HIGH T_C UPDATE

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NOTA BENE:

Because John Clem, our Science Editor, is on travel, Douglas K. Finnemore, Distinguished Professor and Chair of Physics, Iowa State University, has graciously agreed to write "Nota Bene" for this issue.

Rare Earth Cuprates

Andreev bound states in *Y-123* have been studied by M. Aprili et al. (Urbana). Changes in the zero-bias conductance peak with magnetic field indicate that the low-bias conductance conserves the number of states, and that the magnitude of the magnetic-field-induced splitting is dependent on field orientation. This is consistent with the Folgestrom-Rainer-Sauls model in which the splitting is due to a Doppler shift arising from the scalar product between the quasiparticle velocity and the superfluid momentum.

A comparison of the zero-bias conductance peak for several cuprate superconductors by L. Alff (Köln) et al. has been related to the symmetry of the wave function. The zero-bias peak was observed only in systems with a d-wave symmetry, but was absent for the s-wave *Nd-Ce* system.

High-pressure experiments with *Pr-123* by J. Ye (NRIM) et al. reveal a parallelism between the pressure dependence of T_c for superconducting *Pr-123* and that of *Y-123*. For these samples grown by the traveling-solvent float-zone method, *Pr-123* seems to be an ordinary member of the *RE-123* superconducting family.

Hall-angle measurements have been used by Y. Abe (University of Tokyo) et al. to look for pseudogap effects in *Zn*-doped *Y-123*. Deviations of the cotangent of the Hall angle from T^2 behavior suggests that the pseudogap affects the Hall angle through a change in the effective mass, rather than through a change in the Hall scattering rate.

Bi-Cuprates

Microstructural and transport properties of electrophoretically deposited *Bi-2212/Ag* tape composites were studied by S.-L. Huang and D. Dew-Hughes (Oxford) to determine the effects of various heat treatments on critical current performance and the distribution of alkaline-earth cuprate phases. Processing conditions were found that are favorable for the industrial manufacture of tape conductors.

The microstructural and superconducting properties of *Hg*-doped *Bi-2212* were studied by A. Matsumoto et al. (NRIM) in order to study the effects of small pinning centers. The *Hg* substitution enhanced T_C up to 97 K, but the intergrain coupling was diminished by the presence of *Hg.* Critical currents, as measured by magnetic hysteresis, systematically decreased by about an order of magnitude for each ten percent decrease in T_C.

Changes in the transport J_C of *Bi-2223* tapes was studied by D. M. Spiller (Southampton) et al. to determine the effect of excess *Bi-2212* added to the normal *Bi-2223* stoichiometry. The addition of 10% *Bi-2212* to the Endo composition for *Bi-2223* can increase J_C by about a factor of four. They conclude that improvement of grain-boundary quality rather than the introduction of pinning centers leads to the enhancement of J_C.

As reported by A. Bianconi (Rome) et al., angular resolved photoemission has been used to study non-Fermi-liquid behavior and diagonal lattice stripes in cuprate *Bi-2212* superconductors. The line shape of the energy-distribution curves show a spectral function expected for a non-Fermi-liquid behavior. The Fermi surface contour in the “even symmetry” reveals the suppression of spectral weight due to coupling with joint incommensurate charge density wave in the diagonal direction and the spin density wave at $G(\pi,\pi)$.

A study of the *Y* NMR has been carried out by A. G. Kontos et al. (Coventry) for *Y* substituting for *Ca* in *Bi-2212.* The resonance of *Y* on the *Ca* site shifts diamagnetically upon increasing the carrier concentration and paramagnetically upon reducing the temperature, in close relation with the variation of T_C in the system.

The in-plane and out-of-plane magnetoresistance of *Bi-2212* single crystals has been studied by G. Heine

(Vienna) et al. The in-plane magnetoresistance is positive for all temperatures and magnetic fields. Near T_c, the in-plane magnetoresistance is dominated by theromdynamic fluctuations, but at higher temperatures, a smooth transition to the normal-state quasiparticles takes place. In sharp contrast, the out-of-plane magnetoresistance is negative for all temperatures and orientations of the magnetic field. The data are interpreted in the framework of superconducting fluctuation theory.

Other Cuprates

Synchrotron radiation x-ray studies have been used by C. Rial (Madrid) et al. to follow in real time the evolution of oxygen during a thermal treatment to convert *La-214* into the oxygen-rich *La-214* phase. The stability of the oxygen-rich phase seems to be due to the presence of one-dimensional interstitial oxygen ordering along the c-axis, as suggested by the appearance of a pair of superlattice satellite peaks around the mixed parity (012) peak.

High-pressure measurements have been undertaken by S. Sadewasser (Washington University) et al. in order to study time-dependent changes in T_c that occur as atoms diffuse after a change in pressure for $HgBa_2CuO_4$. Results show weak relaxation effects in strongly underdoped and overdoped samples with an activation energy of 0.8-0.9 eV. For the *Hg* compound, the activation energy increases with pressure more rapidly than it does in *Y-123.*

Neutron-diffraction refinement measurements were undertaken by M. Karppinen (Yokohama) et al. to determine the relative effectiveness of doping *Cu-1212:P* with *Ca* and with excess oxygen. Oxygen doping was found to increase hole concentration less efficiently than *Ca* doping and higher T_c values were obtained with *Ca* additions than could be obtained with oxygen alone. These two doping methods also gave different T_c vs *Cu-O* bond-length relations.

Other Superconductors

As reported by A. Amici et al. (Dresden), an extended BCS theory may be constructed in the general case of commensurate magnetic structures such as those illustrated by the borocarbides. In the special case of helical magnetic order, the extended theory is also valid in the incommensurate limit. They suggest an explanation for the anomalies of the *Ho* borocarbide data.

Films

The effect of the patterning process on the microwave surface impedance of *Y-123* thin films was investigated by H. Xin (MIT) et al. With the use of a sapphire dielectric resonator and a stripline resonator, the microwave surface impedance of *Y-123* was measured before and after the patterning process. Experimental and modeled results show that the patterning has no observable effect on the value of R_S or on the power dependence of R_S.

Applications

SQUID measurements were used by G. Wübbeler (Berlin) et al. to study the dc ionic currents that are generated after the injury of a nerve. The device used mechanical modulation of the source-to-detector distance to extend the frequency range below 0.1 Hz. Magnetic field changes of 10 fT were resolved in measuring times of 100 s. Injury related near-dc biomagnetic fields were recorded *in-vivo* with a patient undergoing a diagnostically indicated muscle biopsy.

A Josephson array oscillator with microstrip resonators for the submillimeter region was developed by A. Kawakami et al. (Kobe). The Josephson array oscillators were designed and fabricated to operate near the *Nb* gap of 700 GHz using 11 shunted *Nb/AlOx/Nb* junctions with *Nb* microstrip resonators. Using the RLCSJ model, the outpower of the Josephson oscillator was estimated to be about 0.1 μW at 680 GHz.

A superconducting 4-bit instantaneous frequency meter on a 2" *MgO* wafer has been constructed for operation in the 10 GHz range by M. Biehl et al. (Karlsruhe). Due to integration of power-divider resistors and a large number of air bridges, improved transmission characteristics are achieved in a more reproducible way than with surface-mounted chip resistors and ultrasonically bonded air-bridges.

Theory

The effects of charging and of Josephson plasma resonance on the complex resistivity of high-temperature superconductors has been determined by A. Gurevich (Madison) and M. Tachiki (NRIM). They show that planar crystalline defects parallel to the ab-plane can give rise to a localized Josephson plasma mode formed by a collective Coulomb interaction of interlayer junctions. This results in a pronounced satellite line in the real part of the complex resistivity. The position and amplitude of the line depend on the critical current density and on the parameters of the charge interlayer coupling. The narrowness of the zero-field plasma peak enables one to probe the pairing symmetry of the interlayer coupling.

A comparison of superconductivity in Sr_2RuO_4 and the copper oxides has been made by E. V. Kuz'min and S. G. Ovchinnikov (Krasnoyarsk). They present a model of strongly correlated electrons in a two-dimensional lattice

that allows the cuprates with antiferromagnetic coupling and the Sr_2RuO_4 with ferromagnetic coupling to be considered on the same footing. Singlet superconductivity in the s-state is absent in the strong-correlation limit. The triplet p-pairing occurs due to the ferromagnetic fluctuations and the singlet d-pairing is induced by the antiferromagnetic fluctuations.

Resonant inelastic x-ray scattering in insulating cuprates is examined by K. Tsutsui et al. (Tohoku) using the exact-diagonalization technique on small clusters in the two-dimensional Hubbard model with second- and third-neighbor hopping terms. When the incident photon energy is tuned near the absorption edges, they find that the features of the unoccupied upper Hubbard band can be extracted from the x-ray spectrum through an anisotropic momentum dependence. Results provide an opportunity for the understanding of the different behavior of hole- and electron-doped superconductors.

A spin-wave theory of short-range order in the square-lattice Heisenberg antiferromagnet is formulated by A. Sherman (Tartu) and M. Schreiber (Chemnitz). With growing temperature from T = 0, a gapless mode is shown to arise simultaneously with opening a gap in the conventional spin-wave mode.

The effect of thermal phase fluctuations on the inductances of Josephson junctions, arrays of junctions, and thin films has been calculated by T. R. Lemberger et al. (Ohio State). They find that quantum mechanics supresses fluctuations when the temperature drops below a characteristic temperature controlled by the shunt conductance and the mean-field inductance. They find that thermal phase fluctuations are much more important than phase-slip fluctuations, except very close to the super-to-normal transition.

A paper by G. Khaliullin (Dresden) et al. reports a theory of the local spin polarization in the underdoped cuprates with *Ni* and *Zn* impurities substituted into the planar *Cu* sites. Both types of impurity induce moments on the neighboring *Cu* sites. In the case of *Ni,* these moments partially screen the inherent impurity spin resulting in an effective S = 1/2 moment. They investigate the spatial shape of the impurity-induced spin density.

The Raman response function in the weak-coupling limit has been calculated by D. Manske (Berlin) et al. for a clean d-wave superconductor below T_c using various approaches for the bare coupling between the incident light and the electronic excitations. Within a one-band description, it turns out that the A_{1g} and B_{2g} scattering intensities depend strongly on band-structure effects.

Contributed by Douglas K. Finnemore

Contents:

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COMING EVENTS

(See complete listing of upcoming conferences at our Web site http://www.iitap.iastate.edu/htcu/comevents.html.)

Sept. 27 - 29, 1999:

Statistical Mechanics and Strongly Correlated Systems – Second G. Paladin Memorial, Department of Physics, University of Rome "La Sapienza," Rome, Italy. Conference to honor and remember Giovanni Paladin's scientific work. Topics: chaos and turbulence (scheduled for Monday), phase transition and complex systems (scheduled for Tuesday), and strongly correlated electrons and superconductivity (scheduled for Wednesday). For information please contact G. Bachelet, Dipartimento di Fisica, Universita' di Roma "La Sapienza," P. Aldo Moro 2, I-00185 Roma, ITALY; phone +39 06 49913474; fax +39 06 4463158; e-mail pal99@elena.phys.uniroma1.it or Giovanni.Bachelet@roma1.infn.it; Web site http://axtnt2.phys.uniroma1.it/pal99/index.html.

*Oct. 17 - 19, 1999:

12th International Symposium on Superconductivity (ISS'99), Hotel Metropolitan Morioka, Morioka, Japan. Forum for free exchange of information, to contribute to the advancement of superconductivity and strengthen international cooperation. Symposium will consist of oral and poster sessions, highlighted by a few dozen invited talks on the latest topics related to superconductivity. Will cover the latest findings and related themes in the following research fields of superconductivity: Physics and Chemistry – theory, physical properties, new measurement techniques, vortex physics and weak links, new materials and syntheses, substitution, solid-state chemistry and properties; Bulks – processing, critical current, flux-pinning mechanism, standardization; Wires and Tapes – processing, critical current, and standardization; System Applications – power, transportation, magnet, magnetic shield, and others; Films and Junctions – processing, properties, lithography, junction fabrication, physics and standardization; Electronics – digital, analog, SQUID, and other electronics devices, using HTS and LTS materials. **Abstract deadline, June 30, 1999.** Official language is English. For information, contact ISTEC, Eishin Kaihatsu Bldg. 6F, 34-3 Shimbashi 5-chome, Minato-ku, Tokyo 105-0004, Japan; phone +81 3 3431 4002; fax +81 3 3431 4044. Or contact Japan Convention Services Inc., Nippon Press Center Bldg. 4F, 2-2-1 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-0011, Japan; phone +81 3 3508 1213; fax +81 3 3508 0820.

Feb. 20 - Feb. 25, 2000:

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

RESOURCES

Information

Proceedings:

Impact of Recent Advances in Processing of Ceramic Superconductors, Ceramic Transactions, Volume 84, Proc. of the 99th ACeRS Annual Meeting, Cincinnati, Ohio, edited by Winnie Wong-Ng, U. Balachandran, and Amar Bhalla. Emphasis on breakthroughs in the areas of fabrication of superconductors with high critical current density and discovery of new superconductors. Book also covers ion-beam-assisted deposition (IBAD) and rolling-assisted biaxially textured substrates (RABiTs), as well as latest research in the area of substrate development for coated conductors. Summarizes current status of the four prototype product development, namely transmission cables, motors, generators, and fault-current limiters. Publ. 1998; 240 pp.; price $95.00 ($76 for ACeRS members); ISBN 1-57498-031-9. Contact American Ceramic Society, Book Orders, P.O. Box 6136, Westerville, OH 43086-6136; telephone (614) 794-5890; telefax (614) 794-5892; e-mail accounting@acers.org; Web site www.acers.org.

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