HIGH T_C UPDATE

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NOTA BENE:

As announced in previous issues of the newsletter, we will discontinue the free hard-copy version of the *High-T_C Update* newsletter beginning May 1, 1999, due to lack of funds. The next issue, April 15, will be the last issue sent as hard copy. You must notify us if you wish to receive a PDF version of the newsletter and provide us with your current e-mail address. Please e-mail this information as soon as possible to mitra@ameslab.gov.

Vortices and Columnar Defects

The motion of flux-line lattices in various single crystals of $NbSe_2$ has been observed by A. M. Troyanovskii (Leiden and IHPP-Moscow) et al. using fast scanning tunneling microscopy (STM). The total acquisition time to acquire one image (400 nm × 400 nm and 128 lines) was about 10 s. In crystals with weak point disorder (point pinning), slow collective motion of a large bundle of vortices was seen along one of the principal directions of the flux-line lattice. The longitudinal velocity was found to be modulated with a periodic component related to the vortex lattice parameter, while the transverse center-of-mass displacements were random. In crystals with strong line disorder (correlated pinning) caused by columnar defects produced via fast ion irradiation, collective pinning was observed in fields up to almost double the dose-equivalent field B_ϕ = 0.3 T, while interesting plastic-flow patterns were detected at $2B_\phi$. Movies of such vortex motion can be accessed at the web site http://rulgm5.leidenuniv.nl/~msm/msmain using the link Selected new results.

Reversible magnetization measurements by R. J. Drost (Leiden) et al. show that the pinning energy of vortices localized on amorphous tracks created in $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* single crystals by heavy-ion irradiation can be adjusted by altering the irradiation angle. The pinning energy is found to be proportional to the cross-sectional area of the defects in the CuO_2 planes. Both this size dependence and the observed quadratic temperature dependence of the pinning energy imply a predominant vortex core pinning interaction of pancake vortices with columnar defects, as opposed to an electromagnetic pinning mechanism. The authors also present an independent determination of the value of the Ginzburg-Landau coherence length.

The angular dependence of the irreversible magnetization of $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* crystals with columnar defects inclined from the c axis has been analyzed by A. Silhanek (Bariloche) et al. At high fields, the authors observed a sharp maximum centered on the track direction. At low fields, the authors identified a lock-in phase characterized by an angle-dependent pinning strength, and they found an angular shift of the peak towards the c axis. The interplay among columnar defects, twins, and ab planes generates a variety of staircase structures. The authors show that correlated pinning dominates for all field orientations.

A preprint by G. Pasquini (Buenos Aires) et al. reports the use of ac susceptibility measurements to explore the dynamic response of vortices in *YBCO* single crystals pinned by aligned columnar defects in low dc magnetic fields. Using a combination of techniques for the analysis of the data, the authors investigate the vortex motion as a function of amplitude and frequency of the applied ac field h_{ac}, identifying the influence of both intra- and inter-valley motion. The authors build up a dynamic diagram in the h_{ac} vs T plane, indicating the crossover lines among several regimes in the vortex-solid phase. At low h_{ac}, a linear response with very low dissipation arises from the oscillation of pinned vortices inside the tracks (Campbell regime), while at high h_{ac}, a critical state develops.

Vortex-motion noise in epitaxial $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* films in magnetic fields before and after the introduction of columnar defects via heavy-ion irradiation has

been studied by D. H. Kim (Argonne and Yeungnam) et al. The authors found that irradiation resulted in an increase in the noise-peak height. The authors attribute this increase to a larger vortex bundle size, probably due to an increased length of vortex segments arising from interactions with pinned vortices in columnar defects.

The surface resistance R_S of *YBCO* thin films containing columnar defects produced upon irradiation by 0.9 GeV *Pb* ions has been measured by J. Wosik (TCSUH) et al. At low temperatures, no significant difference was observed between the surface resistance of irradiated and unirradiated films. At higher temperatures, however, the irradiated films exhibited not only a higher R_S but also a nonlinear dependence of R_S on magnetic field. The authors model the behavior in terms of additional losses and/or heating effects in the insulator/superconductor boundary between the amorphous core of the columnar defect (a few nm in diameter) and the surrounding superconducting material.

More Vortices

Using a miniature two-coil mutual-inductance technique, Y. Ando (CRIEPI) and K. Nakamura (CRIEPI and Tokyo Tech) have investigated the linear ac response of the vortex system locally in $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* crystals at various doping. The authors found that a step-like change in the local ac response takes place exactly at the first-order transition (FOT) temperature $T_{FOT}(H)$ determined by a global dc magnetization measurement. The $T_{FOT}(H)$ becomes steeper with increasing doping. In the higher-field region where the FOT is not observed, the local ac response still shows a broadened but distinct feature, which can be interpreted as marking the growth of short-range order in the vortex system.

As reported by M. Nohara (Tokyo and CREST) et al., the quasiparticle density of states (DOS) in the vortex state has been probed by specific-heat measurements in a magnetic field H for clean and dirty superconductors $Y(Ni_{1-x}Pt_x)B_2C$ and $Nb_{1-x}Ta_xSe_2$. The authors find that the quasiparticle DOS per vortex is H-dependent in the clean limit, while it is H-independent in the dirty limit. The authors suggest that their results may be understood in terms of shrinking of the vortex-core radius with increasing magnetic field.

The vortex-lattice structure in an orthorhombic d-wave superconductor in a magnetic field parallel to the c axis has been studied theoretically by Q. Han and L. Zhang (Peking). As the temperature decreases, the authors predict a second-order phase transition, at which the lattice structure should change from a body-centered rectangular lattice elongated along the b-axis direction, but with no rotation relative to the underlying crystal, to a rectangular lattice elongated along the a-axis direction. The authors' theory cannot explain the experimentally observed vortex lattice.

Using an array of miniature Hall probes, K. Behnia (Orsay) et al. have monitored the temporal variation of magnetic-field profiles in a superconducting *Nb* sample during slow sweeps of the external magnetic field. The authors found that a sizable fraction of the increase in the local vortex population occurs in abrupt jumps. The size distribution of these avalanches is described by a power law over a limited range. In contrast, at low temperatures and low fields, huge avalanches with a typical size occur, and the system does not display a well-defined macroscopic critical current.

The time-dependent Ginzburg-Landau equations (TDGL) have been solved by M. Ghinovker (Bar-Ilan) et al. for the case of a type-II superconductor cooled through T_c into its superconducting state in the presence of a small magnetic field. The authors find numerically that the restoration of superconductivity is accompanied by the nucleation of both vortices and antivortices. The authors find that when pinning centers are present, a state consisting of physically separated vortices and antivortices can persist for a long time.

Studies of the dc magnetization of thin, platelike samples of the isotropic type-II superconductor *PbTl*(10%) have been carried out by S. Candia and L. Civale (Bariloche) as a function of the angle between the normal to the sample and the applied magnetic field **H**. The authors determined the magnetization vector **M** by measuring the components both parallel and normal to **H** in a SQUID magnetometer, and they further decomposed **M** into its reversible and irreversible contributions.

A preprint by I. M. Obaidat et al. (UIC) reports magnetization measurements in which a $YBa_2Cu_3O_{7-\delta}$ crystal was cooled to 4.2 K in a magnetic field **H** along the c axis, and then was tilted such that the angle θ between **H** and the c axis varied from 0° to 180°. The authors measured the magnetization **M** of the crystal vs θ and found evidence for the entry of anti-vortices into the sample.

A preprint by V. M. Krasnov (Göteborg and ISSP-Chernogolovka) reports the derivation of an approximate analytic solution for the gauge-invariant phase differences and the local magnetic fields generated by a single fluxon in one of the two Josephson junctions in double stacked Josephson junctions (SJJ's). The author derives the approximate solution for arbitrary junction parameters and coupling strengths, and analyzes the accuracy using perturbation theory.

An extension of the above work is described in a preprint by V. M. Krasnov (Göteborg and ISSP-Chernogolovka) and D. Winkler (Göteborg), who study numerically and analytically

the shape of single fluxons moving at high speeds in double stacked Josephson junctions (SJJ's) for various junction parameters. The authors find that the fluxons can be characterized by two components, with different Swihart velocities and Josephson penetration depths. The authors find that such fluxons may have an unusual shape with an inverted magnetic field in the second junction when the velocity of the fluxon is approaching the lower Swihart velocity. The authors also study the influence of fluxon shape on the flux-flow current-voltage characteristics, and they analyze the spectrum of Cerenkov radiation for fluxon velocities above the lower Swihart velocity.

$RBa_2Cu_3O_{7-\delta}$

The first-order melting transition of the flux-line lattice in a twinned $NdBa_2Cu_3O_{7-\delta}$ *(NBCO)* single crystal grown under low oxygen partial pressure has been observed by A. K. Pradhan et al. (SRL-ISTEC) via transport measurements (a kink in the resistance vs temperature). The authors report that the melting transition is distinctly observed for oxygen partial pressures up to 0.05% during growth and that the transition becomes continuous for higher oxygen pressures. Crystals showing the first-order melting transition do not show a peak effect in J_c vs B, but a significant peak effect develops for crystals grown under oxygen pressures greater than 0.06%.

Binary *(Nd,Sm)*$Ba_2Cu_3O_{7-\delta}$ *[(Nd,Sm)-123]* single-grain bulk superconductors with T_c = 96 K and a high irreversibility field up to 8 T at 77 K have been fabricated in air by A. Hu et al. (Dresden) using a newly developed technique. The initial composition was controlled by using binary $(Nd,Sm)_2BaO_4$ as an addition. The authors found that the present composition yielded critical current densities in the intermediate field regime (1-3 T) larger than those of melt-textured $NdBa_2Cu_3O_{7-\delta}$ and $YBa_2Cu_3O_{7-\delta}$. Microstructural and compositional analysis showed that the *Nd* and *Sm* distributions in the *(Nd,Sm)-123* matrix were homogeneous, but that the atomic ratio of *Nd* to *Sm* was different from that in the nominal composition. The authors suggest that this is due to the different solubilities of *Nd* and *Sm* in the liquid phase.

Bi Cuprates

The anisotropic resistivities of $Bi_2Sr_2Ca_{1-x}Er_xCu_2O_{8+\delta}$ single crystals have been measured and analyzed from 4.2 K to 500 K by T. Kitajima et al. (Waseda), with a focus on the parent antiferromagnetic insulator, x = 1.0. Although the resistivity is semiconducting along both the in-plane and out-of-plane directions, the ratio $\rho_c(T)/\rho_{ab}(T)$ is not a constant; this ratio has a broad maximum near room temperature for x = 1.0. The authors propose that confinement in the CuO_2 plane is at work in the two-dimensional spin-fluctuation regime regardless of the doping level.

Transport ac losses in silver-sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$ *[(Bi,Pb)-2223]* multifilamentary tape in the form of a helix with a 3 mm gap between the turns have been measured by M. Majoros (IRC-Cambridge and Bratislava) et al. in the frequency range 40-125 Hz. The authors found that the apparent losses depend upon the positions of the potential taps and placement of the voltage leads. The authors report that various arrangements measure different contributions to the total losses.

The effects of low oxygen partial pressure and high *Pb* doping in $Bi_{2.2-x}Pb_xSr_2CaCu_2O_{8+\delta}$ *[(Bi,Pb)-2212]* have been investigated experimentally by A. L. Crossley et al. (Imperial). The *Pb* additions resulted in an increase in the intragranular flux pinning at temperatures above 40 K.

Electron-tunneling spectroscopy of pure, *Ni*-doped, and *Zn*-doped $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* has been carried out by A. Mourachkine (Brussels) using a break-junction technique. To explain the data, the author introduces a model involving spinon superconductivity along charge stripes, with coherence among stripes being established by spin waves perpendicular to the stripes.

$La_{2-x}Sr_xCuO_4$

A preprint by S. Wakimoto (Brookhaven and Tohoku) et al. describes neutron-scattering experiments on lightly doped $La_{2-x}Sr_xCuO_4$ *(LSCO)* single crystals in both the insulating (x = 0.03, 0.04, and 0.05) and superconducting (x = 0.06) regions. The authors observed elastic magnetic peaks at low temperatures in all samples, with the maximum peak linewidth occurring at the critical concentration x_c = 0.05. New incommensurate peaks were observed only at x = 0.05, and their positions were rotated by 45° in reciprocal space about (π,π) from those observed for $x \geq 0.06$ in the superconducting phase.

Using a combination of ac susceptibility and muon spin relaxation (μSR), C. Panagopoulos (IRC-Cambridge) et al. have measured the absolute values of the in-plane magnetic penetration depth λ_{ab} of $La_{2-x}Sr_xCuO_4$ *(LSCO)* and $HgBa_2CuO_{4+\delta}$ *(Hg-1201)* as a function of temperature and carrier concentration. In the overdoped region, the authors found that the zero-temperature superfluid density $\rho_S(0)$ is approximately constant and that $\rho_S(T)/\rho_S(0)$ is in reasonably good agreement with the weak-coupling d-wave temperature dependence. In the optimal and underdoped regions, however, $\rho_S(0)$ is rapidly suppressed and there is a marked departure of $\rho_S(T)/\rho_S(0)$ from the weak-coupling

curve. The authors point out a possible correlation between ρ_S and the normal-state energy gap (pseudogap).

Hg Cuprates

As stressed in a preprint by J. A. Wilson and M. Farbod (Bristol), Seebeck data provide valuable information on high-temperature superconducting (HTS) materials over a wide doping range. The authors closely examine Seebeck thermoelectric results from $HgBa_2CuO_{4+\delta}$ *(Hg-1201)* in an effort to understand the normal-state behavior and the approach to superconductivity. The authors discuss the generality of the Seebeck data in all HTS systems, and they expand the pseudogap treatment of G. Hildebrand et al. [*Phys. Rev. B* **56**, R4317 (1997)] to incorporate stripe-phase behavior and a principally electronic negative-U approach to HTS. The authors discuss pseudogap formation in light of recent angle-resolved photoelectron spectroscopy (ARPES) and tunneling results. The paper emphasizes the importance of the following aspects to the mechanism of superconductivity in the cuprates: two-dimensionality, square-planar geometry, saddle points, two-subsystem mixed-valent organization, and resonant shell-filling-driven negative-U fluctuations.

A closely related paper by M. Farbod et al. (Bristol) reports an examination of the Seebeck behavior of $HgBa_2CuO_{4+\delta}$ *(Hg-1201).* The authors report that this system, whether stoichiometric or *Hg*-deficient, appears to behave in a fashion similar to the $La_{2-x}Sr_xCuO_4$ and $YBa_2Cu_3O_{7-\delta}$ systems in that a dip in $T_c(p)$ appears at p ~ 1/8 (p = hole count). The authors take this concentration of holes to mark the point at which stripe-phase formation in the organization of charge and spin in the two-subsystem, mixed-valent, HTS materials changes from one charge-wall-loading scheme to another.

Junctions

The effect of a magnetic field upon the Josephson critical current of a junction between two d-wave superconductors has been investigated theoretically by X.-Z. Yan (Texas A&M and Beijing) and C.-R. Hu (Texas A&M). The authors find that when the crystal orientation of one (or each) superconductor relative to the interface normal is such that midgap states exist at the interface, there is a component of the tunneling current due to the midgap states. For a junction with a flat {001}/{110} or {100}/{110} interface, this component makes the predominant contribution to the current. The predicted current vs field dependence differs significantly from the conventional Frauenhofer pattern and is in agreement with recent measurements by Y. Ishimaru et al. [*Phys. Rev. B* **55**, 11851 (1997)] on *YBCO* junctions. This occurs because the critical current depends upon not only the Frauenhofer factor but also the current density, which is a linear function of B for weak B.

The dc Josephson current in unconventional superconductor / ferromagnet / unconventional superconductor (S/F/S) junctions has been studied theoretically by Y. Tanaka (Nagoya) and S. Kashiwaya (ETL). The authors find that when both superconductors have d-wave symmetry, the Josephson current is drastically suppressed as the exchange interaction increases. On the other hand, when the two superconductors have different parities (e.g., s-wave and p-wave), the Josephson current increases as the exchange interaction increases.

A preprint by Y. Tanaka (Nagoya) et al. presents a theory for the Josephson effect in an unconventional superconductor / one-dimensional electron gas / unconventional superconductor (S/O/S) junction, where the Josephson current is carried by components injected perpendicular to the interface. The authors find that when the superconductors on both sides have triplet symmetry, the Josephson current is enhanced at low temperature because of zero-energy states formed near the interface. The authors suggest that the parity of the superconductor can be identified by measuring the Josephson current in an S/O/S junction.

The nonequilibrium current noise in voltage-biased short disordered superconductor / normal-metal / superconductor (S/N/S) Josephson junctions has been calculated by Y. Naveh and D. V. Averin (SUNY-Stony Brook) within the scattering theory of multiple Andreev reflections. The predicted noise exhibits subharmonic gap structure, “quantization” of the effective charge q*, a pronounced zero-temperature singularity at low bias voltages, and excess noise at large voltages.

$YBa_2Cu_3O_{7-\delta}$ *(YBCO)* artificial grain-boundary Josephson junctions have been fabricated by F. Tafuri (Napoli) et al. by controlling the orientation of the *MgO* seed layer, which results in 45° tilt and twist boundaries. The authors found that the tilt and twist boundaries exhibited significant differences in their Josephson properties.

The phase-dependent differential thermopower of s-wave superconductor / normal-metal / d-wave superconductor (S/N/D) junctions has been calculated by S. Sergeenkov and M. Ausloos (Liege). The authors discuss the experimental conditions under which predicted behavior could be measured.

Films

The B-T phase diagram for thin-film $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* with **B** parallel to the superconducting layers has been constructed by J. L. O’Brien (New South Wales) et al.

from GHz transport measurements to 150 T. The authors find evidence for a transition from a high-T regime, dominated by orbital effects, to a low-T regime, where paramagnetic limiting drives the quenching of superconductivity. Up to 110 T, the upper critical field is found to be linear in T and in remarkable agreement with extrapolation of magnetization measurements up to 6 T by U. Welp et al. [*Phys. Rev. Lett.* **62**, 1908 (1989)]. Beyond this, however, a departure from linear behavior occurs at T = 74 K, where a 3D-2D crossover is expected to occur.

A simple technique for the growth of ribbonlike single-crystalline films of $Bi_2Sr_2CaCu_2O_{8+\delta}$ *(Bi-2212)* on *Ag* substrates has been developed by S. Arisawa (NRIM and CREST) et al. The films were produced under ambient pressure by melting *Bi-2212* powder on the substrate. The ribbons were found to be extremely thin (~1 μm) and to stick firmly to the substrate. The ribbonlike films showed superconducting transitions with an onset temperature of ~80 K.

The normal-state and superconducting properties of $La_{1.85}Sr_{0.15}CuO_4$ *(LSCO)* thin films have been measured by W. Si et al. (Penn State) as a function of lattice strain and oxygen content. The authors report that both full oxygenation and compressive in-plane strain are critical for the properties of these films.

The field and angular dependencies of the resistive broadening of epitaxial $(YBa_2Cu_3O_{7-\delta})_{24}/(PrBa_2Cu_3O_{7-\delta})_2$ multilayer thin films have been measured by Z. H. Wang (Shanghai) et al. The results for the activation energy U and the characteristic temperature T* can be scaled by the 2D model proposed by P. H. Kes et al. [*Phys. Rev. Lett.* **64**, 267 (1990)].

Applications

A preprint by E. Broide (Separator Ltd.) reports an experimental investigation of the abnormally high sensitivity to low-power impulse electromagnetic radiation (IEMR) in systems that include a sensing element consisting of a resonant circuit with a secondary coil and a high-temperature superconductor (HTS) core. The core was produced using epoxied composites containing HTS powder *[*$YBa_2Cu_3O_{7-\delta}$ and $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+\delta}$*]*. The author suggests the possibility of applications in small antennas operating at the temperature of liquid nitrogen.

Theory

Laser pump/probe experiments by C. J. Stevens et al. [*Phys. Rev. Lett.* **78**, 2212 (1997)] on $YBa_2Cu_3O_7$ and thermomodulation optical data and analysis by M. J. Holcomb et al. [*Phys. Rev. B* **53**, 6734 (1996)] on a selection of HTS materials have been theoretically examined by J. A. Wilson (Bristol). The work centers on universal 1.5 eV - 2 eV features that appear below T_c. The author argues that these are not simple p-to-d band-to-band excitations but instead are associated with the mixed-valent and negative-U states that are responsible for the high-temperature superconductivity.

An explanation of the negative isotope effect observed for *Cu* in underdoped $YBa_2Cu_3O_{7-\delta}$ is proposed in a preprint by A. A. Abrikosov (Argonne). The author shows that such an effect can be due to scattering of electrons from low-frequency phonons that are not associated with oscillations of the total ionic charge density. The negative isotope effect is specific to superconducting layered cuprates with a d-wave order parameter and is absent in s-wave superconductors. Although the theory does not reproduce all observed features of the dependence of the isotope effect on oxygen concentration, it agrees qualitatively with the general trend of enhancement with decreasing T_c.

Calculations of the optical conductivity for a two-dimensional system using a simple model of the electronic spectrum with "hot patches" on the Fermi surface, with non-Fermi-liquid renormalization of the spectral density (pseudogap) on these patches, have been carried out by M. V. Sadovskii (Ekaterinburg). The author shows that this model qualitatively reproduces basic anomalies of optical experiments in the pseudogap state of the cuprates.

A preprint by D.-H. Lee (UC-Berkeley) takes the point of view that at short distances and high energies, the undoped and underdoped cuprates resemble the π-flux phase of the t-J model. The author presents a mechanism by which pairing grows out of the doped π-flux phase, and pairing symmetry is determined by a parameter controlling the quantum tunneling of gauge flux quanta. For zero tunneling, the symmetry is $d_{x^2-y^2} + id_{xy}$, while for large tunneling it is $d_{x^2-y^2}$; a zero-temperature critical point separates these two limits.

Two preprints by M. Matsumoto (Shizuoka) and M. Sigrist (Shizuoka and Kyoto) theoretically explore ways of probing the possibility of $p_x \pm ip_y$ order-parameter symmetry in superconducting Sr_2RuO_4. One of the preprints examines chiral optical absorption by a single vortex. Because there are two types of vortices, with winding orientations the same as or opposite to the angular momentum of the Cooper pair, chiral optical absorption is a possible experiment to detect the orbital-dependent superconductivity. The other preprint examines the spectrum of electronic states near a surface or a domain wall in a p-wave superconductor, which may be observable by scanning tunneling microscopy (STM).

Qualitative features of the mean-field BCS-like theory of superconductivity in a strongly disordered system of fermions with short-range order are discussed in a paper

by I. F. Herbut (Dalhousie). For the case of infinite-range hopping, the superconducting gap is uniform in space, and there is a smooth BCS-BEC (Bose-Einstein-condensation) crossover with decrease in density at weak disorder; at moderate densities, or larger disorder, the mean-field ground state is the "localized superconductor" of M. Ma and P. A. Lee [*Phys. Rev. B* **32**, 5658 (1985)]. For nearest-neighbor hopping between localized states, the gap becomes highly nonuniform in space but stays finite everywhere at temperatures less than the mean-field transition temperature T_{MF}.

A preprint by K. Tanaka and F. Marsiglio (Alberta) tests the canonical BCS wave functions for fixed number of electrons for the attractive Hubbard model. The authors present results in one dimension for various chain lengths, electron densities, and coupling strengths.

Four papers listed in this issue, all with first author A. Aftalion (Ecole Normale Supérieure), discuss fundamental mathematical properties of one-dimensional solutions (e.g., dependent only upon the coordinate x) of the time-independent Ginzburg-Landau equations of superconductivity.

Other Activities

Further improvements in the design of a scanning evanescent microwave microscope (SEMM), capable of quantitative measurements of dielectric properties and surface resistance with submicron spatial resolution, are described in a preprint by F. Duewer et al. (LBNL). Using tip-sample feedback control, the authors have been able to achieve simultaneous noncontact imaging of topography and surface resistance with high spatial resolution.

Measurements of the Hall effect in the borocarbides $LuNi_2B_2C$ and YNi_2B_2C are reported by V. N. Narozhnyi (IHPP-Troitsk, Dresden, and Wroclaw) et al. for both the normal state and the superconducting mixed state. The behavior of both compounds was found to be quite similar in the mixed state, but the magnetoresistance in the normal state was found to be much larger in $LuNi_2B_2C$ than in YNi_2B_2C. The authors attribute the differences in behavior to differences in the topology of the Fermi surfaces of these compounds.

As noted in a preprint by J. A. Wilson (Bristol), the layered chloro-nitride β-*HfNCl,* when partially intercalated with organo-solvated *Li,* shows superconductivity at 26 K. The author discusses the origin of superconductivity in this material and suggests that a scenario similar to that for the Rb_3C_{60} family of intercalated fullerenes might be appropriate.

Ph.D. Thesis

An investigation of nonlinear microwave emission by $YBa_2Cu_3O_{7-\delta}$ *(YBCO)* and $Ba_{0.6}K_{0.4}BiO_3$ *(BKBO)* is reported in the Ph.D. thesis of A. A. Gallitto (Palermo). The author studied the second- and third-harmonic signals as a function of temperature, applied magnetic field, and input power level, and proposed a phenomenological theory of these effects, which accounts for the results in *YBCO* near T_c at low applied field. In *BKBO,* the author suggests that harmonic emission at temperatures far from T_c may be due to nonlinear processes in weak links (74 refs.).

Contributed by John R. Clem

Contents:

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TECHNOLOGY NEWS

(Also see Applications section of Nota Bene.)

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

The Superconductivity Group of Metal Manufactures Ltd. (MM) has been elected to membership of the Australian Technology Showcase (ATS), an international campaign to promote Australian innovation in the spotlight of the 2000 Olympics. The Superconductivity Group works in a strategic partnership with the University of Wollongong which is engaged in HTS research. The MM group has already supplied HTS tape to the southeast Asian region, and has recently marketed HTS products to Europe and North America. The company supplies *Bi-2223* tapes

with different sheathing materials *(Ag, Ag-Au, Ag-Mg,* etc.), and filaments n = 1 to 61, carrying currents in excess of 40 A and J_c values > 20,000 A/cm^2. Filaments can be twisted for low ac loss, or supplied in the tape-in-tube or wire-in-tube formats. MM also supplies high-current busbars, leads, and cables, and items fabricated from HTS tape such as coils in racetrack, solenoidal, or torroidal formats. MM has a broad and active in-house R&D effort, which is carried out in close collaboration with the University of Wollongong, and is currently working on fundamental mechanisms and processes in high-temperature superconductors, new fabrication technologies for *Bi-2223* tapes, and has just set up a facility to investigate the manufacture of *YBCO*/Hasteloy tapes using PLD. The marketing strategy of MM will include the use of its patent base for both commercial protection and for future bargaining. Cross-licensing deals are thought to be the most likely activities in any future HTS strategic alliances with overseas companies. For further infomation, contact Tim Beales, Superconductivity Manager, Metal Manufactures Ltd., Level 33, Gateway, Sydney, NSW 2000, Australia; telephone +61 2 4221 5725; telefax +61 2 4221 5731; e-mail tb1960@msn.com.au.

As announced by Superconductor Technologies Inc. (STI), new SuperFilter(R) SIX-Pak Cellular A-Band and B-Band front-end filter and amplifier systems were recently introduced for the wireless communications industry. The product simultaneously delivers selectivity and sensitivity as a result of the company's proprietary superconducting materials and cryogenic technologies. The SuperFilter(R) SIX-Pak resolves base-station performance tradeoffs and delivers good coverage extension and interference rejection in a practical, low-profile package. The six-in-one design combines all the filters and LNAs (low-noise amplifiers) needed in fully sectored cellular base stations, reducing per-rf path pricing by 40% or more for all base station types. STI's filter and amplifier systems effectively deepen coverage in urban cells and extend coverage in suburban or rural cells. Industry standard rack-mount packaging measures a compact 17" × 25" × 7". At 130 W, the SuperFilter(R) SIX-Pak has very low power requirements and operates on a standard 27 V power supply. Company officials state that the self-contained SuperFilter(R) SIX-Pak is a maintenance-free solution for enhanced base-station performance. For more information, contact Blake Isaacs, Director of Marketing, or Jim Evans, Chief Financial Officer, Superconductor Technologies Inc., 460 Ward Drive, Santa Barbara, CA 93111; telephone (805) 683-7646; telefax (805) 967-0342; e-mail info@suptech.com; Web site http://www.suptech.com.

Contributed by Sreeparna Mitra

PREPRINTS

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A. A. Abrikosov, "Theory of the Negative Isotope Effect on Copper in Underdoped *YBCO*." Contact Janice Coble, Materials Science Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439; telephone (630) 252-5497; telefax (630) 252-9595; e-mail coble@anl.gov. 74.20.Fg; 74.25.Kc; 74.62.Dh; 74.72.Bk.

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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 25 - 28, 1999: Fifth Twente Workshop – Digital Applications, Josephson Junctions and Sensors, Low Temperature Division, University of Twente, The Netherlands. Aim of this meeting is an international exchange of latest results on the electronic applications of superconductors. Workshop will have an extended review on the subjects to show what the expectations are, and what can be realized. Subjects for this years workshop are: digital applications, RSFQ-logic, sensors, film growth, Josephson junctions, and interconnects. Morning sessions devoted to invited talks with discussion breaks; afternoon sessions to include contributed papers and daily poster sessions. Number of participants is limited to 50. For information, contact Ir. H.J.H. Smilde, University of Twente, Department of Applied Physics (TN/LT), P.O. Box 217, 7500 AE Enschede, The Netherlands; telephone +31 53 489 3841; telefax +31 53 489 1099; e-mail h.j.h.smilde@tn.utwente.nl; Web site http://www.esas.org/workshops/twente5.

July 12 - 23, 1999: XI Workshop on Strongly Correlated Electron Systems, International Centre for Theoretical Physics, Trieste, Italy. Will contain a special focus on open problems and perspectives in strong correlation physics. The workshop will include both experimentalists and theorists, and will foster the interaction between them. Topics of special attention include: quantum phase transitions, realizations of correlated electron physics in mesoscopic devices, experimentally motivated aspects of cuprate physics, giant magnetoresistance and novel phenomena in transition metal oxides, complex heavy fermions, and quantum glasses. Scientists and students from all countries that are members of the UN, UNESCO or IAEA can attend the Workshop. Funds to cover local expenses for a very limited number of participants available. Workshop will be conducted in English. **Application deadline, April 30, 1999.** Contact XI Workshop on Strongly Correlated Electron Systems, The Abdus Salam International Centre for Theoretical Physics, P.O. Box 586, I-34100 Trieste, Italy; telephone +39 40 2240111; telefax +39 40 224163; e-mail smr1144@ictp.trieste.it.

July 19 - 24, 1999: International Summer School, Advanced Methods in Surfaces and Interfaces. Objective of the school is to present and discuss the most recent advances in surface and interface science. Speakers will present pedagogical lectures on advanced experimental and theoretical studies of superconductors, semiconductors, metals and biomaterials. Topics will include (among others): optical methods, spectromicroscopy, synchrotron radiation related techniques, electron microscopy, electron holography, x-ray diffraction, scanning tunneling microscopy and spectroscopy (STM, STS), photoreaction and photostimulated desorption, helium atom beam scattering, dichroism, absorption spectroscopy, STM image simulation, new generation synchrotron sources. Limited to 80 participants/students. **Preregistration deadline, May 31, 1999.** For more information, contact Claude Zwicky, IPA-EPFL, CH-1015 Lausanne, Switzerland; telefax +41 21 693 4666; e-mail zwicky@ipasg.epfl.ch; Web site http://dpwww.epfl.ch/surfaces99/.

Aug. 4 - 11, 1999:* 22nd International Conference on Low Temperature Physics (LT22), Helsinki University of Technology (HUT), Otaniemi, Espoo and Helsinki, Finland. Topics will include: quantum gases, fluids, and solids; superconductivity; magnetism and lattice properties; quantum electron transport; applications; materials; and techniques. LT22 will have limited funds to assist graduate students, junior faculty, as well as participants from institutions and countries where support is difficult to obtain. **Preregistration and abstract deadline, April 15, 1999. Proceedings will appear as a special issue of *Physica B – Cond. Mat.,* in April 2000. For information, contact Conference Service Bureau, TSG-Congress Ltd., Kaisaniemenkatu 3 B 31, FIN-00100 Helsinki, Finland; telephone +358 9 628044; telefax +358 9 667675; e-mail info@tsgcongress.fi. For technical information, contact the LT22 Office, Low Temperature Laboratory, Helsinki University of Technology, P.O. Box 2200, FIN-02015 HUT, Finland; telephone +358 9 451 2962; telefax +358 9 451 2969; e-mail info@LT22.hut.fi; Web site http://lt22.hut.fi/LT22/LT22.html.

Aug. 27 - 29, 1999: Workshop on Superlattice and Microstructures, Cancun, Mexico. Tentative topics are: a) Preparation and Characterization – growth, scanning probe microscopy, microscopy, surface techniques, x-rays, lithography; b) Superconductivity – tunneling; superlattices,

Josephson junctions, small structures, thin films, vortices; c) Magnetism – exchange bias, transport, tunneling, collective modes, magnetotransport; d) Semiconductors – quantum hall effect, optical properties of superlattices, surfaces; e) Unusual Systems – amorphous, microstructures, oxides, complex materials, transport through one atom. For information, contact one of the organizers: Ciro Falcony, Departamento de Física, Centro de Investigacion y de Estudios Avanzados del, IPN, P.O. Box 14-740, México, 07000 D.F., Mexico; telephone +525 747 3800, ext. 6168 or 6159; telefax +525 747 7097; e-mail cfalcony@fis.cinvestav.mx or Ivan K. Schuller, Department of Physics, University of California, San Diego, La Jolla, CA 92093-0319; e-mail ischuller@ucsd.edu. Information also available at http://web.telesat.com.co/~tablaz/cancun99/index.html.

**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 (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. 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.

Nov. 15 - 18, 1999: 44th Annual Conference on Magnetism and Magnetic Materials, Fairmont Hotel, San Jose, Calif. The Conference annually brings together scientists and engineers interested in recent developments in all branches of fundamental and applied magnetism. Emphasis is placed on experimental and theoretical research in magnetism, the properties and synthesis of new magnetic materials, and advances in magnetic technology. Invited and contributed papers. Topics are: fundamental properties, cooperative phenomena and strongly correlated systems, transport properties, computational magnetics and imaging, soft magnetic materials and applications, hard magnetic materials and applications, structured materials, other magnetic materials, magnetic recording, applications, and interdisciplinary topics. **Abstract deadline, May 15, 1999.** Proceedings will be published in *J. Appl. Phys.* For information, contact Diane Suiters, Conference Coordinator, Courtesy Associates, 2000 L Street, NW Suite 710, Washington, DC 20036; phone (202) 973-8668; fax (202) 973-8722; e-mail magnetism@courtesyassoc.com; Web site http://www. magnetism.org/.

RESOURCES

Information

Proceedings: *Symmetry and Pairing in Superconductors* – Proceedings of the NATO Advanced Research Workshop, Yalta, Ukraine, April 29-May 2, 1998, edited by Marcel Ausloos and Sergei Kruchinin. Contains latest findings of leading researchers on high-T_c superconductivity, including considerations of the order parameter and the pairing conditions. Both theoretical and advanced experimental results are outlined. Considerations of d-, s-, or more complicated order-parameter symmetry are discussed at length, serving as a benchmark for an overall view of the field. Details of experiments on junctions and fluctuations, both in the presence and absence of a magnetic field are presented. Electronic, optical, magnetic, and transport properties are discussed. Publ. 1999; 424 pp.; price $192 (hardbound) or $84 (PB); ISBN 0-7923-5520-2 (HB) or 0-7923-5521-0 (PB). Contact Kluwer Academic Publishers, Customer Service Department, P.O. Box 358, Accord Station, Hingham, MA 02018-0358; telephone (781) 871-6600; telefax (781) 871-9045; e-mail kluwer@wkap.com. Outside the Americas, contact Kluwer Academic Publishers, Customer Service Department, P.O. Box 989, 3300 AZ Dordrecht, The Netherlands; telephone +31 78 639 23 92; telefax +31 78 639 22 54; e-mail services@wkap.nl.

New Book: *Electromagnetic Absorption in the Copper Oxide Superconductors,* by Frank J. Owens and Charles P. Poole, Jr. This volume presents an overview of the field with an emphasis on the new superconducting materials. Elementary introduction to superconductivity, properties most essential to understanding electromagnetic absorption of the superconducting state, outline of both basic theories and salient experimental results are presented. Contents are: the superconducting state, new superconductors, experimental methods and complementary techniques, electromagnetic absorption in the normal state, zero-magnetic-field microwave absorption, low-magnetic-field-induced microwave absorption, electromagnetic absorption due to vortex motion, infrared and optical absorption, applications, and index. Publ. 1999; 212 pp.; price $82.50; ISBN 0-306-45948-5. Contact Kluwer Academic Publishers, Order Department, P.O. Box 358, Accord Station, Hingham,

MA 02018-0358; telephone (781) 871-6600; telefax (781) 871-6528; e-mail kluwer@wkap.com. Outside the U.S., contact Kluwer Academic/Plenum Publishers, Book Department, P.O. Box 322, 3300 AH Dordrecht, The Netherlands; telephone +31 78 639 23 92; telefax +31 78 654 64 74; e-mail services@wkap.nl.

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