HIGH T UPDATE

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$RBa_2Cu_3O_{7-\delta}$

Two preprints by H. Ikuta (Nagoya) et al. report improvements in the melt-processing of $RBa_2Cu_3O_{7-\delta}$ *(R-Ba-Cu-O, R = Nd* and *Sm)* and significant increases in the flux-trapping ability of the resulting samples. In the first paper, the authors found that adding *Ag* to the starting materials solves some problems that had been encountered in the melt-processing of large *R-Ba-Cu-O* bulk superconductors; the addition of *Ag* was found to prevent the formation of cracks, such that the samples showed no indication of weak links in the trapped magnetic-field profiles at 77 K. Peak values of the trapped magnetic field at 77 K were 0.4 T for a *Nd-Ba-Cu-O* sample of diameter 18 mm and 0.96 T for a *Sm-Ba-Cu-O* sample of diameter 33 mm. In the second paper, the authors report measurements of the trapped magnetic field versus temperature in various *Sm-Ba-Cu-O* samples. At 77 K, the peak trapped field in a sample of diameter 36 mm was 1.7 T, more than twice that of similar-sized melt-processed *Y-Ba-Cu-O* samples at the same temperature; at 65 K, the peak trapped field was 4.7 T. For a *Sm-Ba-Cu-O* sample of diameter 30 mm, the trapped field was 8.0 T at 40 K. Further attempts to magnetize the *Sm-Ba-Cu-O* samples at still lower temperatures resulted in sample cracking because of the strong Lorentz-force-induced tensile stresses that develop as the applied field decreases.

To examine local mechanical properties of melt-textured $RBa_2Cu_3O_{7-\delta}$ *(R = Y* and *Nd),* R. Provoost (Leuven) et al. have carried out a detailed analysis of micro-Raman spectra recorded around the nonsuperconducting R_2BaCuO_5 inclusions imbedded in these materials. The Raman spectra were recorded every 0.4 or 0.5 μm along a line crossing one or more inclusions on two specific samples. In fast-melt-processed $YBa_2Cu_3O_{7-\delta}$ samples, the authors found a softening of the *Y-123* Raman modes around inclusions. On the other hand, in oxygen-controlled-melt-grown $NdBa_2Cu_3O_{7-\delta}$ samples, where the cooling rate is much lower, the authors observed a hardening of the *Nd-123* modes around the $Nd_4Ba_2Cu_2O_{10}$ inclusions.

The flux-pinning characteristics of ternary melt-processed $(Nd_{0.33}Eu_{0.33}Gd_{0.33})Ba_2Cu_3O_y$ *(NEG)* have been studied by M. R. Koblischka et al. (SRL-ISTEC) in the temperature range 60 K ≤ T ≤ 90 K. The authors found that the *NEG* samples exhibit a strongly developed peak effect in the dependence of the critical current upon the external magnetic field H_a. Scaling of the bulk pinning forces versus the reduced field $h = H_a/H_{irr}$ (H_{irr} is the irreversibility field) yields a peak at $h_0 = 0.5$, which is an indication that pinning is produced by a spatial variation of the transition temperature.

Magneto-optical investigations have been carried out by A. Das et al. (SRL-ISTEC) to investigate the uniformity of flux penetration and flux trapping in $(Nd_{0.33}Eu_{0.33}Gd_{0.33})$-$Ba_2Cu_3O_y$ *(NEG)* superconductors melt-processed in a reduced oxygen atmosphere. The authors found that the critical state was well established in the entire sample, showing that the sample was a single grain without weak links.

O K-edge and *Cu* L_{23}-edge x-ray absorption spectra in $(Nd_{1.05-x}Pr_x)Ba_{1.95}Cu_3O_{7-\delta}$ (x = 0.0-0.5) have been measured by J. M. Chen (SRRC-Hsinchu) et al. to investigate how the variation of hole states relate to the superconductivity in this material. The results demonstrate that the suppression of superconductivity upon substituting *Pr* into the $(Nd_{1.05-x}Pr_x)Ba_{1.95}Cu_3O_{7-\delta}$ system arises predominantly from the hole-depletion effect.

Measurements of the electrical resistivity and thermoelectric power in the system $Y_{1-x}Ca_xBa_2Cu_3O_{7-\delta}$ (x = 0 and 0.2) have been carried out by M. Akoshima and Y. Koike (Tohoku) to determine T_c and p, the hole concentration per *Cu*. The authors conclude that the 60 K plateau of T_c in the *Y-123* phase should be attributed to the 1/8 anomaly seen previously in the *La-214* and *Bi-2212* phases, and not to ordering of oxygen vacancies in the $CuO_{1-\delta}$ chains. The authors also conclude that it is very likely that dynamical stripe ordering of spins and holes exists in all high-T_c cuprates, and that the

behavior of the stripe order at p ~ 1/8 is responsible for the anomalous suppression of superconductivity there.

The magnetoconductivity of $YBa_2Cu_3O_{7-\delta}$ has been measured by J. Axnäs et al. (Stockholm) in magnetic fields B up to 12 T in temperatures up to 2.55 T_c for **B**||c and up to 1.7 T_c for **B**||ab. The authors found that their data, as well as previously published data, can be well described by including the Maki-Thompson (MT) terms and the previously neglected density-of-states effects. The authors emphasize that all previous analyses neglecting the MT terms must be reexamined.

A preprint by C. P. Bidinosti et al. (UBC) reports measurements of the magnetic-field dependence of the penetration depth $\lambda(H)$ for untwinned $YBa_2Cu_3O_{6.95}$ for temperatures 1.2-70 K in dc fields up to 42 Oe and directions 0°, ±45°, and 90° with respect to the crystal b-axis. The experiment used an ac susceptometer with fields applied parallel to the ab-plane of thin platelet samples. At low temperatures, the authors found the field dependence of $\Delta\lambda = \lambda(H) - \lambda(0)$ to be essentially linear in H, ranging from 0.04 Å/Oe for $\Delta\lambda_a$ to 0.10 Å/Oe for $\Delta\lambda_b$, values comparable with the T = 0 Yip and Sauls prediction for a d-wave superconductor. However, the authors report that the systematics versus temperature and orientation do not agree with the d-wave scenario, probably due in part to residual sample problems.

Bi Cuprates

Using constant-initial-energy angle-scanning photoemission, supported by energy distribution curves, N. L. Saini (Roma) et al. have studied topological features of the $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* Fermi surface. The resulting Fermi surface measured over an extended Brillouin zone shows broken segments with partial gaps around $(\pi,0)$ and shadow bands around $(0.5\pi,0.5\pi)$ and equivalent locations. The data also provide evidence for new electronic states at the Fermi surface due to a one-dimensional band with small dispersion and small k_F along the $(\pi,0)$ direction. The authors argue that these features are related to charge ordering in the CuO_2 plane along the $(-\pi,\pi)$ direction and spin fluctuations along the $(\pi,0)$ direction.

Reversible magnetization measurements with applied field parallel to the c-axis have been carried out by X. Zhao (Hefei) et al. for a series of *Bi-2212* single crystals with different oxygen content varying from undoped to overdoped states. The authors analyzed the magnetization versus temperature to obtain both T_c and (via λ_{ab}) n_S/m^*. A deviation from a linear relationship between T_c and n_S/m^* was observed. The authors explain the deviation in the underdoped region as a result of structural distortion and disorder scattering, and in the overdoped region as a consequence of phase-separation-related pair breaking.

The effect of *Pr* doping on the structure and superconductivity of the *Bi-2212* system is described in two papers by X. Sun (Hefei) et al., who prepared $Bi_2Sr_2Ca_{1-x}Pr_xCu_2O_y$ single crystals with x = 0-0.78. The superconducting transition temperature increases slightly at first and then drops gradually with *Pr* doping, with complete suppression of superconductivity occurring when x = 0.60.

Periodic pressing has been used by F. Marti et al. (Genève) to achieve critical current densities of *Pb*-containing multifilamentary *Ag*-sheathed *Bi-2223* tapes up to about 3.5×10^4 A/cm^2 at 77 K in self-field. This corresponds to a 30-40% increase over the values obtained for conventionally rolled tapes starting with the same powders. The periodically pressed tapes also were found to be less sensitive to the duration of the first annealing time. The authors present a brief description of the periodic pressing machine, and they stress that this technique is a practical, scalable process for the fabrication of long lengths of *Bi-2223*.

A factor of ~1.5 enhancement in critical current I_c of a *Bi-2223/Ag* tape has been achieved by T. Chiba (Brookhaven) et al. through the use of a preheat treatment, 600°C for 6 h, prior to the final heat treatment at 840°C. This treatment also resulted in improvements in the resistive transition width and specimen-to-specimen reproducibility. The authors suggest that better intergranular connectivity, rather than enhanced vortex pinning strength, is responsible for the improvements.

Global transport measurements and local Hall-probe-array measurements have been carried out by Y. Radzyner (Bar-Ilan) et al. on a section of silver-clad *Bi-2223* tape. The two methods show good agreement at low temperatures and low fields but diverge at high temperatures and relatively high fields. Under the latter conditions, the currents induced by the magnetic field tend to flow within the grains, while the transport current must flow along the sample. The “brick-wall” model aptly describes the flow of transport currents but fails to describe the flow of intragranular currents induced by an external magnetic field.

LSCO

Electronic Raman continua of $La_{2-x}Sr_xCuO_4$ single crystals with various levels of doping have been measured by O. V. Misochko (ISSP-Chernogolovka) and S. Uchida (Tokyo) for light polarized both within the CuO_2 planes and along the c-axis. For the two cases, different doping dependencies of the A_{1g} scattering strength in the normal state were observed. Based on the redistribution of the continua below T_c, the authors infer that the superconducting energy gap is anisotropic, although evidence for pure d-wave pairing (ω^3 low-frequency behavior) is absent at any doping.

Vortices

Sub-nanovolt-resolution longitudinal and Hall voltages have been measured by G. D'Anna (EPFL) et al. in an ultrapure $YBa_2Cu_3O_{7-\delta}$ single crystal. The Hall anomaly and the first-order vortex-lattice melting transition were observed simultaneously. Changes in the dynamic behavior of the vortex solid and liquid were found to be correlated with features of the Hall conductivity σ_{xy}. With the magnetic field oriented at an angle from the twin boundaries, the Hall conductivity was found to sharply decrease toward large negative values for temperatures decreasing below the vortex-lattice melting transition.

A phase transition within the molten phase of the Abrikosov vortex system without disorder in extreme type-II superconductors has been found by A. K. Nguyen and A. Sudbø (Trondheim) via large-scale Monte Carlo calculations. It involves breaking a U(1) symmetry, and it has a zero-field counterpart, unlike vortex-lattice melting. Its hallmark is the loss of number conservation of connected vortex paths threading the entire system in any direction, driving the vortex line tension to zero. This tension plays the role of a generalized stiffness of the vortex liquid and serves as an order parameter for the transition, at which a weak specific heat anomaly is predicted. The authors discuss the interplay between this new transition and the vortex-lattice-melting transition, and they suggest an experimental test.

A theory of quasiparticle transport in the mixed state of a d-wave superconductor has been developed by M. Franz (Johns Hopkins) under the assumption of a disordered vortex array. The author identifies a universal regime at fields above $H^* = c^*H_{c2}(T/T_c)^2$, characterized by a field-independent longitudinal thermal conductivity κ_{xx}^e. The author argues that this behavior is responsible for the high-field plateau in κ_{xx}^e experimentally observed in high-T_c cuprates [K. Krishana et al., *Science* **277**, 83 (1997); H. Aubin et al., *Science* **280**, 9a (1998)].

Vortex creep in layered superconductors of finite thickness with columnar defects has been theoretically investigated by T. Dröse and C. Morais Smith (Hamburg). The authors find that a crossover from rigid to elastic vortex creep occurs when the sample thickness, external driving current, or the pinning strength of the defect is varied. The authors study the crossover behavior in detail for currents J close to the critical current density J_c ($J_c - J << J_c$).

As pointed out by L. Burlachkov et al. (Bar-Ilan), numerical studies of flux creep in superconductors show that the distribution of the magnetic field at any stage of the creep process can be well described by the condition of spatial constancy of the activation energy, independent of how U depends upon the field B and current density J. The authors formulate a semi-analytical approach to the creep problem and generalize the logarithmic solution for flux creep, obtained for U = U(J), to the case that U has a strong dependence upon B.

The transport-current distribution in clean 2H-$NbSe_2$ crystals has been studied by Y. Paltiel (Weizmann Institute) et al. by measuring the self-induced magnetic field across the sample using a linear Hall array with 19 sensors. The authors found that below T_c most of the current flows at the edges of the crystals because of strong surface barriers, which dominate the transport properties and the resistive transition. The measured critical current is thus determined by the critical current for vortex penetration through the surface barrier rather than by bulk pinning.

ac Losses

A method to measure true ac losses in superconducting cables has been developed by M. Däumling (NKT) et al. The authors carry out a resonant current experiment, which they call RESCUE, in which a capacitor is short-circuited with the cable, and the decay of the voltage or current oscillations in the resonant circuit is measured as a function of time. The decay rate has two components, a purely exponential one, due to Ohmic dissipation in the leads and contacts, and a non-exponential one, due to hysteretic losses in the superconductor. The authors have used this method to measure the ac losses in a superconducting cable model of length 1 m.

Using a linear spline approximation for the E-J characteristics of a superconductor and representing the solution in the form of a series, V. Sokolovsky et al. (Ben-Gurion University of the Negev) have derived analytical expressions for ac losses. The authors assert that these expressions explain experimentally observed frequency and magnetic-field dependencies of ac losses. The authors also show how the analytical solutions can be applied for various forms of E-J characteristics by defining effective critical current densities and flux-flow resistivities.

Thin Films

A preprint by N. Kim et al. (Pohang) reports the fabrication of small-size stacks on the surface of $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* single crystal with bulk transition temperature $T_c \approx 90$ K, each containing a few intrinsic Josephson junctions. Below a critical temperature $T_c' = 35$ K, the authors observed a weakened Josephson coupling between the CuO_2 superconducting double layer at the crystal surface and the adjacent bilayer deeper in the stack. The quasiparticle branch in the I-V data of the weakened Josephson junction fits well to the tunneling characteristics of a d-wave superconductor/insulator/d-wave superconductor

(D'ID) junction. The tunneling resistance in the range $T_c' < T < T_c$ agrees well with the tunneling in a normal metal/insulator/d-wave superconductor (NID) junction.

As reported by S. Sakai et al. (ETL), in the growth of *Bi-Sr-Ca-Cu-O (BSCCO)* films by molecular-beam epitaxy (MBE), the sticking coefficients of *Sr, Ca,* and *Cu* are unity, but that of *Bi* is very sensitive to growth temperature. Moreover, the temperature dependence of the *Bi* sticking coefficient for growth of Bi_2O_3 is very different from that for *BSCCO*. The authors point out that this property leads to a useful self-limiting function for growth of *Bi*-based multi-element oxides, and they demonstrate this for MBE growth of $Bi_2Sr_2CuO_6$ *(Bi-2201)* and $Bi_4Ti_3O_{12}$ *(BiT).*

When $NdBa_2Cu_3O_{7-\delta}$ single crystals are used as the target to produce $NdBa_2Cu_3O_{7-\delta}$ films by pulsed-laser deposition (PLD), smooth, nearly droplet-free films have been obtained, in contrast to the case when polycrystalline sintered targets are used. To understand the reasons for the differences, Y. Li et al. (SRL-ISTEC) have studied the surfaces of both kinds of PLD targets and found major differences in their surface morphologies. After a long period of laser ablation, the sintered target displays a cone-shaped columnar surface morphology, while the single-crystal target exhibits a continuous, smooth, undulating morphology with ridges and grooves.

Using a sapphire dielectric resonator method, M. V. Jacob (James Cook and Delhi) et al. investigated the effect of *Ag* on the 25 GHz microwave properties of superconducting *YBCO* thin films prepared by PLD on *MgO* substrates. The authors found that when the *Ag* doping level in the targets was increased from 2 to 10 wt% *Ag,* the surface resistance of the resulting *YBCO* films decreased by 20%, which correlated with improved microstructure of the films.

Various technology issues in deposition of high-temperature superconducting *YBCO* thin films by reactive evaporation are discussed by V. C. Matijasevic and P. Slycke (Conductus). The key elements are oxygen pocket heaters and sensitive atomic beam monitors. Tunable-diode laser sensors seem to be the most promising technology for vapor flux measurement and control.

Modifications of a commercial atomic force microscope (AFM) have been made by O. Schneegans et al. (Paris), enabling the authors to obtain simultaneous topographical and local contact resistance surface images of *YBCO* films within the same area of the sample. The authors fitted the AFM with a conducting probe, made of doped silicon coated with doped diamond.

YBCO thin films have been grown by H.-U. Habermeier et al. (MPI-Stuttgart) on vicinal cut $SrTiO_3$ (001) single crystals. The films show a pronounced anisotropy in both the resistivity and flux-pinning properties in the substrate plane. The anisotropy is caused by planar defects generated via self-organization of the *YBCO*, leading to an exceptionally large critical current density up to 8×10^7 A/cm^2 at 4.2 K.

Measurements of the complex ac sheet impedance of c-axis-oriented *YBCO* thin films have been measured by M. Calame et al. (Neuchâtel) in the frequency range 10^2-10^5 Hz for film thicknesses varying between 24 Å and 1100 Å. The authors present measurements for the thinnest films and examine their consistency with predictions of the Kosterlitz-Thouless theory for the vortex-antivortex unbinding transition.

A paper by F. Lombardi et al. (Göteborg) reports studies of the electrical transport properties of the grain boundaries (GBs) formed at the top and bottom edges of *YBCO* step edge Josephson junctions for different values of the step angle α. The authors took advantage of the shadowing effect to define a superconducting electrode contacting the superconductor between the top and bottom grain boundaries. In this way, the authors could determine, for example, that for $\alpha \approx 60°$, the top GB is responsible for the weak-link behavior of the step-edge junctions.

Measurements of the temperature dependence of the critical current density $J_c(T)$ and the current dependence of the energy barrier against vortex motion $U_{eff}(J)$ in epitaxial c-axis-oriented *YBCO* and *TBCCO* films are reported by J. Jung (Alberta) et al. The authors carried out measurements on rings in a persistent mode using a scanning Hall probe that can measure both the axial (parallel to the c-axis) and the radial (parallel to the ring's surface) components of the persistent current's self-field. The authors found that both $J_c(T)$ and $U_{eff}(J)$ appear to be governed by Josephson nanostructures in the ab-planes of *YBCO* and *TBCCO*.

A preprint by O. M. Stoll (Tübingen) et al. reports the observation of a novel intrinsic step structure in the flux-flow resistance of epitaxial c-axis-oriented films of $Nd_{2-x}Ce_xCuO_4$ as a function of current at intermediate magnetic fields $B_{c1} << B < B_{c2}$. The effect was observed only when the sample was cooled with superfluid helium. To explain the underlying instability, the authors propose a model based on the strongly energy-dependent density of states available near the Fermi energy for quasiparticle scattering in the superconducting mixed state in the clean limit.

The effect of spin-polarized injection on the superconducting order parameter has been investigated by M. S. Osofsky (NRL) et al. in a device consisting of $YBa_2Cu_3O_{7-\delta}$/Au/$Ni_{0.8}Fe_{0.2}$ layers. The authors present a nonequilibrium theory that qualitatively agrees with the experiment but predicts injection currents that are several orders of magnitude too large.

Thick Films

High-rate evaporation techniques have been used by V. F. Solovyov (Brookhaven) et al. to deposit *Y, BaF_2,* and *Cu* precursor films onto $SrTiO_3$ single-crystal substrates at rates in excess of 10 nm/s. *Y* and *Cu* were deposited by electron-beam heating, and thermal heating was used for BaF_2. Post-deposition annealing was used to form 3 μm thick c-axis-oriented *YBCO* films. Critical current densities of 1.8×10^5 A/cm^2 at 1 T (**H**||c) and 77 K were achieved. The results indicate that the BaF_2 post-annealing process is one of several possible candidate methods for the production of thick *YBCO* coatings for large-scale applications.

As reported by S. Miura et al. (SRL-ISTEC), thick *YBCO* films have been grown on *MgO* (100) by liquid-phase epitaxy. Transmission electron microscopy (TEM) images revealed that the films consisted of large grains whose misorientation angles were less than 1°. Although dc critical current density values decreased with increasing film thickness, even a 7 μm thick film had a J_c of 9×10^5 A/cm^2 in zero field at 77 K. These and further measurements suggest that LPE-grown *YBCO* films have superior dc and rf electrical properties.

Applications

The use of a cryogenic near-field scanning microwave microscope to image microwave electric fields from superconducting and normal-metal microstrip resonators is described in a preprint by A. S. Thanawalla (Maryland) et al. The microscope employs an open-ended coaxial probe and operates from 77 K to 300 K in the 0.01-20 GHz frequency range with a spatial resolution of about 200 μm. The authors describe the operation of the system and present microwave images of *Cu* and $Tl_2Ba_2CaCu_2O_{8+\delta}$ *(Tl-2212)* microstrip resonators, showing standing-wave patterns at the fundamental and second-harmonic frequencies.

As reported by U. Mizutani (Nagoya) et al., the pulsed-field-magnetization (PFM) technique is the most efficient tool in magnetizing melt-processed high-T_c bulk superconductors in the temperature range 30-80 K. Having analyzed the process of flux penetration, the authors have developed a procedure called IMR, involving iterative magnetizing pulsed fields with reducing amplitudes, which has been found to be effective in magnetizing melt-textured *YBCO* superconductors at temperatures down to 30 K. Using these findings, the authors constructed a prototype quasi-permanent magnet system capable of producing a magnetic field of 0.8 T at a height of 7 mm above the surface of a *YBCO* superconductor (diameter 35 mm and height 14 mm) magnetized by PFM at 30 K.

The fabrication of metal-sheathed high-T_c superconducting current leads with J_c = (1.6-1.8) $\times 10^4$ A/cm^2 at 77 K under self-field conditions is described in a preprint by J.K.F. Yau (Hong Kong, CSIRO, and University of New South Wales) et al. The authors found that section-wise uniaxial pressing could be used to provide the necessary intermediate mechanical deformation between heat treatments of silver-sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$ superconducting tapes.

Theory

In a preprint by B. Jankó (Chicago) et al., the authors argue that incoherent pair tunneling in a cuprate superconductor junction with an optimally doped superconducting and an underdoped normal lead can be used to detect the presence of pairing correlations in the pseudogap phase of the underdoped lead. The authors estimate that the junction characteristics most suitable for studying the pair tunneling current are close to those in recently fabricated tunneling devices.

The pairing pseudogap in the spectral function has been studied by G. Preosti (Argonne) et al. as a function of interplane coupling. The authors obtain analytical expressions for the self-energy in the critical regime for any degree of anisotropy. The authors find that the frequency dependence of $\sum(\omega)$ is qualitatively different in two and three dimensions, and they discuss the crossover from two- to three-dimensional behavior. By considering the anisotropy of the Fermi velocity and gap along the Fermi surface, the authors can qualitatively explain recent photoemission experiments on high-temperature superconductors concerning the temperature-dependent Fermi arcs seen in the pseudogap phase.

The role of collective modes in various experiments on the cuprates has been investigated by T. Dahm (MPI-Dresden) et al. The authors calculate the neutron-scattering, photoemission (ARPES), and Raman-scattering intensities below T_c within the fluctuation-exchange (FLEX) approximation for the two-dimensional Hubbard model. The authors show that the large peak in the dynamical spin susceptibility arises from a weakly damped spin-density-wave collective mode. This gives rise to a dip between the sharp low-energy peak and the higher-binding-energy hump in the ARPES spectrum. The authors also show that the collective mode of the amplitude fluctuation of the d-wave gap yields a broad peak above the pair-breaking threshold in the B_{1g} Raman spectrum.

Electronic correlations in the ground state of an idealized infinite-layer high-T_c compound have been computed by G. Stollhoff (MPI-Stuttgart) using the ab-initio method of local ansatz. Using this method, the author shows how details of the correlation functions and a good understanding of the relevant short-range correlation features can be obtained. The first application for a metallic high-T_c compound shows

a fairly good agreement between the computed and measured magnetic correlation functions.

The phase diagram of a generalized t-J model taking superconducting, flux, and charge-density-wave states into account has been derived by E. Cappelluti and R. Zeyher (MPI-Stuttgart). The investigation was based on the leading expressions of a 1/N expansion enforcing the constraints by means of X-operators. The authors found a strong competition between d-wave superconducting and d-wave flux states. As a result, the transition temperature T_c for superconductivity showed a maximum near a doping value $\delta = \delta_c \sim 0.13$ for J/t = 0.3.

By carrying out a canonical transformation of the three-band Hubbard model, M. Cini et al. (Roma) show how one can obtain an effective Hamiltonian that describes the propagation of a pair of dressed holes, including all many-body effects.

The combined effect of both nonmagnetic and magnetic impurities on the superconducting transition temperature has been studied by L. A. Openov (Moscow State Engineering Physics Institute) within the BCS model. The author derives an expression for the critical temperature as a function of potential and spin-flip scattering rates for a two-dimensional superconductor with arbitrary in-plane anisotropy of the superconducting order parameter, ranging from isotropic s-wave to d-wave (or any pairing state with nonzero angular momentum) and including anisotropic s-wave and mixed (d+s)-wave as particular cases. This expression generalizes the well-known Abrikosov-Gor'kov formula for the critical temperature of impure superconductors.

Properties of low-energy excitations in one-dimensional superconductors and density-wave systems have been examined by M. I. Salkola (Florida State and Stanford) and J. R. Schrieffer (Florida State). The authors find that in addition to the usual spin and charge quantum numbers, a new, independently measurable attribute is required to describe elementary low-energy excitations: the winding number w, which determines, in multiples of π, how many times the phase of the order parameter winds as an excitation is transposed from far left to far right. The corresponding topological excitations can be viewed as composite particles made of spin or charge degrees of freedom and dressed by kinks in the order parameter.

Other Activities

A preprint by V. V. Moshchalkov et al. (Leuven) reports a comparison of the resistivity $\rho(T)$ of the underdoped cuprates with that of the even-chain spin-ladder (SL) compound $Sr_{2.5}Ca_{11.5}Cu_{24}O_{41}$ under pressure. The SL $\rho(T)$ data are fitted by the 1D quantum transport model. Taking into account the scaling behavior at $T < T^*$ of the resistivity of the underdoped cuprates $YBa_2Cu_4O_8$ and $YBa_2Cu_3O_x$ to that of $Sr_{2.5}Ca_{11.5}Cu_{24}O_{41}$, the authors assume that the former are also in the 1D regime at temperatures $T_c < T < T^*$. In this interpretation, the pseudogap of underdoped high-T_c cuprates is simply the spin gap of the even-chain SL's associated with stripe formation in the CuO_2 planes at $T < T^*$.

Four strategies for increasing the critical temperature of new superconductors are proposed in a preprint by M. Marezio et al. (Parma). These are based on (i) band-structure calculations, which may lead to systems different from known ones; (ii) high-resolution electron-microscopy studies, which may lead to different structural arrangements within the same systems; (iii) systematic studies of phase diagrams; and (iv) *in-situ* high-pressure studies of the critical temperature of known systems, which may lead to cation or anion substitutions simulating at ambient pressure the structure stable under pressure and responsible for the higher T_c.

As reported by N. Markovic et al. (Minnesota), the superconductor-insulator transition in ultrathin films of amorphous *Bi* can be tuned by changing the film thickness, with and without an applied magnetic field. The authors present an experimentally determined phase diagram for T = 0 as a function of thickness and magnetic field. The authors performed a finite-size scaling analysis to determine the critical exponent νz, which was found to be 1.2±0.2 for the zero-field transition and 1.4±0.2 for the finite-field transition. Both results differ from the exponents found for the magnetic-field-tuned transition in the same system, 0.7±0.2.

Overviews

A book chapter by J. M. Tranquada (Brookhaven) discusses phase separation, charge segregation, and superconductivity in the layered cuprates. In $La_2CuO_{4+\delta}$, oxygen interstitials are mobile near room temperature, giving a homogeneous phase, while cooling to lower temperatures can lead to segregation into phases with distinct oxygen concentrations. In $La_{1.6-x}Nd_{0.4}Sr_xCuO_{4+\delta}$, the experimental evidence appears to be consistent with a picture in which the holes doped into the planes segregate into stripes that act as domain walls between antiferromagnetic domains, with a π phase shift across the domain walls. A dynamical form of this modulation provides one model for interpreting the spin correlations in $La_{2-x}Sr_xCuO_4$ and $YBa_2Cu_3O_{6+x}$ (181 refs.).

Some of the major experimental features of microwave nonlinearity in high-temperature superconductors, both intrinsic and extrinsic, are reviewed by S. M. Anlage et al. (Maryland). The elimination or control of nonlinearities in

these materials will require a microscopic understanding of the defects and geometrical features that produce extrinsic forms of nonlinearity. The authors believe the best route to this goal is through a quantitative microscopic imaging of materials properties, electromagnetic fields, and currents at microwave frequencies and cryogenic temperatures (92 refs.).

The physical mechanisms of microwave losses in high-T_c superconductors, especially at high power levels, are discussed in an overview by M. Golosovsky (Hebrew University of Jerusalem). The author uses an impedance-plane analysis as a tool for quantitative comparison of experiment and theory. The author discusses several models of nonlinear microwave performance of high-T_c superconductors, including coupled-grain and rf critical-state models, and estimates their characteristic time scales (71 refs.).

A review of some of the systematics of the thermoelectric power of cuprates and other superconductors (*Ni-Zr, Ni-Zr-Al,* Chevrel-phase compounds, K_3C_{60}, *NbN,* and $Ba_{1-x}K_xBiO_3$) has been prepared by A. B. Kaiser and G. C. McIntosh (Victoria University of Wellington). The authors present data and discuss some possibilities for explaining the behavior of the thermopower (52 refs.).

Some non-accelerator high-frequency applications of superconductors are reviewed by S. M. Anlage et al. (Maryland). These include the use of high-T_c superconductors in front-end band-pass filters in cellular telephone base stations, the high-temperature superconductor space experiment (the HTSSE program), and high-speed digital electronics. The authors also present an overview of their work on a near-field scanning microscope that can be used to investigate the microwave properties of metals and dielectrics on length scales as small as 1 μm (37 refs.).

As noted in a brief review by M. Murakami (SRL-ISTEC), *R-Ba-Cu-O* superconductors with *R-Ba* solid solution *(R = Nd, Sm, Eu,* and *Gd)* exhibit T_c and J_c values higher than those of melt-textured *Y-Ba-Cu-O* when they are melt-processed in a reduced oxygen atmosphere. The author points out some important microstructure and processing issues that need to be addressed in studying the *R-Ba-Cu-O* systems, which have more complicated phase relations than the *Y-Ba-Cu-O* system (23 refs.).

Contributed by John R. Clem

Contents:

***High-T_c Update* is available without charge to interested persons. Recipients are expected to participate in this information exchange by sending us preprints, reprints, meeting news, research news, etc. Contributions to defray the cost of newsletter printing and mailing are welcome.**

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.

An agreement between American Superconductor Corporation (ASC) and Carolina Power & Light (CPL) was signed recently to distribute ASC's line of industrial power quality solutions based on superconducting magnetic energy storage (SMES) technology. Normal operation of electric utility grids is designed to minimize power outages. However, severe weather, traffic accidents, and unforeseen equipment failures can lead to power interruptions or voltage sags. According to industry data, these momentary interruptions and voltage sags cost U.S. industries billions of dollars annually in damaged equipment and lost production.

Housed in a portable 48-foot trailer, American Superconductor's SMES products use an energy storage electromagnet made with low-temperature superconducting wire. SMES units use power electronics to sense momentary electrical power disturbances, more than 80 percent of which last less than two seconds, and instantly provide supplemental power to eliminate the disturbance. Once incoming electric power is stabilized, machinery is switched back to the utility power source. American Superconductor accomplished the first successful marriage of HTS current leads with its low-temperature SMES product line in the AmeriMark installation. The addition of HTS technology to the SMES system decreased American Superconductor's manufacturing costs significantly and decreased SMES annual electrical operating costs for the customer by about 55 percent.

Under the terms of the agreement, CP&L, which generates and provides electricity and energy services to more than 1.1 million customers in the Carolinas, will market American Superconductor's SMES units to its commercial

and industrial customers through a dedicated sales force. American Superconductor will provide sales and customer service training and technical support for CP&L sales and engineering personnel.

The agreement formalizes a six-year working relationship between American Superconductor and CP&L. The two companies participated in an Electric Power Research Institute project involving installation and testing of SMES units in various industrial settings in CP&L's service area. For further information please contact Kathy Cadigan, Corporate Communications, American Superconductor Corporation, Two Technology Drive, Westborough, MA 01581; telephone (508) 836-4200 ext. 222.

Conductus, Inc., announced an award of $1.67 million over two years to develop low-loss tunable microwave devices for applications in wireless and satellite communications with an option for a two-year continuation of the program for another $2.2 million. Under this project, Conductus will team with Space Systems Loral to develop the technology necessary for a broad range of advanced wireless products for both terrestrial commercial applications as well as military and space-based applications. Conductus will work to develop tunable filters using thin-film tunable-dielectric materials and high-performance, HTS filter technology. Technology developed under the new program could lead to lower costs in manufacturing existing products as well as to advanced new products for the wireless industry. Among the possibilities for new products are filters that can be electrically and rapidly tuned to different frequency bands and whose characteristics can be altered to meet specific application requirements. Such technology is of interest to both commercial and military customers for terrestrial as well as satellite applications.

The initial effort will be to develop tunable dielectrics and fabrication processes to achieve high-quality materials with intrinsic figures-of-merit (such as tunability and loss characteristics) offering improvements at least ten times the performance currently achieved in state-of-the-art research labs. The reactive evaporation technology Conductus uses in its filter manufacturing process will be utilized for large-area deposition of tunable dielectric materials. Together with Loral, Conductus will then utilize these high-performance tunable dielectric thin films for low-loss tunable microwave devices for wireless and satellite communications. This project is part of a DARPA-sponsored initiative known as FAME (Frequency Agile Materials for Electronics) whose overall goal is to develop hybrid structures for frequency-agile filters, antennas, oscillators, and phase shifters utilizing field dependent properties of ferroelectrics, ferrites and other novel materials. For further information, contact Conductus, Inc., 969 W. Maude Avenue, Sunnyvale, CA 94086, telephone (408) 523-9950; telefax (408) 523-9999.

Contributed by Sreeparna Mitra

PREPRINTS

To obtain a particular preprint, contact the first author at the address given at the end of the citation. Help us expand this list by sending us your complete preprint. **Please specify where and when your paper was submitted.** An * next to an entry indicates it is a correction or revision of a previous entry. PACS codes and/or key words are given at the end of the citation.

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COMING EVENTS

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

*Nov. 16 - 19, 1998:

11th International Symposium on Superconductivity (ISS'98), Fukuoka Sunpalace Hotel, Fukuoka, Japan. Organized by the International Superconductivity Technology Center (ISTEC). Symposium will consist of oral and poster sessions and invited talks in the following topics: Physics – theory, physical properties, and new measurement techniques; Chemistry – new materials and syntheses, substitution, solid-state chemistry, and properties; Critical Current – flux-pinning mechanism, vortex physics, and weak links; Wires, Tapes, and Bulk – solid-state powder ceramics, chemical-solution processing, melting solidification, and chemical-vapor deposition; Films and Junctions – processing, properties, lithography, junction fabrication, and physics; Device Applications – digital, analog, SQUID, and other electronic devices; System Applications – power, power transportation, magnets, magnetic shields, and other system applications; Standardization – standardization for electromagnetic, mechanical, and microwave properties measurements. Will also include exhibition of materials and devices. Proceedings to be published. Official language is English. For further information, contact ISS'98 Secretariat, ISTEC, Eishin Kaihatsu Bldg. 6F, 34-3 Shimbashi 5-chome, Minato-ku, Tokyo 105-0004, Japan; telephone +81 3 3431 4002; telefax +81 3 3431 4044.

*May 30 - June 3, 1999:

10th International Symposium on Intercalation Compounds (ISIC 10), Okazaki, Japan. Tenth in the series. Will focus on basic ideas in both the physics and chemistry of intercalation materials such as graphite, fullerenes, carbon nanotubes, chalcogenides, oxides, clays, zeolites, and other related materials. Topics to be covered: new intercalation compounds and new synthetic routes; thermodynamics, kinetics, and reaction mechanisms; structure and lattice dynamics; phase transitions; electronic properties, charge transfer, and band structures; transport properties and superconductivity; magnetic properties; electrochemical properties; intercalation electrodes for advanced batteries; and other present and potential applications. Scientific program will consist of plenary lectures as well as oral and poster sessions. Proceedings to be published as a special issue of Molecular Crystals and Liquid Crystals. **Abstract deadline, December 15, 1998.** For further information, contact Toshiaki Enoki, ISIC 10, Department of Chemistry, Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152-8551, Japan; fax +81 3 5734 2242; e-mail isic@chem.titech.ac.jp; Web site http://www.chem.titech.ac.jp/~isic/.

July 7 - 10, 1999:

Ninth International Workshop on Critical Currents (IWCC9-99), University of Wisconsin, Madison, Wisconsin. IWCC9-99 will be the ninth in a series of workshops devoted to study and discussion of the critical current density in superconductors. This three and one-half day workshop will be organized around keynote talks on flux pinning, grain-boundary properties, and the current-limiting mechanisms of single and polycrystalline superconductors. Extensive discussion time will be given to these key topics. **Abstract deadline, January 10, 1999.** For further information, contact M. M. Adams, Conference Coordinator, 1500 Engineering Drive, Room 917 ERB, Madison, WI 53706; telephone (608)263-5029; telefax (608)263-1087; e-mail madams@engr.wisc.edu.

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:

Electron Transport in Mesoscopic Systems, Chalmers University of Technology and Göteborg University, Göteborg Sweden. Satellite to the LT-22 Conference in Helsinki, Finland (Aug. 4-11, 1999). The five main topics are: single charge tunneling, Andreev reflections and proximity effects in S/N structures, transport in quantum dots and wires, time-dependent transport in mesoscopic structures, and superconducting nano-circuits. Format is expected to be two sessions for each main topic with a rapporteur starting the first session (giving an introduction to the topic, the recent progress in the field, and the outstanding problems to be solved with possible projections) and a regular invited speaker starting the other one. Three additional oral contributions and time for extended discussions planned. Attendance limited to about 200 persons. For information, contact Tord Claeson,

Conference Chair, Department of Physics, Chalmers University of Technology, S-41296 Göteborg, Sweden; e-mail f4atc@fy.chalmers.se.

Sept. 14 - 17, 1999:* Fourth European Conference on Applied Superconductivity (EUCAS'99), Melia Gran Sitges, Hotel in Sitges, Barcelona, Catalonia, Spain. Aim is to provide a forum for presentation and discussion of the developments in the field of the applications of superconductivity, in both large and small scale, including the most recent advances in the subject. All aspects of applied superconductivity will be covered, from both a scientific point of view (which include contributions from the fields of physics, electronics, material properties, chemistry, and engineering), and also an industrial perspective. Conference will encourage new cooperation on European and wider international levels. The program will be divided into two main sections. Large Scale & Power Applications will include fusion and SMES, detectors and accelerators, fault current limiters, motors and generators, high magnetic fields, wires and cables, materials related to large-scale applications, system aspects, and other applications. Small Scale & Electronic Applications will include Josephson Junctions, SQUIDs, digital applications, mixers/detectors, passive devices, oscillators and volt standards, materials related to superconducting electronics, system aspects, and other applications. **Abstract deadline, March 15, 1999. For further information, contact Xavier Obradors, Institut de Ciencia de Materials de Barcelona (ICMAB-CSIC), Campus de la UAB, E-08193 Bellaterra (Barcelona), Catalonia, Spain; phone +34 93 580 18 53; fax +34 93 580 57 29; e-mail eucas99@icmab.es; Web site http://www.icmab.es/eucas99.

RESOURCES

Information

Proceedings: *Lectures on the Physics of Highly Correlated Electron Systems:* Proceedings of the Second Training Course in the Physics of Correlated Electron Systems and High-T_c Superconductors, Vietri sul Mare, Salerno, Italy (Oct. 13-25, 1997), edited by Ferdinando Mancini. This proceedings volume is not a collection of articles, but a book consisting of three chapters, covering the lectures of three well-known researchers on dissipative quantum systems (the orthogonality catastrophe, the Kondo model, macroscopic quantum phenomena, and Coulomb blockade); d-wave superconductivity (impurity scattering, post WHH theory of H_{c2}, Abrikosov's vortex lattice, extended GL equation and stability of the square lattice, quasiparticle spectrum around a single vortex, *YBCO* and d+s wave model); and numerical techniques (Monte Carlo and quantum Monte Carlo techniques, Lanczos method, high-T_c cuprates, Hubbard model, and colossal magnetoresistance in manganites). Readership: postdoc-level individuals in highly correlated electron systems and graduate students in superconductivity. Publ. 1998; 208 pp.; price $62; ISBN 1-56396-789-8. For information, contact Springer-Verlag New York, P.O. Box 2485, Secaucus, NJ 07096; phone (800) SPRINGER (777-4643); fax (201) 348-4505. For orders outside U.S. and Canada, contact Springer-Verlag Berlin, P.O. Box 31 13 40, D-10643 Berlin, Germany; phone +49 30 82787 0; fax +49 30 82787 301; e-mail orders@springer.de.

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FYI

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Position Open: A postdoctoral (or visiting faculty) position is available in experimental condensed matter/material physics at the Department of Physics & Astronomy beginning September 1998. Work involves electrical and magnetic characterization of magnetic multilayers and tunnel junctions of high-temperature superconducting materials. A Ph.D. in condensed-matter physics or related area and a working knowledge of SQUID magnetometry and ac susceptometry techniques are required. Please submit a letter of application, résumé, and a list of three references with phone numbers and e-mail addresses to Lowell E. Wenger, Department of Physics & Astronomy, Wayne State University, Detroit, MI 48202; e-mail lwenger@sun.science.wayne.edu.

Postdoctoral positions are available in the area of condensed-matter theory at the International Centre for Theoretical Physics (ICTP) for the 1999-2000 academic year. Current research areas include strongly correlated electron systems, disordered and mesoscopic systems, *ab-initio* electronic structure studies, quantum liquids and solids, surface physics, statistical physics, and complex systems. Appointments will be made for one year, with the possibility of renewal for a second year. **Application deadline, December 31, 1998.** Send application, including detailed curriculum vitae, list of publications, and letters of recommendation to Condensed Matter Secretary, ICTP, P.O. Box 586, I-34100 Trieste, Italy; phone +39 040 2240347; fax +39 040 224163; e-mail buranell@ictp.trieste.it.

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