HIGH T_c UPDATE

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ARPA

NOTA BENE:

Films

A recent paper by B. Dam et al. (Amsterdam) [Nature **399**, 439 (1999)] presented evidence that at low temperatures dislocations are the dominant flux-pinning centers in laser-ablated thin films of $YBa_2Cu_3O_{7-\delta}$ deposited on (100) $SrTiO_3$ substrates. (See also Nota Bene item in the September 15, 1999, issue of High-T_c Update.) A related preprint by J. M. Huijbregtse et al. (Amsterdam) concludes that the pinning is due to dislocations formed at the substrate-film interface. The authors found that they could tune the dislocation density over two orders of magnitude (~1-100 μm^{-2}) by varying the substrate temperature or by depositing a layer of Y_2O_3 precipitates before starting the $YBa_2Cu_3O_{7-\delta}$ growth process. In contrast to the artificial columnar defects in bulk created via heavy-ion irradiation, strong-pinning linear defects in thin films show a nonrandom spatial distribution. The radial dislocation distribution function was found to approach zero at small distances, indicating short-range ordering of the defects.

As noted in a preprint by C.-Y. Yang (Wisconsin-Madison) et al., the deposition of chemically and structurally optimized epitaxial oxide films onto inexpensive biaxially textured substrates may well be a key to the manufacture of practical high-T_c superconductor cable for power applications. The authors point out that chemical solution heteroepitaxy is a nonvacuum, relatively simple technique that is readily scalable to production quantities. The preprint describes the properties of a $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* film grown on a solution-deposited $NdGaO_3$ *(NGO)* buffer layer on (100) $SrTiO_3$ *(STO).* The 25-nm-thick *NGO* buffer layer was dip-coated onto the *STO* single crystal from a solution of metal methoxyethoxides in 2-methoxyethanol. Pulsed-laser deposition (PLD) was used to grow a 250-nm-thick *YBCO* film on the *NGO*. The x-ray-diffraction ϕ- and ω-scans indicated that the *YBCO* film was highly oriented with a full width at half maximum peak breadth of 1.14° for in-plane and 0.46° for out-of-plane alignment. The transport critical current density J_c was found to be 1×10^6 A/cm^2 (77 K, 0 T). The authors conclude that buffer layers grown by solution synthesis are viable templates for *YBCO* growth and that this technique shows promise for the future of coated conductors in technology.

Epitaxial thin films of *YBCO* have been deposited on yttria-stabilized zirconia *(YSZ)* by J. Gao (Hong Kong) et al. using PLD. The authors found that the initial epitaxy of *YBCO* thin films grown on *YSZ* can be significantly improved by using $La_{2-x}Sr_xCuO_4$ *(LSCO)* as a buffer layer. The x-ray-diffraction measurements showed that the epitaxial *YBCO* had a single in-plane orientation with *YBCO* [100] || *LSCO* [100] || *YSZ* [110]. Real-time resistance measurements revealed that with *LSCO* buffer layers the initial formation of the *YBCO* ultra-thin films changes from island growth to layer-by-layer growth.

The effect of compressive epitaxial strain induced in (001)-oriented $La_{2-x}Sr_xCuO_4$ *(LSCO)* and $La_{2-x}Ba_xCuO_4$ *(LBCO)* thin films on $LaSrAlO_4$ substrates has been studied by H. Sato (NTT) et al. The authors found that the superconducting transition temperatures T_c of these films reached 44 K and 47 K, respectively, with $\delta \approx 0$. When both films had $\delta > 0$, T_c reached 49K, higher than the values for bulk samples. Noting that films with lower residual resistivity have higher T_cs, the authors speculate that the T_c enhancement is caused by reduced antiferromagnetic spin fluctuations in the CuO_2 planes due to changes in the $Cu\text{-}O_{apex}$ (copper-apical oxygen) bond length.

A preprint by M. Sato et al. (SRL-ISTEC) reports on well-characterized a-axis trilayers made of $NdBa_2Cu_3O_{7-\delta}$ and $PrBa_2(Cu,Co)_3O_{7-\delta}$ films with smooth surface morphology and high crystallinity. The thin films were grown on (100) $SrTiO_3$ *(STO)* substrates by rf + dc hybrid sputtering. Planar junctions fabricated from these trilayers exhibited Josephson current and well-developed Shapiro steps under 7-20 GHz microwave radiation. The current-voltage characteristics were qualitatively consistent with the resistively shunted junction (RSJ) model.

As noted by Y. Li et al. (SRL-ISTEC), successful fabrication of high-T_c superconducting thin-film devices largely depends on the quality of trilayer superconductor-insulator-superconductor heterostructures. In high-T_c multilayer technology, the essential prerequisite is an all-epitaxial structure, smooth surface, and abrupt interface without interdiffusion. However, the difficulty of oxygen diffusion through insulators into bottom superconducting layers is a common problem. The authors note that *Sr_2AlTaO_6 (SAT)* is an excellent insulator with a good lattice match to *YBCO* and promising dielectric properties. The authors used PLD to deposit *SAT/$NdBa_2Cu_3O_{7-\delta}$ (NBCO)* bilayers on *La*-doped *Sr_2AlTaO_6 (LSAT)* and *STO* substrates, and they found that because of the high stability and crystallinity of the *SAT* insulator, oxygen diffusion through *SAT* into the bottom *NBCO* layer became difficult. They did find, however, that after annealing for 5 h, the T_c reached a nearly saturated value of 90.5 K. Measurements of the magnetization hysteresis loop yielded a critical current density of 2.8×10^6 A/cm^2 at 77 K in an applied magnetic field of 100 G, results comparable with those on single *NBCO* layers deposited on *LSAT* and *STO* substrates.

Measurements of the c-axis conductance have been carried out by J. C. Martínez et al. (Mainz) on superlattices (total thickness ≈ 200 nm) in which the repeating layers were two unit cells of *$YBa_2Cu_3O_{7-\delta}$ (Y-123)* and seven unit cells of *$PrBa_2Cu_3O_{7-\delta}$ (Pr-123).* These quasi-2D structures did not show clear superconducting coupling along the c axis. Instead, the authors observed tunneling with a gap of $\Delta_c = 5.0 \pm 0.5$ meV for the direction perpendicular to the superconducting planes. The conductance spectra showed well-defined quasi-periodic structures attributed to the superlattice structure. From the data, the authors deduced a low-temperature c-axis coherence length of $\xi_c = 0.24 \pm 0.03$ nm.

$RBa_2Cu_3O_{7-\delta}$

Measurements of the normal-state c-axis magnetoresistance have been used by N. E. Hussey (Tokyo) et al. to probe the origin of the metallic c-axis transport in slightly overdoped *$YBa_2Cu_3O_{7-\delta}$* ($\delta = 0.05$). The authors find that an orbital contribution to the transverse magnetoresistance, a signature of coherent band motion, arises only from the component of the magnetic field perpendicular to the *CuO* chains. According to the authors, this result implies that the chains are primarily responsible for coherent c-axis transport in *$YBa_2Cu_3O_{7-\delta}$* and that those regions of the *CuO_2* planes not hybridized with the chains remain effectively two-dimensional, even in the absence of a normal-state gap.

A preprint by H. J. Fink (UC-Davis) reports a theoretical analysis of surface-resistance experiments by the Vancouver group on high-quality *$YBa_2Cu_3O_{6.99}$* single crystals. The resistance measurements are from 1.14 to 75.3 GHz, and the author finds good numerical agreement over that frequency interval for all temperatures. The author extracted the real part of the microwave conductivity $\sigma'(T)$ and obtained a Drude-like conductivity spectrum below 25 K, in agreement with the model. The author also found that the scattering rate of the thermally excited quasiparticles increases with temperature, in agreement with a Grüneisen temperature-dependent intrinsic resistivity at low temperatures.

Direct measurements of the forces on superconducting vortices in *$YBa_2Cu_3O_{7-\delta}$* using high-Q single-crystal-silicon double-torsional oscillators have been carried out by J. T. Markert et al. (Texas-Austin) and by J. T. Markert and K. Mochizuki (Texas-Austin). In the first paper, the authors report studies of the crossover from pinning to viscous motion of vortices. In the second paper, the authors measured the longitudinal force but found no evidence for the transverse force within experimental error.

High-resolution capacitance dilatometry studies from 5 K to 500 K of untwinned *$YBa_2Cu_3O_x$ (Y-123)* single crystals with $x \approx 6.95$ and 7.0 have been carried out by P. Nagel (Karlsruhe) et al. Large contributions to the thermal expansivities due to *O* ordering were found for $x \approx 6.95$, but these disappear below a kinetic glass-like transition near room temperature. The kinetics at this transition are governed by an energy barrier of 0.98±0.07 eV, in good agreement with other *O*-ordering studies. Using thermodynamic arguments, the authors show that *O* ordering in the *Y-123* system is particularly sensitive to uniaxial stress along the chain axis, and they suggest that the lack of well-ordered chains in *Nd-123* and *La-123* is most likely a consequence of a chemical-pressure effect.

The fabrication of *$YBa_2Cu_3O_{7-\delta}$ (YBCO)* superconductors using the top-seeded melt-growth (TSMG) process with a multiseeding technique is reported by Y. A. Lee (KAERI) et al. By using several seeds at the same time, large samples could be fabricated in a short time with a simple heat treatment. The best *YBCO* samples were obtained when the seeds were arranged with no spacing between them. The individual grains in the *YBCO* sample then behaved as a single domain and showed no deterioration of magnetic flux-trapping properties at the grain boundaries.

Other Cuprates

Using an ac technique, R. S. Gonnelli (Torino) et al. have measured the ab-plane resistivity of *$La_{2-x}Sr_xCuO_4$* single crystals with small *Sr* content ($0.052 \le x \le 0.075$) between 4.2 K and 300 K. The authors interpret the deviation from linearity of the $\rho_{ab}(T)$ curve at a temperature T_{ch} as due to a progressive slowing down of the fluctuations

of preformed charge stripes. The authors also speculate that an electronic phase transition from a nematic stripe phase to a more ordered smectic phase is responsible for some anomalies near T_c.

Andreev-reflection and tunneling studies of a single crystal of underdoped $Nd_{1.85}Ce_{0.15}CuO_{4+\delta}$ *(NCCO)* have been carried out by A. Mourachkine (Brussels) using *Ag, Pt-Ir,* and *Nb* tips to clarify the symmetry of the order parameter. The author observed a Josephson current using a *Nb* tip, suggesting the presence of an s-wave order parameter, and observed a zero-bias conductance peak using a *Ag* tip, suggesting the presence of a d-wave order parameter.

Two preprints by L. Fàbrega (Barcelona) et al. report on properties of *Hg*-based cuprate superconductors. In one of these, the authors performed muon-spin and magnetization experiments to investigate the effects of *O* and *Re* in $Hg_{1-x}Re_xBa_2CuO_{4+\delta}$ *[(Hg,Re)-1201]* superconductors. Near optimal doping, the authors found that the optimal T_c and λ values were nearly independent of x. Moreover, no traces of c-axis metallization induced by *Re* were observed. In the second preprint, the authors report ac susceptibility studies of $HgBa_2CuO_{4+\delta}$ *(Hg-1201),* $Hg_{0.82}Re_{0.18}Ba_2CaCu_2O_{6+\delta}$ *[(Hg,Re)-1212],* and $Hg_{0.82}Re_{0.18}Ba_2Ca_2Cu_3O_{8+\delta}$ *[(Hg,Re)-1223].* The authors found that $\chi''(T)$ in a dc field exhibits two peaks, and they attribute the peak at higher temperature to surface barriers and that at lower temperature to bulk pinning.

Inelastic and elastic neutron scattering experiments have been carried out by U. Staub (PSI-Villigen) et al. to investigate the magnetic properties of *Pr* in $Pb_2Sr_2PrCu_3O_{8+\delta}$. The authors found a magnetic ordering of the *Pr* sublattice with two different ordering wave vectors, corresponding to antiferromagnetic order within the plane and ferromagnetic and antiferromagnetic ordering along the c direction, similar to the *R = Tb* analog. The authors also were able to find a set of crystal-field parameters describing the observed magnetic excitations, and they conclude that their results strongly suggest the importance of the magnetic quasi-triplet ground state to the suppression of superconductivity by *Pr* in these cuprates.

The possibility of coexistence of superconductivity and ferromagnetism in the hybrid ruthenate-cuprate compound $RuSr_2GdCu_2O_8$ *(Ru-1212)* has been investigated theoretically by H. Shimahara and S. Hata (Hiroshima). The authors calculated critical fields for superconductivity taking into account the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) state in a model with Fermi surfaces whose shapes are similar to those obtained by a band calculation. They found that the FFLO critical field is enhanced by the Fermi-surface structure and that it is large enough to support coexistence of superconductivity and ferromagnetism on a microscopic scale in *Ru-1212.* The authors also suggest a scanning tunneling microscope experiment to probe the spatial oscillation of the order parameter.

RNi_2B_2C

The paramagnon contribution to the quasiparticle inelastic scattering rate in disordered superconductors has been calculated by T. P. Devereaux (Waterloo). Using Anderson's exact eigenstate formalism, the author found that the scattering rate is Stoner-enhanced and is further enhanced by the disorder relative to the clean case in a manner similar to the disorder enhancement of the long-range Coulomb contribution. The author discusses the results in connection with the possibility of conventional or unconventional superconductivity in the borocarbides.

Precise measurements of the resistivity vs temperature of YNi_2B_2C (T_c = 15.5 K) single crystals have been analyzed by R. S. Gonnelli (Torino) et al. in the framework of Bloch-Grüneisen theory and electron-phonon coupling. The authors determined the transport electron-phonon spectral function that best fits the resistivity data, inserted this into the real-axis Eliashberg equations, and then solved these equations to determine the normalized tunneling conductance under the assumptions of s-wave and d-wave symmetry.

Ni K-edge extended x-ray absorption fine structure (EXAFS) measurements on superconducting YNi_2B_2C ($T_c \approx 15.2$ K) in the temperature range 5-220 K have been performed by A. Yu. Ignatov (Southern Illinois) et al. The results show that below $T_D \sim 60$ K local structure is distorted from the perfect I4/mmm crystalline structure expected from diffraction measurements. Two different *Ni-Ni* distances separated by ~0.09 Å can be extracted at 5 K. The authors argue that YNi_2B_2C is inhomogeneous at the atomic length scale.

Measurements by H. Michor et al. (Wien) have revealed that the reduction of T_c in solid solutions of $Y_{1-x}R_xNi_2B_2C$ (*R* = rare earth) under hydrostatic pressure is significantly enhanced relative to the behavior of YNi_2B_2C. The authors show that this enhanced reduction is due to a pressure-induced increase of the magnetic exchange integral J_{sf}. The corresponding effect of chemical pressure arising from the change of the lattice parameter a upon rare-earth substitution is found to be in quantitative agreement with the hydrostatic pressure effect.

Vortices

A preprint by T. B. Doyle (Natal) et al. presents results of calculations for the field profiles as well as the local and global magnetization in $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* single-

crystal specimens in the vortex-solid/liquid intermediate state. The calculated results are in good agreement with the results of local induction measurements. The calculations are based on the assumption of a first-order transition between different equilibrium constitutive $B^{rev}(H)$ relations for the solid and liquid vortex-matter states at a characteristic hysteretic internal field H_m. The authors describe procedures for the accurate determination of the entropy of melting from global and local magnetization data in the intermediate-state regime.

A related paper by T. B. Doyle (Natal) et al. reports self-consistent fits of a treatment including specimen shape, vortex pinning, and surface effects to experimental *Bi-2212* magnetization data for platelet and prism single-crystal specimen geometries. In accord with theoretical expectations, the platelet specimen exhibits a sharp dimensional crossover transition from 3D to quasi-2D (arrowhead) behavior at about the predicted crossover field B_{2D} for temperatures $T \leq 40$ K. The magnetic hysteresis in this specimen is shown to be predominantly due to the shape/geometry effect and to 3D small-bundle and large-bundle collective pinning behavior above and below this transition, respectively. The prism specimen shows a diffuse crossover transition, and the hysteresis is shown to be dominated by surface vortex pinning and a distributed surface-barrier mechanism.

A preprint by A. Morello (Grenoble and Torino) et al. reports measurements of the irreversible magnetization of an overdoped *$Bi_2Sr_2CuO_6$ (Bi-2201)* single crystal up to B = 28 T and down to T = 60 mK, from which the irreversibility line $B_{irr}(T)$ was determined. The authors found that the data can be interpreted in the entire temperature range as a 3D anisotropic vortex-lattice melting line with Lindemann number $c_L = 0.13$.

Fine structure in the magnetization of small *Al* disks ($\kappa = \lambda/\xi \approx 0.3$) with diameters 1.5 μm and 2.4 μm in magnetic fields along the disk axis is reported by A. K. Geim (Nijmegen) et al. The authors compare their results with Ginzburg-Landau calculations and interpret the observed multiple phase transitions in terms of either merger of vortices into a single giant vortex or switching between different metastable arrays of the same number of vortices.

Magnetization measurements by S. Chaudhary (Indore) et al. show a pronounced peak effect in samples of *$Mo_{0.825}Re_{0.175}$* and *$Mo_{0.8}Re_{0.2}$*. The peak effect occurs close to the $H_{c2}(T)$ line. The authors stress that the magnetization results do not exhibit any of the anomalies reported in *$CeRu_2$* or *$NbSe_2$*.

A preprint by P. Benetatos and M. C. Marchetti (Syracuse) reports calculations in which nonlinear hydrodynamics is used to evaluate disorder-induced corrections to the vortex-liquid tilt modulus for finite screening length and arbitrary disorder geometry. The authors' explicit results for aligned columnar defects yield a criterion for locating the Bose-glass transition at all fields.

The transport properties of *Nb/CuMn* multilayers with a regular array of electron-beam-produced antidots (holes) have been measured by C. Attanasio (Salerno) et al. at different temperatures in the presence of external perpendicular magnetic fields far above the matching field. Upon measuring the I-V characteristics, the authors observed hysteresis, which disappeared when approaching the upper critical magnetic field $H_{c2}(T)$. The authors relate the onset of the hysteresis to the presence of an irreversibility line.

Theory

As noted by N. A. Mortensen (Technical University of Denmark) et al., the magnetic resonance at 41 meV observed in neutron-scattering studies of *$YBa_2Cu_3O_{7-\delta}$* holds a key position in the understanding of high-T_c superconductivity. Starting with the SO(5) model for superconductivity and antiferromagnetism, the authors have calculated the effect of an applied magnetic field on the neutron-scattering cross section of the magnetic resonance. In the presence of vortices, the neutron-scattering cross section shows clear signatures of fluctuations in both the magnitude and phase of the superconducting order parameter ψ. The authors find that in reciprocal space (a) the scattering amplitude is zero at $(\pi/a,\pi/a)$, (b) the resonance peak is split into a ring with radius π/d centered at $(\pi/a,\pi/a)$, where d is the lattice constant of the triangular vortex lattice, and (c) the splitting π/d therefore scales with the magnetic field as $\sqrt{B}$.

A preprint by J.-X. Li (Nanjing) et al. uses the slave-boson approach to the t-t'-J model to examine the spectra observed in ARPES measurements and the resonance peak observed by neutron scattering. The authors find that the peak/dip/hump ARPES features arise from the scattering of electrons by collective spin excitations, which also give rise to the neutron resonance mode. The authors show that the theoretically expected doping dependencies and the dispersions of the peak/dip/hump positions are consistent with experiment. The results also indicate that the recently observed $\cos(6\theta)$ deviation from the pure d-wave dependence of the gap parameter $\Delta(\theta)$ also results from renormalization by spin fluctuations.

Possible causes of deviations from the simple $d_{x^2-y^2}$-wave picture of high-T_c superconductivity observed in *Bi-2212* have been analyzed by G.G.N. Angilella (Catania) et al. The authors considered the issue of whether nonlinear, high-energy corrections to the superconducting energy spectrum $E_{\mathbf{k}}$ around the gap nodes induce deviations in

the predicted power-law behavior of several electronic properties at low or intermediate temperatures. The authors find that nonlinear corrections to $E_{\mathbf{k}}$ in general introduce additional energy scales into the problem, and that deviations from the usual power-law behavior of the superconducting electronic properties are expected at such energy scales. However, the authors find that both the magnitude and sign of the deviations depend upon the model under consideration.

A microscopic model for strongly correlated electrons with both on-site and nearest-neighbor Coulomb repulsion on a 2D square lattice has been investigated by M. Berciu and S. John (Toronto). The authors used the configuration interaction (CI) method to study the quantum translational and rotational motion of various charge magnetic solitons and soliton pairs. The model provides a unified microscopic basis for (a) non-Fermi-liquid transport properties, (b) d-wave preformed charge carrier pairs, (c) mid-infrared optical absorption, (d) destruction of antiferromagnetic long-range order with doping, and (e) certain aspects of angle-resolved photoemission spectroscopy (ARPES).

A related paper by M. Berciu and S. John (Toronto) demonstrates that the CI approximation captures essential features of the exact (Bethe Ansatz) solution of the 1D Hubbard model and that it systematically describes fluctuation and quantum-tunneling corrections to the Hartree-Fock approximation.

Some of the consequences of the quantum-critical-point scenario are discussed in a preprint by C. Di Castro et al. (Roma). In particular, the authors show that the strong k-dependent scattering of the quasiparticles with quasi-critical charge and spin fluctuations reproduces the main features of the low-energy spectral weights and the observed Fermi surfaces. In the underdoped cuprates, the attractive k-dependent charge scattering drives the formation of the pseudogap at the M points below the crossover temperature T*.

A class of nearly exactly solvable models of the electronic spectrum of two-dimensional systems with fluctuations of short-range order of dielectric (e.g., antiferromagnetic) or superconducting type is considered in a preprint by M. V. Sadovskii (Ekaterinburg). Such models lead to the formation of an anisotropic pseudogap state on certain parts of the Fermi surface. The models can be used to calculate the spectral density, density of states, and conductivity in the normal state, as well as some properties in the superconducting state.

Andreev interferometry - the sensitivity of the tunneling current to spatial variation in the local superconducting order at an interface - is proposed in a preprint by D. E. Sheehy et al. (Illinois-Urbana) as a probe of the spatial structure of the phase correlations in the pseudogap state of the cuprate superconductors. To demonstrate this idea theoretically, the authors consider a simple tunneling model in which the tunneling current is related to the equilibrium phase-phase correlator in the pseudogap state. The authors suggest that measurements of the low-voltage conductance through mesoscopic contacts of varying areas should make it possible to obtain phase-phase correlation information.

The Josephson current for c-axis coherent tunneling between two layered superconductors, each with internal coherent tight-binding intra- and interlayer quasiparticle dispersion, has been calculated exactly by G. B. Arnold (Notre Dame) and R. A. Klemm (Argonne). The results also apply when one or both of the superconductors is a bulk material, and they include the usually neglected effects of surface states. For weak tunneling, the results reduce to the authors' previous results derived using the tunneling Hamiltonian. The authors find that regardless of the order-parameter symmetry, these coherent-tunneling results using a tight-binding intralayer quasiparticle dispersion are inconsistent with recent c-axis twist bicrystal experiments by Q. Li et al. [Phys. Rev. Lett. **83**, 4160 (1999)] in *Bi-2212.*

The structure of the Meissner effect in a current-carrying cylindrical wire with arbitrary disorder has been studied by J. Sánchez-Cañizares (Madrid) et al. using a numerical procedure that is exact within the quasiclassical approximation. The authors find a distribution of current that is nonmonotonic as a function of the radial coordinate. For high currents, the authors find that a robust gapless superconducting state develops at the surface of both clean and dirty wires.

An exact analytical solution has been found by G. P. Mikitik (Kharkov) and E. H. Brandt (MPI-Stuttgart) for the critical-state problem in long, thin superconducting strips in a perpendicular magnetic field when the critical current density $J_c(B)$ depends upon the local magnetic induction according to a certain three-parameter model. The authors assert that the model describes both isotropic superconductors with this $J_c(B)$ dependence and superconductors with anisotropic pinning described by a dependence $J_c(\theta)$, where θ is the tilt angle of the flux lines away from the normal to the specimen plane.

A related paper by G. P. Mikitik (Kharkov) and E. H. Brandt (MPI-Stuttgart) describes the solutions for the currents and fields in a thin, flat superconductor of arbitrary shape and with arbitrary in-plane and out-of-plane flux-pinning anisotropy, when the superconductor is subjected to an external magnetic field normal to its plane. The authors show that the general three-dimensional critical-state problem for this superconductor reduces to the two-dimensional problem of an infinitely thin sample of the same shape but with a modified induction dependence of the critical sheet current. Methods of solving

the latter problem are well known. This finding enables the study of critical states in realistic samples of high-T_c superconductors with various types of anisotropic flux pinning. As examples, the authors investigate the critical states of long strips and rectangular platelets of high-T_c superconductors with pinning by either the ab planes or extended defects aligned with the c axis.

Other Activities

The electron-phonon coupling in fullerene C_{28} has been calculated from first principles by N. Breda (Milano) et al. The authors find that the value of the associated coupling constant $\lambda/N(0)$ is a factor of three larger than that for C_{60}. Assuming, for C_{28}-based solids, values of the Coulomb pseudopotential μ^* and the density of levels at the Fermi surface N(0) similar to those in the alkali-doped fullerides A_3C_{60}, the authors predict $T_c(C_{28}) \approx 8\ T_c(C_{60})$.

A preprint by M. Suenaga (Brookhaven) et al. reports that ac losses in stacks of powder-in-tube (PIT) processed *Bi-2223/Ag* tapes were measured in perpendicular magnetic fields and compared with calculated hysteresis losses based on the critical-state model. The authors found that the agreement between the calculated and measured losses is excellent for fields beyond the full penetration fields, but that the theory does not fully account for the low-field losses.

A finite-element program has been used by B. Zeimetz et al. (Cambridge) to calculate current distributions in superconductors, assuming a nonlinear (power-law or percolation-type) local dependence of the electric field on current density. The authors studied a bicrystal geometry, which forms the basic building block of *Bi-2223* PIT tapes and other polycrystalline conductors. The results support the propositions of the railway-switch model, insofar as grain boundaries do not play a dominant role in *Bi-2223* PIT tapes. However, the brick-wall model also is vindicated, in that c-axis transport plays a decisive role for dissipation and critical currents. The crucial point is that the intrinsic J_c anisotropy of the material is more important than the details of the microstructural geometry.

Five related preprints, by R. Weinstein (TCSUH) et al., R.-P. Sawh (TCSUH) et al., A. Gandini (TCSUH) et al., and two by W. Hennig et al. (TCSUH), discuss the achievement of strong pinning in trapped-field magnets and the application of such materials for magnetic levitation. The paper by R. Weinstein et al. discusses numerous aspects of *U/n* processing: (a) insertion of uranium into HTS precursor powders prior to texturing and (b) irradiation with thermal neutrons after texturing. One of the preprints by W. Hennig et al. reports some advantages of a levitation system in which a superconducting trapped-field magnet of 1.5 T levitates above the center of a ring of zero-field-cooled high-temperature superconductors.

Contributed by John R. Clem

Contents:

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Giuseppe G. N. Angilella, Asle Sudbø, and Renato Pucci, "Extended $d_{x^2-y^2}$-Wave Superconductivity: Flat Nodes in the Gap and the Low-Temperature Asymptotic Properties of High-T_c Superconductors." To be published in Eur. Phys. J. B. Dipartimento di Fisica, Università degli Studi di Catania, 57 Corso Italia, I-95129 Catania, ITALY; phone +39 095 7195 499; fax +39 095 383023; e-mail giuseppe.angilella@ct.infn.it; preprint also available at http://xxx.lanl.gov/abs/cond-mat/0001046. 74.25.-q; 74.25.Jb; 74.20.Mn; 74.72.Hs.

G. B. Arnold and R. A. Klemm, "Theory of Coherent c-Axis Josephson Tunneling Between Layered Superconductors." Submitted to Phys. Rev. B. Department of Physics, University of Notre Dame, Notre Dame, IN 46556; R. A. Klemm's e-mail at Argonne National Laboratory klemm@anl.gov; preprint also available at http://xxx.lanl.gov/abs/cond-mat/0001272.

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e-mail luciam@physics.unisa.it; preprint also available at http://xxx.lanl.gov/abs/cond-mat/0001205. 74.60.Ge; 74.60.Jg.

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Chau-Yun Yang, Ataru Ichinose, S. E. Babcock, J. S. Morrell, J. E. Mathis, D. T. Verebelyi, M. Paranthaman, D. B. Beach, and D. K. Christen, "Microstructure of a High J_C, Laser-Ablated $YBa_2Cu_3O_{7-\delta}$/Sol-Gel Deposited $NdGaO_3$ Buffer Layer/(001) $SrTiO_3$ Multi-Layer Structure." To be published in Physica C (in press). Contact S. E. Babcock, Applied Superconductivity Center and Department of Materials Science and Engineering, University of Wisconsin-Madison, 1500 Engineering Drive, Madison, WI 53706; telephone (608) 263-5696; telefax (608) 263-1087; e-mail babcock@engr.wisc.edu. Key words: *YBCO,* sol-gel, buffer layer, coated conductors.

B. Zeimetz, R. P. Baranowski, and J. E. Evetts, "Investigation of Local Current Flow in Polycrystalline, Anisotropic Superconductors Using Finite Element Simulation." Submitted to J. Appl. Phys. Department of Materials Science, Cambridge University, Pembroke Street, Cambridge CB2 3QZ, UNITED KINGDOM; telephone +44 1223 334375; telefax +44 1223 334373; e-mail bpz20@cam.ac.uk.

COMING EVENTS

*(An * indicates a previously listed event. Also see complete listing of upcoming conferences and workshops at our Web site http://www.iitap.iastate.edu/htcu/comevents.html.)*

***April 16 - 19, 2000:** 6th Twente Workshop on Superconducting Electronics, Congress Center "Drienerburght," University of Twente, Enschede, The Netherlands. Aim of this meeting is an international exchange of latest results and new ideas on the electronic applications of superconductors focusing on the following areas of research: using fundamental aspects for new device concepts (e.g. π junctions, qubits); relation between materials properties and transport; advanced circuitry;

spin-dependent transport; and novel applications. Morning sessions devoted to invited talks with discussion breaks; afternoon sessions devoted to contributed papers. **Abstract deadline, March 15, 2000.** For information, contact Ingrid Oomen or Alexander Brinkman, Department of Applied Physics (TN/LT), University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands; telephone +31 53 489 2806; telefax +31 53 489 1099; e-mail i.oomen@tn.utwente.nl or a.brinkman@tn.utwente.nl.

**April 24 - 28, 2000:* Superconducting and Related Oxides – Physics and Nanoengineering IV, Marriott's Orlando World Center Resort and Convention Center, Orlando, Fla. Part of SPIE's 2000 AeroSense Symposium. Fourth in the series of SPIE conferences focused on basic issues in physics and materials science of high-temperature superconductors and related compounds that may be relevant for their applications in electronics, optics, and optoelectronics. Topics will include: a) structural, transport, magnetic, and thermal properties of thin films of cuprates and related compounds; b) homoepitaxy, new substrate materials, epitaxial and morphological properties, interface smoothness and disorder, layer thickness fluctuations, interdiffusion, and strain; c) proximity effects, surface and interface effects, and superconductors in contact with insulators, semiconductors, normal metals, ferro- and antiferromagnets, piezoelectrics, etc.; d) search for novel high-temperature superconducting phases by atomic engineering; e) electronic structure, charge redistribution, localization, single-particle and collective excitations, and Josephson phenomena in natural and artificial superlattices; f) novel device concepts, electric field effect in heterostructures, hybrid optoelectronic devices, and cryoelectronics. Three-day exhibition. Proceedings to be published. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010; telephone (360) 676-3290; telefax (360) 647-1445; e-mail OR@spie.org; Web site http://www.spie.org/web/meetings/calls/or00/confs/OR15.html.

May 24 - 27, 2000:* Sixth Symposium on High Temperature Superconductors in High Frequency Fields (HTS-HF 2000), The Island of Capri, Naples, Italy. Organized by I.N.F.M. and Dipartimento Scienze Fisiche, and the University Federico. Aim of this biannual symposium is to bring together distinguished researchers involved in the study of the properties of high-temperature superconductors in rf and microwave fields, with emphasis on fundamental properties and material aspects, experimental methods, and market-emerging targets. Three areas have been identified as the main topics of the 2000 symposium: (1) Science and technology of HTS at microwave frequencies – new ideas and novel materials; correlation between microwave properties and material structure, morphology, defects, and impact on devices; nonlinear effects, harmonic generation and inter-modulation distortion in devices, and understanding and standardization of measurements. (2) Microwave applications of HTS – recent advances in telecommunication systems; tunable devices and totally agile superconducting systems; NMR and MRI applications; spatial probing; and cryopackaging issues. (3) Space applications of HTS – state-of-the-art North American and European programs. Scientific program will include keynote lectures supplemented by poster sessions, and ample time will be given to discussions and socialization. Participation is by invitation only and is presently limited to about 80 attendants. **Abstract deadline, March 15, 2000. For information, contact Annamaria Mazzarella, Conference Secretariat; telephone +39 081-8534123 or -8661381; telefax +39 081-5267654; e-mail cib@secyann.cib.na.cnr.it.

June 18 - 23, 2000:* European Conference on Energy Dispersive X-Ray Spectrometry (EDXRS 2000), Kraków, Poland. Aim of the conference is to bring together scientists working either in basic research in x-ray spectrometry, detectors and sources, or involved in applications of x-ray spectrometry or some of the related experimental techniques. Main topics: interaction of photons and particles with matter and modeling; new developments in instrumentation (instruments utilizing polarized radiation, synchrotron radiation and other x-ray sources, grazing angle spectrometers, portable instruments); energy dispersive x-ray detectors (cryo-detectors, low-Z detectors, Peltier-cooled detectors, dedicated pulse processing); quantitation and data handling (sample preparation, quality control and quality assurance, simulation, modeling, software); x-ray optics (capillaries, mirrors, multilayers, TXRF, imaging); microanalysis and elemental mapping (micro-XRF, micro-PIXE, EPMA); and x-ray spectrometry applications in life and environmental sciences, earth sciences, art and cultural heritage, material sciences, and industry. **Abstract deadline, March 1, 2000. The official language of the Conference is English. For information, contact EDXRS-2000 Secretariat, Faculty of Physics and Nuclear Techniques, University of Mining and Metallurgy, Al. Mickiewicza 30, 30-059 Kraków, Poland; telefax +48 12 6340010; Web site http://www.ftj.agh.edu.pl/wfitj/conf/edxrs/.

July 3 - 28, 2000:* United States Summer School in Condensed Matter and Materials Physics, Boulder, Colo. New summer school for graduate students and postdocs in condensed-matter and materials physics has been established and will be held annually in Boulder. This first one is entitled *Introduction to Superconductivity: Fundamentals and Applications.* Main themes of the school will be basic principles of superconductivity, quantum dynamics of vortices and electrons, vortices in D > 2 and critical phenomena in superconductors, high-temperature and other unconventional superconductors, physics and applications of vortex dynamics, nonequilibrium superconductivity, mesoscopic and nanoscale superconducting systems, materials, applications, and devices. **Application deadline, May 1, 2000. Most local expenses will be covered by the

summer school (supported by the National Science Foundation, University of Colorado at Boulder, NIST, and Lucent). For further information, contact Z. Tesanovic, Department of Physics and Astronomy, 315 Bloomberg Center, Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218-2686; telephone (410) 516-5391; telefax (410) 516-7239; e-mail cmsummer@pha.jhu.edu or zbt@pha.jhu.edu. For details and application forms see Web site http://www.indiana.edu/~uscmpsc/.

Aug. 1 - 4, 2000:* Minisymposium on Correlation in Mesoscopic Systems, Miramare, Trieste, Italy. Objective is to bring together leading researchers actively working in the field of normal-metal mesoscopic systems and 2D metal-insulator transitions, in order to discuss the most recent developments and research directions. Topics are interaction in mesoscopic systems, 2D delocalization transition, and non-equilibrium mesoscopics. Scientists and physicists from all countries that are members of the UN, UNESCO or IAEA can attend the Minisymposium. Some funds are available for subsistence allowance to a limited number of participants from developing countries. No registration fee. **Deadline for participation request, March 31, 2000. Request for participation obtainable via e-mail from smr1234@ictp.trieste.it. Contact Ms. E. Brancaccio, Minisymposium on Correlation in Mesoscopic Systems, International Centre for Theoretical Physics, Strada Costiera 11, I-34014 Trieste, Italy; telephone +39 040 2240284; telefax +39 040 2245163; e-mail SMR1234@ictp.trieste.it; Web site http://www.ictp. trieste.it/cgi-bin/ICTPsmr/mkhtml/smr2html.pl?smr1234/Bulletin.

Sept. 13 - 16, 2000:* The Second International Conference on Inorganic Materials, University of California, Santa Barbara. Meeting will provide an opportunity to highlight recent developments and to identify emerging and future areas of growth in this field. Topics include electronic materials, structural materials and ceramics, biomaterials, intermetallics, catalytic and porous materials. Emphasis on oral presentations by invited speakers combined with extended poster sessions. **Abstract deadline, February 25, 2000. Official language is English. A tabletop exhibition will run for the duration of the conference. For information, contact Sarah Wilkinson, Second International Conference on Inorganic Materials, Elsevier Science Ltd., The Boulevard, Langford Lane, Kidlington, Oxford, OX5 1GB, United Kingdom; telephone +44 1865 843691; telefax +44 1865 843958; e-mail sm.wilkinson@elsevier.co.uk.

FYI

(High-T_c Update takes no responsibility for want ads listed in this section.)

Position open: Postdoctoral research position available for study of the origin of nonlinearity in the microwave properties of HTS thin films. Supported by funding from the National Physical Laboratory. Interested candidates should have experience in working with superconducting materials at high frequencies and will join an established interdisciplinary research group at Imperial College, London. Close interaction with collaborators both in the UK and US. Position is available immediately; initial term is 18 months. Salary: £16,286 plus London allowance. **Application deadline, February 29, 2000.** To apply, send a full CV and list of references to L. F. Cohen, Imperial College, Blackett Laboratory, London SW7 2BZ, UNITED KINGDOM; email l.cohen@ic.ac.uk.

Students who wish to pursue a Ph.D. in the superconductivity field are invited to apply to the Institute for Beam Particle Dynamics Group at the University of Houston. Work involves development of pinning centers by both chemical and irradiation methods, and currently concentrates on a variety of problems in *Y123, Nd123, Sm123,* and *BiSCCO.* The group also studies levitation, magnet arrays and bearings, and pulsed magnetization. Stipend of $15,000 per year. For information, contact Roy Weinstein, Institute for Beam Particle Dynamics, University of Houston, Houston, TX 77204-5506; telephone (713) 743-3600; telefax (713) 747-4526; e-mail weinstein@uh.edu.

Positions open: Engineers or scientists needed for development of mechanical process optimization of powder-in-tube (PIT) *Bi-2223* tapes. Work will involve R&D on optimization of mechanical deformation in PIT tapes, development of mechanical deformation equipment for alternative wire geometries, twisting and stranding processes, twisting and stranding equipment, and general support in mechanical design. Candidates must have a Ph.D. or M.Sc. in Mechanical Engineering and 1-3 years industrial or research experience in mechanical processing. Experience with rolling and drawing processes, processing of powder, and industrial manufacturing experience desired. For information, contact Per Vase, Vice President Engineering, Nordic Superconductor Technologies A/S, Priorparken 685, 2605 Brondby, Denmark; telephone +45 43482508; cell phone +45 21714001; telefax +45 43482501; e-mail p.vase@nst.com.

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