(Yb_{1-x}Ca_x)Cu_2O_{6+z}$ exhibiting a variety of doping levels and distributions of holes by *Ca* substitution for *Yb* (x = 0.25 and 0.35) and *O* doping ($0.55 \le z \le 0.96$). The authors found that the more homogeneous the hole distribution was, the better the H_{irr} characteristics were. The authors discuss the individual contributions to the H_{irr} characteristics from (a) the hole concentration in the infinite-layer block, (b) the thickness of the charge-reservoir block, and (c) the hole concentration in the charge-reservoir block.

Bi Cuprates

Using magneto-optical imaging, M. R. Koblischka (Oslo and SRL-ISTEC) et al. have obtained flux patterns of monofilamentary, silver-sheathed $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ *(Bi-2223)* tapes at various temperatures between 12 K and 77 K. Above 50 K, the flux distributions were found to be nearly homogeneous, indicating uniform current flow. As the temperature was lowered, the observed flux patterns developed indications of granularity. This effect was most pronounced at the lowest temperature investigated. From these observations the authors deduced the temperature dependence of the transport current density, J_{trans}, and the current density of the grains, J_{grain}. The authors show that the appearance of granularity in the flux patterns at low temperatures can be explained by assuming a very steep temperature dependence of the intragranular current density, which is large at low T and decreases rapidly with increasing T until $J_{grain} \approx J_{trans}$ at about 50 K. The absence of granularity above 50 K shows that the current flow there is dominated by the transport currents.

Two preprints by Q. Y. Hu et al. (NHMFL-Tallahassee) describe properties of *AgMn*-sheathed $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* tapes. In these papers the authors note that *Bi-2212* has a processing advantage over *Bi-2223,* in that a partial-melting process can be employed. Moreover, the critical current densities of *Bi-2212* and *Bi-2223* are very similar at 4.2 K. These facts have led the Magnet Lab collaborators to choose *Bi-2212* as a conductor to fabricate insert coils for high-field applications at low temperature, such as an HTS insert coil for 25 T NMR. One of the preprints discusses continuous processing of multifilamentary tape, and the other reports on heat-treatment optimization and sample characterization.

Electron-tunneling spectroscopy of slightly overdoped $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* single crystals at low temperatures has been carried out by A. Mourachkine (Brussels) using a break-junction technique. The author finds at least two different superconducting gaps and concludes that (a) the largest gap results from pairing of spinons and (b) the second superconducting gap has $d_{x^2-y^2}$ symmetry.

Films

The temperature and magnetic-field dependencies of the conductivity of $YBa_2Cu_3O_{7-\delta}$ films in the transition region have been analyzed by D. V. Shantsev et al. (St. Petersburg), taking into account spatial inhomogeneity in the transition temperature T_c. The authors used an effective-medium approximation and a Gaussian distribution of T_c. The authors also measured the T_c inhomogeneity in microbridges using low-temperature scanning electron microscopy and found that the typical T_c dispersion is approximately 1 K with a resolution of about 1 μm.

The temperature- and field-dependent dynamical relaxation rate Q(T,H) has been determined by J. B. Jönsson and K. V. Rao (Royal Institute of Technology) for epitaxial c-axis-oriented $YBa_2Cu_3O_{7-\delta}$ *(Y-123)* and $HgBa_2CaCu_2O_{6+\delta}$ *(Hg-1212)* thin films using an efficient ac susceptibility technique. From a single temperature scan, in which consecutive measurements of χ' were performed at a number of frequencies in a relatively large ac field H_{ac}, the authors determined the critical current density $J_c(T,H_{ac},f)$ as a function of temperature and ac field, and subsequently extracted $Q(T,H_{ac})$. The ac susceptibility technique was found to reproduce the characteristic plateau-like temperature dependence for the relaxation rate in the *Y-123* system. The relaxation rate for the *Hg-1212* thin film showed a monotonic increase with temperature up to a maximum at about 95 K. Both films exhibited quantum creep of about Q(0) = 0.01 in the field range studied.

A preprint by E. M. González (Madrid) et al. reports the growth of a-axis-oriented $ErBa_2Cu_3O_7/PrBa_2Cu_3O_7$ and $ErBa_2Cu_3O_7/SrTiO_3$ multilayers by dc sputtering on (100) $SrTiO_3$ substrates, and discusses their characterization by structure refinement from x-ray-diffraction profiles. The angular dependence of the resistivity in the mixed state allowed the authors to study the interplay among different types of dissipation mechanisms, including intrinsic, surface, microscopic-defect, and superlattice-induced pinning mechanisms.

The photodoping of $YBa_2Cu_3O_{7-\delta}$ grain-boundary junctions is discussed in a preprint by A. Gilabert (Nice) et al. Persistent photoinduced superconductivity (PPS) and persistent photoinduced conductivity (PPC) occur in underdoped $YBa_2Cu_3O_{7-\delta}$ thin films and in $YBa_2Cu_3O_{7-\delta}$ grain-boundary junctions. In the latter case, illumination can be used to tune the Josephson coupling of the junctions in dc SQUIDs.

Applications

A preprint by Ya. S. Greenberg (Jülich) reports an extension of a recent theory of high-T_c rf SQUIDs operating in the presence of large thermal fluctuations. The author derives explicit analytical expressions for the amplitudes of higher harmonics of the current circulating in a SQUID loop; these expressions are necessary for the determination of the junction critical current I_c and the inductive coupling coefficient of the SQUID loop to its tank circuit, k^2. To determine the junction resistance R with acceptable accuracy, the author solves the Fokker-Planck equation to first order in the parameter q = ωL/R, where ω is the bias frequency and L is the loop inductance. From these results, the author derives simple expressions that allow I_c, R, and k^2 to be determined from experimentally measured small-signal voltage-frequency characteristics.

Other Activities

As noted in a preprint by E. L. Altschuler (UC-San Diego) and M. Lades (Livermore), sulfur has recently been found to be a superconductor at high pressure. At ~93 GPa, T_c is 10.1 K and sulfur is in a base-centered orthorhombic (bco) structure, while at ~160 GPa, T_c is 17 K and sulfur is in a rhombohedral (β-*Po*) structure. The mechanism for superconductivity in sulfur is not known; a band-structure calculation does not find superconductivity in sulfur until 500 GPa. The authors suggest that, similar to the case of the cuprates, the mechanism for superconductivity in sulfur involves 2D conducting planes, which emerge as the planar rings in sulfur at low pressure pucker at higher pressures (bco and β-*Po*).

An inhomogeneous superconducting ring (hollow cylinder) in a magnetic field is theoretically considered in a preprint by A. V. Nikulov (Chernogolovka). The author predicts that when the magnetic flux within the ring is not an integral number of flux quanta, a direct voltage should appear across the section with the lowest critical temperature when it is switched periodically between the normal and superconducting states. The author notes that if the switching occurs because of periodic changes of temperature, then the inhomogeneous superconducting ring behaves as a classical heat engine with maximum Carnot efficiency.

Overviews

As noted in a book chapter by K. C. Goretta and N. Chen (Argonne), $YBa_2Cu_3O_{7-\delta}$ *(Y-123),* $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212),* and $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$ *[(Bi,Pb)-2223]* are difficult to densify by simple heat treatment. The authors show that selective use of eutectic liquids and partial decomposition of *Y-123* can lead to nearly complete densification. Solid-state sintering in the absence of mechanical deformation is completely ineffective in densifying *Bi-2212* or *(Bi,Pb)-2223* superconductors. Melting-and-solidification heat treatments can densify *Bi-2212* but not *(Bi,Pb)-2223* because of gross phase separation. Reactive sintering by a transient liquid is effective for sintering of *(Bi,Pb)-2223* and can be used for *Bi-2212*. Metallic *Ag* can be used to create small concentrations of a liquid phase and thus promote densification (71 refs.).

A book chapter on the mechanical properties of bulk high-temperature superconductors has been prepared by K. C. Goretta (Argonne). The author discusses data on the bending strength, fracture toughness, and elastic moduli of bulk *Y-123, Bi-2212, (Bi,Pb)-2223,* and $TlBa_2Ca_2Cu_3O_9$ *(Tl-1223)* specimens. The data strongly suggest that the maximum tensile strain without fracture of bulk compacts, tapes, or wires is ≈0.2%. While *Ag*-alloy sheaths on wires and tapes probably impart beneficial residual stresses, it is probable that much of the apparent strain tolerance of these composite conductors is due to current shunting into the normal sheath to avoid cracks in the superconductor (37 refs.).

Contributed by John R. Clem

Contents:

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TECHNOLOGY NEWS

(Also see Applications section of Nota Bene.)

This section describes progress in manufacturing, product development, and technology transfer in the high-T_c superconductivity field. Please send your contributions (product development information, news regarding technology transfer efforts, or any information you would like to share about your corporation or laboratory) to the editor.

A high-temperature superconducting (HTS) power cable developed by Southwire, consisting of a single-phase, 5-m HTS cable, has been tested at Oak Ridge National Laboratory (ORNL). The cable carried 1400 A, which was an achievement 12% above design. The Southwire/ORNL cable test facility included the 5-m HTS cable assembly with two terminations, a cryogenic liquid-nitrogen cooling system, dc and ac power supplies, and an instrumentation system. In the next phase of the project, Southwire will demonstrate HTS power distribution by testing a three-phase power system, each cable being 30 m in length, in an industrial setting. Southwire plans to install HTS cable to power three of its plants in Carrollton. Because cities continue to grow with more power demands daily and because urban areas are physically constrained on space for underground cable installations, HTS cables hope to answer these needs by providing more transmitted power using the same amount of space. Southwire is one of six U.S. companies to receive funding from the U.S. Department of Energy for HTS research and one of two companies in the United States developing HTS cable. For information, contact Mallard Holliday, Corporate Communications, Southwire Company, One Southwire Drive, Carrollton, GA 30119; telephone (800) 444-1700, ext. 4833; telefax (770) 832-4584; e-mail mallard_holliday@southwire.com.

A new product called Distributed-SMES, or D-SMES™ was announced recently by American Superconductor Corporation (ASC), that seeks to assure reliability throughout large-scale electric transmission networks by continuously monitoring the networks and instantaneously injecting power to compensate for momentary dips in voltage. The D-SMES units, approximately the size of a truck trailer, are based on ASC's proprietary superconducting magnetic energy storage (SMES) technology. By broadening the application of SMES technology from factories to transmission networks, the D-SMES units will enable networks to rapidly return to a stable operating condition, thereby avoiding wide-scale power failures. D-SMES units will also enhance the power transfer capabilities of existing networks without costly investment in new transmission facilities. For more information, contact Stan Piekos, American Superconductor Corporation, Two Technology Drive, Westborough, MA 01581; telephone (508) 836-4200; telefax (508) 836-4248; e-mail spiekos@amsuper.com.

Contributed by Sreeparna Mitra

PREPRINTS

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Y. Yuzhelevski and G. Jung, "Artificial Reversible and Programmable Magnetic Pinning for High-T_c Superconducting Thin Films." To be published in Physica C. Contact G. Jung, Department of Physics, Ben Gurion University of the Negev, P.O.Box 653, 84105 Beer-Sheva, ISRAEL; telephone +972 7 472124; telefax +972 7 281340; e-mail jung@bgumail.bgu.ac.il. 74.60.Ge.

Igor Zutic and Oriol T. Valls, "Tunneling Spectroscopy for Ferromagnet/Superconductor Junctions." Submitted to Phys. Rev. B. Department of Physics, University of Maryland at College Park, College Park, MD 20742-4111; e-mail igor@cooperon.umd.edu; preprint also available at http://xxx.lanl.gov/abs/cond-mat/9902080. Key words: Andreev reflection, spin polarization, differential conductance. 74.80.Fp; 74.50.+r; 74.72.-h.

COMING EVENTS

*(An * indicates a previously listed event.)*

June 20 - 24, 1999: Conference of Interdisciplinary Sciences & Applications of Oxides with Strong Electron Correlation, Kunming, Yunnan, China. Satellite to the IUMRS-ICAM '99 Conference in Beijing, China. Topics will include new physical phenomena, effects, and mechanisms of strongly correlated materials; industry, applications, and comprehensive technology of strongly correlated materials; electron correlation in high-T_c superconductors; correlation in colossal magnetoresistance manganese; and preparation and physical properties of strongly correlated oxides. **Abstract deadline, March 15, 1999; preregistration deadline, March 31, 1999.** For information, contact P. X. Zhang, Yunnan Polytechnique U., Kunming, Yunnan, China 650051; phone +86 871 330-4195 or -4215; fax +86 871 335-9681; e-mail pxzhang@ynpu.edu.cn.

*July 29 - Aug. 2, 1999:

International Workshop on Low Temperature Physics in Microgravity Environment (CWS-99), ISSP, Chernogolovka, Moscow Region. Satellite to the LT-22 Conference in Helsinki, Finland (Aug. 4-11, 1999). Topics are: studies in low-temperature and fundamental physics in microgravity environment, equilibrium and critical phenomena in quantum fluids and solids, suspended droplets, laser cooling, relativistic effects, and low-temperature techniques for fundamental studies in space. Number of participants limited to 50. **Abstract deadline, March 15, 1999.** For information, contact Leonid Mezhov-Deglin, Institute of Solid State Physics, Russian Academy of Sciences, 142432 Chernogolovka, Moscow Region, Russia; e-mail mezhov@issp.ac.ru.

*July 30 - Aug. 3, 1999:

LOCALIZATION 1999 – Disorder and Interaction in Transport Phenomena, Hamburg, Germany. Satellite to the LT-22 Conference in Helsinki, Finland (Aug. 4-11, 1999). Covers the physics of transport phenomena in the presence of disorder, chaos, and interactions, in particular concentrating on weak localization, hopping transport, metal-insulator transitions, non-Fermi-liquid behavior, many-particle localization, disorder and superconductivity, superconductor-insulator transitions, disorder and magnetism, quantum transport in nanostructures, quantum Hall effects, topological disorder, quantum percolation, disorder and quantum chaos, classical wave localization, coherence and dephasing, and dirty bosons. For further information contact Bernhard Kramer, Institute for Theoretical Physics, Jungiusstr. 9, University of Hamburg, D-20355 Hamburg, Germany; telephone +49 40 4123-4997 or -2408; telefax +49 40 4123-4997 or -6798; e-mail kramer@physnet.uni-hamburg.de.

*Aug. 12 - 15, 1999:

International Symposium on Ultralow Temperature Physics (ULT99), PTI Educational Centre, St. Petersburg, Russia. Satellite to the 22nd International Conference on Low Temperature Physics (LT22). Will provide a forum for the presentation and discussion of the results of recent scientific investigation in ultralow temperature physics. The main topics are: quantum liquids and solids, solids at ultralow temperatures, Bose-Einstein condensation, ultralow-temperature techniques, and thermometry. Limited financial support (mainly for students) is available. **Abstract deadline, March 15, 1999.** Contact Mikhail P. Volkov, Symposium Secretary, Ioffe Physico-Technical Institute, 26 Polytechnicheskaya, 194021 St. Petersburg, Russia, telephone +7 812 515 9229; telefax +7 812 515 6747; e-mail M.Volkov@shuvpop.ioffe.rssi.ru; Web site http://www.ioffe.rssi.ru/ULT99/. Or contact Vladimir V. Dmitriev, Program Committee Chairman; telephone +7 095 137 6174; telefax +7 095 938 2030; e-mail dmitriev@kapitza.ras.ru.

Sept. 15 - 17, 1999:

The Third International Conference on Low Dimensional Structures and Devices (LDSD 99), Renaissance Antalya Resort, Antalya, Turkey. Conference intends to provide forum for researchers, engineers, and product developers engaged in the full spectrum of research and development, from fundamental research to product manufacturing and systems applications. Conference will also provide opportunity for broad overview of the field by covering a wide range of materials growth techniques, materials, characterization, processing, device fabrication, microsystems, applications, and other related topics. Oral presentations, posters, and exhibition. **Abstract deadline, March 5, 1999.** Invited and oral papers will be published in a special edition of *Materials Science & Engineering B,* and poster papers will be in a special edition of *Microelectronics Engineering.* For information, contact Sue Stewart, LDSD99 Conference Secretariat, 4 Manor Farm Barns, Church Lane, Charlton-on-Otmoor, Kidlington Oxon OX5 2UA, United Kingdom; telephone +44 1865 331040; telefax +44 1865 331125; e-mail suestewart@compuserve.com; Web site http://www.elsevier.nl/locate/ldsd99.

Sept. 19 - 23, 1999:

Superconducting Materials Aspects: Research & Technology (SMART 99), Giens Peninsula, Hyeres, France. Second SMART Conference; satellite to the EUCAS'99 Conference in Sitges, Barcelona, Spain (Sept. 14-17, 1999). Will provide an opportunity to present new results and exchange ideas on the following research and technology topics: phase chemistry and processing of bulk and thick-film materials, crystal-growth processes, relationships between materials structure and relevant properties, electromagnetic interactions, and applications. Materials of interest are mainly superconducting ceramics, superionic conductors, giant-magnetoresistive materials, nanocrystals, ferroelectrics, organic electronics and photonics materials, nanotubes, thermoelectric materials and ceramic matrix composites. Organizers plan for four working days without parallel sessions. Program will consist of keynote and contributed papers (oral or posters). Industrial participants are encouraged to present technological state-of-the-art and to raise practical questions. Level of the meeting is that of an Advanced Research Workshop with ample time for discussions. Attendance limited to about 80 persons. **Abstract deadline, April 15, 1999.** For information, contact Gilbert Vacquier, Co-Chair and Conference Secretary, LPCM (Case 26), Centre Saint-Charles, 3 Place V. Hugo, F-13331 Marseille Cedex 03, France; telephone +33 491 10-6271; telefax +33 491 10-6448 or -6237; e-mail smart@newsup.univ-mrs.fr; Web site http://www.supras.phys.ulg.ac.be/smart-99.html.

Feb. 20 - Feb. 25, 2000:

6th International Conference on Materials and Mechanisms of Superconductivity and High Temperature Superconductors (M^2S-HTSC-VI), George R. Brown Convention Center, Houston, Texas. Hosted by the Texas Center for Superconductivity at the University of Houston and sponsored by federal agencies and industry. Co-Chairs: C. W. Chu, W. K. Chu and K. Salama. This series of meetings, established in 1988 two years after the discovery of high-temperature superconductors, is dedicated to superconductivity and related phenomena, and the host materials of these phenomena. The Conference will bring together members of the international low- and high-temperature superconductivity community to focus on recent insights into low- and high-temperature superconductor physics, materials, and devices. Emerging areas and future trends will also be highlighted. General conference topics include, but are not limited to, experimental and theoretical studies of Superconducting Materials – low temperature, high temperature, fullerite, heavy fermion, organic, new; Physical Properties – mechanisms, magnetic, electrical, optical, thermal, mechanical, acoustic; Synthesis and Processing – thin films, superlattices, thick films, bulk; and Applications – small current (SQUIDs, junctions, microwave devices) and large current (cables, transformers, motors, generators, magnetic levitation devices). **Abstract deadline, September 15, 1999.** For information, contact M^2S-HTSC-VI Conference Secretariat, Texas Center for Superconductivity, University of Houston, 3201 Cullen Boulevard, Houston, TX 77204-5932; telefax (713) 7743-8216; Web site http://m2s-conf.uh.edu.

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Positions available: With the formation of the research network "Supercurrent" within the framework of the Training and Mobility Program of the European Union, applications are invited, from nationals of the European Union, for postdoctoral positions at the Atomic Institute of the Austrian Universities, Institute of Applied Physics, University of Linz, and the University of Oxford, Magnet Group at Clarendon Laboratory, Oxford. Interested persons holding a Ph.D. in physics or materials science, experienced in superconductivity, and wishing to participate in a research program focused on micro- and nanostructural aspects of high-temperature superconducting materials and on advanced characterization techniques of their properties under high-current/high-field conditions, are encouraged to apply. Contact Harald W. Weber, Network Coordinator, Atominstitut der Osterreichischen Universitäten, Stadionallee 2, A-1020 Vienna, Austria, e-mail weber@ati.ac.at; Dieter Bäuerle, Johannes Kepler Universität Linz, Altenbergerstrasse 69, A-4040 Linz, Austria, e-mail dieter.baeuerle@jk.uni-linz.ac.at; or Harry Jones, Clarendon Laboratory, Oxford University, Parks Road, Oxford OX1 3PU, United Kingdom, e-mail h.jones1@physics.ox.ac.uk.

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