NATO

ADVANCED RESEARCH WORKSHOP

PROGRAM

Physics and Materials Sciences of High Temperature Superconductivity, IV

North Atlantic Treaty Organization
ADVANCED RESEARCH WORKSHOP

Physics and Materials Sciences of High Temperature Superconductivity, IV

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Dr. Ram Kossowsky, President
Emerging Technologies, Inc.
A Consulting Company
Pittsburgh, Pennsylvania, USA

Dr. Josef Novak, Director
Institute of Electrical Engineering
Slovak Academy of Science
Bratislava, Slovak Republic

Professor Miroslav Jelinek
Czech Academy of Science
Institute of Physics
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Program

Physics and Materials Science of
High Temperature Superconductivity

SUNDAY, 21 July 1996

14:30	Bus departs from Poprad Airport
15:00	Bus departs from Poprad Rail Station
19:15	Welcome party
20:00	Dinner

MONDAY, 22 July 1996

07:00-08:30	Breakfast
08:30-08:45	Welcome, procedural discussions. Dr. Ram Kossowsky
	Session I : Physics and Theory
	Chairman: Prof. Josef Novak
08:45-09:55	Prof. Thomas. Timusk : "The Unconventional Thermodynamics of High Temperature Superconductors" (1)
09:55-10:15	Discussion
10:15-11:00	Dr. Ann van Otterlo: "Vortices in Type II Superconductors" (2)
11:00-11:30	Break
11:30-11:45	Discussion
11:45-12:55	Prof. Vladimir Pan: Vortex Behavior in Different Pinning Potential for Moderately Anisotropic High T_c Superconductors (3)
12:55-13:10	Discussion
13:15-	Lunch
	Chairman: Prof. Thomas Timusk
16:30-17:15	Dr. Ernst Haase: "The Violation of the BCS Theory and the Extensions Required to Include the Effects of a Nearby Phase Transition" (4)
17:15-17:30	Discussion
17:30-18:15	V. F. Solovjov: "The Flux Line Lattice States in Single -Crystalline Superconductors with Weak Pinning" (5)
18:15-18:30	Discussion
18:30-19:00	Break
19:00-19:45	Prof. Kohiji Kishio: 'Chemical Control of Anisotropy and Flux Pinning in Hg-Based Superconductors" (6)
19:45-20:00	Discussion
20:00	Dinner -

TUESDAY, 23 July 1996

07:00-08:30	Breakfast
	Chairman: Prof. Vladimir Pan
08:30-09:15	Dr. Donglu Shi: "A Novel Approach to High In-Field J_c at 77 K in Bi-Sr-Ca-Cu-O (7)
09:15-09:30	Discussion
09:30-10:15	Prof. Sam Bose: "Exchange -Correlation Effects on Plasmon Mediated Superconductivity of a Layered Two-Dimensional System (8)
10:15-10:30	Discussion
10:30-11:00	Break

11:00-11:45	Dr. Nicole Bontempts: "Microwave Dissipation and the Structure of the Vortex Lattice in $Bi_2Sr_2CaCu_2O_{8-\delta}$ **(9)**
11:45-12:00	Discussion
12:00-12:30	Dr. V.V. Kabanov: "Theory of Superconducting T_c of Doped Fullerenes" (10)
12:30-12:45	Discussion
13:00	Lunch
14:30:-22:30	Excursion: Wooden Float rafting on the frontier river Dunajec. About a 4 Km cruise through a narrow canyon. Evening meal included. Dinner. **Cost: $15.00 per person.**

WEDNESDAY, 24 July 1996

07:00-08:30	Breakfast
08:30-10:00	**PANEL Discussion**, Moderator, Prof. Vladimir Pan: "Theory and Practice Outlook for Pinning. Is it Achievable? "
	Session II : Materials and Materials Science
	Chairman: Prof. Miroslav Jelinek
10:00-11:10	Dr. James Jorgensen: "Structural Features That Control the Properties of High-T_c Superconductors" (11)
11:10-11:30	Discussion
11:30-11:45	Break
11:45-12:30	Dr. John Market: "Studies of Infinite -Layer, T'-Phase and 1-D-Ladder Copper-Oxide Compounds" (12)
12:30-12:45	Discussion
13:00-	Lunch Set Up Posters, Session 1.
	Chairman: Prof. Anatoli Nikulin
16:30-17:40	Prof. Vsevolod Gantmackher: "The Superconducting Response and Scaling Relations in the Metastable Alloys Near the Superconductor-Insulator Transition" (13)
17:40-18:00	Discussion
18:00-18:45	Break
18:45-19:15	Dr. Anwar ul Haq: "Synthesis of New HTSC for Perspective Applicatiuons"(14)
19:15-19:30	Discussion
19:30-20:15	Poster Session 1-A
20:15	Dinner

THURSDAY, 25 July 1996

07:00-08:30	Breakfast
	Session III: Thin Films
	Chairman: Dr. John Jorgensen
08:30-09:40	Dr. Alex Braginski: "Thin Film Devices" (15)
09:40-10:00	Discussion
10:00-10:45	Dr. Bernd Kabius: "Microstructure of Artificial Grain Boundaries in Thin Films of $Yba_2Cu_3O_7$ and $Bi_2Sr_2CaCu_2O_8$ (16)
10:45:11:00	Break

11:00-11:15	Discussion
11:15-11:45	Miroslav Jelinek: "Pulsed Laser Deposition of Thin Films" (17)
11:45-11:55	Discussion
11:55-12:35	Martin Forrester: "HTS Digital Integrated Circuit Fabrication" (18)
12:35-12:45	Discussion
12:45-13:30	Poster Session 1-B
13:30	Lunch
	Set Up Posters for Second Session
	Chairman: Dr. Norbert Klein
16:30-17:00	John Hermann: "Low Temperature H-T Phase Diagram of $Nd_{1.85}Ce_{0.15}$ $CuO_{4-\delta}$ Thin Films (19)
17:00-17:15	Discussion
17:15-17:45	Break
17:45-18:15	G. Gibson: "Structural Disorder Investigation of YBCO 123 Thin Films Using Raman Microscopy" (20)
18:15:18:30	Discussion
18:30- 20:00	Poster Session 2-A
20:00-	Farewell Dinner. Folk Music Band

FRIDAY, 26 July 1996

07:00-08:30	Breakfast
	Session IV: Applications
	Chairman: Dr. Ram Kossowksy
08:30-09:40	Prof. A. D. Nikulin: "Materials Science Foundation for Technical Superconductors" (21)
09:40-10:00	Discussion
10:00-10:45	Prof. Leao Rodrigues: "Novel Superconducting Electrical Machines" (22)
10:45-11:00	Discussion
11:00-11:30	Break
11:00-12:10	Dr. Norbert Klein: "Applications of High Temperature Superconductors in Microwave Technology- A State of the Art Report" (23)
12:10-12:30	Discussion
13:00	Lunch
16:00-17:00	Poster Session 2-B
17:00-18:30	**Panel Discussion** - Moderator, Dr. Alex Braginski: "Are Thin Film Devices Closer to Reality, vis-a-vis Bulk Materials? Compare the two -Defects, Compositional Uniformity, Oxygen Profile....
18:30-18:45	Break
18:45-20:15	**Panel Discussion** - Moderator: Dr. John Jorgensen: "The General Outlook After 10 years of Most Extensive Research - Materials, Machines, Funding, etc.
20:15-20:30	Closing Remarks - ARW Directors
20:30	Dinner

SATURDAY, 27 July 1996

08:30- 0930	Breakfast

Abstracts of Oral Presentations

THE UNCONVENTIONAL ELECTRODYNAMICS OF HIGH TEMPERATURE SUPERCONDUCTORS.

T. Timusk, D.Basov, A. Puchkov and T. Startseva.
McMaster University Hamilton, Ontario, Canada

The copper oxide superconductors exhibit very unusual transport properties for currents flowing both along the conducting ab planes and the c-axis. We will summarize recent results of infrared spectroscopy on several materials over a range of doping levels. Of particular interest are the underdoped materials which show a pseudogap phase above the superconducting transition temperature. Measured along the c-axis, the gap shows up as a depression in the conductivity, while along the ab plane only the scattering rate of the carriers is reduced. The experiments suggest that preformed pairs are formed well above the superconducting transition temperature, which lead to dramatic changes in electronic structure in the normal state. Surprisingly, only minor changes are seen at the onset of coherent, large scale superconductivity.

VORTICES IN TYPE II SUPERCONDUCTORS

Anne van Otterlo, Dima Geshkenbein, and Gianni Blatter
Theoretische Physik, ETH-Hoenggerberg, CH-8093 Zuerich, Switzerland

The vortex equation of motion is important for understanding flux-flow dissipation, thermo-electric effects, vortex creep, etc. We discuss the Magnus, Iordanski, and Kopnin-Kravtsov forces on a vortex, as well as its mass. In particular we focuss on the role of the localized quasi-particles in the vortex core, as well as on the role of particle-hole asymmetry, which is crucial for understanding the observed sign change in the Hall effect in the mixed state. Particle-hole asymmetry also causes vortices to carry a line-charge, which, acounting for metallic screening, we estimate to be observable using modern nano-scanning techniques. We discuss the relation between the sign of the vortex charge and the occurrence of a Hall-anomaly.

VORTEX BEHAVIOR IN DIFFERENT PINNING POTENTIAL FOR MODERATELY ANISOTROPIC HIGH-T_c SUPERCONDUCTORS

V.M. Pan, V.F. Solovjov, V.L. Svetchnikov, A.L. Kasatkin
Institute for Metal Physics, Vernadsky Blvd., 36, Kiev 252142, Ukraine

Abrikosov vortex line interaction with different type of crystal defects is considered for $YBa_2Cu_3O_{7-\delta}$. Two sorts of quenched disorder are shown to give major contributions into the anisotropic and nonmonotonous field dependencies of critical current density, J_c, and volume pinning force for perfect single crystals: (i) point-like defects - oxygen vacancies, (ii) planar defects - twins. 2D↔3D dimensional crossover in flux line lattice interaction with pinning potential are shown to be observed in quasi-statics as well as in dynamics. The most effective pinning is ensured by linear defects (e.g., dislocation) parallel to applied field. The highest J_c biaxially-oriented thin films reveal dense edge dislocation structure (up to $\sim 10^{11} cm^{-2}$). A consistent model of depinning from linear defect and motion along the dislocation array in small-angle tilt boundary is developed for single vortex to evaluate J_c and its dependence upon misorientation of adjacent domains.

THE VIOLATION OF THE BCS THEORY AND THE EXTENSIONS REQUIRED TO INCLUDE THE EFFECTS OF A NEARBY PHASE TRANSITION

Ernst L. Haase
c/o Forschungszentrum Karlsruhe, IMF III, D-76021 Karlsruhe, FRG
FAX: 0049-7247-823956, Tel. -822807, E-Mail: haase@imf.fzk.de

While numerous experimental results support the conventional BCS electron-phonon mechanism, quite a number of specific data lie up to a factor of two above the predictions of the strong coupling BCS/Eliashberg theory. In particular the observed dependence of the electron-phonon matrix element on the vibrational amplitude for strong coupling superconductors violates the BCS theory. It is proposed to account for high temperature superconductivity in terms of a largely conventional BCS/Eliashberg-theory, extended to include additionally the effects of a nearby structural phase transition (SPT). Experimental data show that the SPT at the temperature T_p causes a resonance like enhancement of the phonon population numbers with energies near $k_B T_p$ and an additive term having the same shape due to the increased vibrational motion of the lattice near the SPT. In many respects, these additional vibrations of the SPT act like an additional broad phonon with an integrated intensity comparable to that of the narrow phonons. There is strong interference between both due to anharmonious phonon-phonon interaction. These are the "electronic" states. Hence in the calculation of the superconducting and thermodynamic quantities using the Eliashberg-theory, $\alpha^2F(\varepsilon)$ is replaced by $\alpha(\varepsilon)^2F(\varepsilon) + c*\alpha(\varepsilon)^2$. Here α^2 is the product of the electronic density of states $N(\varepsilon_F)$ and the normally constant electron-phonon matrix element, $F(\varepsilon)$ the spectrum of those phonons, that strongly couple to the electrons and c is a constant determined from the ratio of the intensities of the phonons to the SPT "phonon". $\alpha(\varepsilon)^2$ then has a resonant shape and is taken from the SPT specific heat, the $T = 0$ "electronic" continuum or the excess specific resistance due to the SPT. The physical reasons for the choice of this ansatz are discussed. It corresponds to the Fröhlich/Weisskopf picture, extended by including the effect of a nearby SPT. The specific heat of the superconducting phase transition sits on the tail of that of the SPT. Adiabaticity causes the charge carriers to move with the ions, thereby increasing their specific heat. This causes an increase of the superconducting specific heat jump ΔC above its BCS value. The system decreases its free energy substantially through the transition of certain phonon modes from chaotic thermal oscillations to collective ionic motion, in particular as the temperature falls below T_c. This is also shown independently by diffuse X-ray scattering. This doubles their amplitude, hence the specific heat jump ΔC and the ensuing thermodynamic properties. This strong coupling of the superconducting with the structural order parameter is also evident in the temperature dependence of the order parameter below T_c. This is very similar to the situation in antiferromagnetism. Using the experimental $\alpha(\varepsilon)^2$ and phonon spectra, the superconducting and thermodynamic quantities are then readily calculated using Rainer's code for the solution of the Eliashberg equations. Results are presented for the calculation of T_c and the isotope effect as function of the Sr-fraction for La-214 and as function of the oxygen content for Y-123 and are in good agreement with the data. Several dimensionless quantities occurring in the BCS theory are exceeded beyond the appropriate strong coupling enhancement factors in agreement with data. The qualitative agreement of numerous experimental data with the present ansatz confirms it further. Shape and magnitude of the critical fields agree with experiment.

THE FLUX LINE LATTICE STATES IN SINGLE-CRYSTALLINE SUPERCONDUCTORS WITH WEAK PINNING

V.F. Solovjov, V.M. Pan
Instiute for Metal Physics, Vernadsky Blvd. 36, 252142, Kiev, Ukraine

The single-crystalline superconductors being samples with low defect content offer an unique possibility to explore the flux line lattice properties in a "clean" limit which is expected to be simple "model" case. But it proves out that the flux in the single crystals sometimes exhibits anomalous properties. This contribution to the workshop is intended as a brief review which considers the flux states in the single-crystalline samples: ones that predicted theoretically and ones that observed in the experiment. As an illustration we use results of transport and magnetic measurenets of HTSC samples of YBCO, BSSCO and LSCCO. The discussion concerns the following aspects of the problem: influence of crystalline anisotropy, dynamic states, joint action of various pinning centres, effect of strong pinning centres.

CHEMICAL CONTROL OF ANISOTROPY AND FLUX PINNING IN Hg-BASED SUPERCONDUCTORS

Kohji Kishio

Department of Applied Chemistry, University of Tokyo, Tokyo 113, Japan

We have previously reported that $HgM_2Ca_{n-1}Cu_nO_y$ (M=Ba or Sr, n=1~4) can be chemically stabilized by doping a small amount (0.1~0.25) of high-valence transition metal ions such as Cr or Re. These compounds show stronger flux pinning behavior than undoped materials and even compared to other HTSC such as $YBa_2Cu_3O_7$.

By a neutron diffraction analysis on the Hg(Re)SrCaCuO (n=2,3) compounds, Re was found to occupy the Hg-site with fully coordinated oxygen ions, giving rise to the stabilization of Hg(Re)O plane in the crystal structure. Furthermore, extremely large spin depolarization rate observed in our recent muon spin relaxation measurement suggests a possibility of the metallized Hg(Re) layer which should result in the better electrical conduction along the c-axis direction and reduces the anisotropy of the system. The flux pinning strength in the doped Hg-based compounds thus seems to have been enhanced by the increase in the interlayer coupling strength due to the decrease in the electromagnetic anisotropy.

We present structural characterization results such as X-ray, neutron diffraction and HRTEM as well as electromagnetic measurements of various samples and discuss the chemical control, in particular, of the doping state and the microscopic crystal structure in the present mercury-based systems.

The present work is a collaboration with Kyoto University, Argonne National Laboratory, New Zealand Industrial Research Limited and University of Konstanz.

A NOVEL APPROACH TO HIGH IN-FIELD J_c at 77 K IN Bi-Sr-Ca-Cu-O

Donglu Shi
Department of Materials Science and Engineering,University of Cincinnati, Cincinnati, OH 45221-0012

The J_c of Bi-Sr-Ca-Cu-O at 77 K is rapidly reduced to less than 1000 A/cm^2 at even small applied field (< 0.5 T), which is not satisfactory for major large-scale applications. The mechanism responsible for such a behavior has been identified as a 3D to 2D vortex crossover that is directly related to the distance (d_i) between the conduction Cu-O bilayers. For Bi-Sr-Ca-Cu-O, d_i is relatively large compared to that of $YBa_2Cu_3O_x$, and thus it has a lower crossover temperature and field. In contrast to the previous effort in flux pinning, we show that the bilayer coupling strength can be enhanced by the reduction of d_i, which leads to an increased 2D to 3 D crossover. A novel materials approach to increase J_c at 77 K is presented.

EXCHANGE-CORRELATION EFFECTS ON PLASMON MEDIATED SUPERCONDUCTIVITY OF A LAYERED TWO-DIMENSIONAL SYSTEM

S.M. Bose*
Department of Physics and Atmospheric Science
Drexel University, Philadelphia, PA 19104

The exchange-correlation effect on the normal and superconducting state properties of a layered two-dimensional electron gas has been investigated. The Hubbard-type local field correction can lead to charge density wave instability and thus, induce metal-insulator phase transition at a carrier density corresponding to $p_F \approx 1/c$ (c being the interlayer separation). In this region of phase transition, plasmon-mediated superconductivity is suppressed. However, it is shown that at higher carrier densities superconductivity can exist with T_c having a bell-shape dependence on the carrier density, thus qualitatively verifying recent experimental observations.
*Work done in collaboration with Y.M. Malozovsky.

MICROWAVE DISSIPATION AND THE STRUCTURE OF THE VORTEX LATTICE IN $Bi_2Sr_2CaCu_2O_{8+\delta}$ SINGLE CRYSTALS

N. Bontemps, H. Enriquez,
Ecole Normale Supérieure, 24 rue Lhomond 5231 Paris Cedex 05 (France)

The vortex lattice in a superconductor with Josephson-coupled layers was investigated theoretically by Bulaevskii and Feinberg. Depending on field magnitude and orientation with respect to the layers, vortices may be locked parallel to these layers as Josephson vortices, or assume a tilted configuration with straight effective cores : this change occurs through the so-called lock-in transition. I will show how the dissipation measured at 10 GHz in $Bi_2Sr_2CaCu_2O_{8+\delta}$ single crystal platelets, is related to the structure of the vortex lattice itself. A cavity perturbation technique, where the sample is placed in a homogeneous microwave magnetic field, allows to probe simultaneously the surface resistance associated with currents within the ab plane and along the c axis. Clear experimental evidence for the lock-in transition and for an intermediate state involving Josephson strings that connect two-dimensional vortices is found. The analysis yields the anisotropy parameter ($\gamma \approx 70$) for the $Bi_2Sr_2CaCu_2O_{8+\delta}$ compound.

Theory of Superconducting T_c of doped fullerenes

A.S. Alexandrov and V.V. Kabanov

Loughborough University of Technology, Loughborough LE11 3TU, U.K. and IRC in Superconductivity, University of Cambridge, Cambridge CB3 OHE, U.K.

We develop the nonadiabatic polaron theory of superconductivity of M_xC_{60} taking into account the polaron band narrowing and realistic electron-phonon and Coulomb interactions. By the use of the polaronic-type function and the "exact" diagonalization in the truncated Hilbert space of vibrons we calculate the ground state energy and the electron spectral density of the C_{60}^- molecule. This allows us to describe the photoemission spectrum of C_{60}^- in a wide energy region and determine the electron-phonon interaction. The strongest coupling is found with the high-frequency pinch A_{g2} mode and with the Frenkel exciton. We clarify the crucial role of high-frequency bosonic excitations in doped fullerenes. The Eliashberg-type equations are solved for low-frequency phonons. The value of the superconducting T_c, its pressure dependence and the isotope effect are found in a remarkable agreement with the available experimental data.

STRUCTURAL FEATURES THAT CONTROL THE PROPERTIES OF HIGH-T_c SUPERCONDUCTORS

James D. Jorgensen
Materials Science Division and Science and Technology Center for Superconductivity,
Argonne National Laboratory, Argonne, IL 60439.

The high-T_c superconductors display a wide range of chemical compositions and structures, within the constraints imposed by the layered nature of these compounds. It is no surprise, then, that studies of the crystal chemistry have provided the first insight into the underlying physics and have guided attempts to "design" optimum compounds. The superconducting properties (both T_c and J_c) depend in a critical way on the overall chemical composition and structure and also on more subtle features such as the presence of defects and short-range oxygen ordering. In this lecture, I will provide a review of what we have learned from the structures of these materials and how we are attempting to use this information to design new compounds with optimized properties.

This work is supported by the US DOE-BES, contract W-31-109-ENG-38 and the NSF Office of Science and Technology Centers, grant DMR 91-20000.

STUDIES OF INFINITE-LAYER, *T'*-PHASE, AND 1-D-LADDER COPPER-OXIDE COMPOUNDS*

J. T. Markert, K. Mochizuki, and A. V. Elliott
Department of Physics, The University of Texas, Austin, TX 78712 USA

Recent experimental studies of electron-doped infinite-layer compounds (e.g., $Sr_{1-x}La_xCuO_2$), electron-doped *T'*-phase compounds (e.g., $Nd_{2-x}Ce_xCuO_4$), and spin-1/2 quasi-1-D ladder compounds (e.g., $Sr_{14}Cu_{24}O_{41}$, $SrCu_2O_3$, and $Sr_2Cu_3O_5$) are presented, including structural, magnetic, and transport measurements. Studies of steric effects indicate that superconductivity disappears in *both* electron-doped systems for values of the in-plane lattice constant *a* below a critical value, $a_{cr} \approx 3.92$ Å. Attempts to hole dope both the infinite-layer and *T'* phases are described. Apparently, delocalized holes cannot be introduced into the ambient-pressure *T'*-phase materials (Ln_2CuO_4; Ln = Nd–Gd); some studies of low-temperature-synthesis rare-earth-free *T'*-phase $La_{2-x}Y_xCuO_4$ are discussed. The infinite-layer parent compound series $Ca_{1-x}Sr_xCuO_2$ makes accessible a large range of Cu-O bond lengths; we discuss high pressure synthesis and properties of $Ca_{1-x-y}Sr_xM_yCuO_2$ for both electron (*M* = La, etc.) and hole (*M* = Na, K) doping. For the quasi-1-D ladder compounds, high-pressure syntheses of $SrCu_2O_3$ and $Sr_2Cu_3O_5$ are discussed. Also, the ambient-pressure parent compound $Sr_{14}Cu_{24}O_{41}$ may be electron-doped (La is soluble in $Sr_{14-x}La_xCu_{24}O_{41}$ for $0 \leq x \leq 4$); changes with such electron doping are discussed. Collaborative studies of these systems using μSR, NMR, and other spectroscopies are overviewed.

*Supported by the United States National Science Foundation Grant. No. DMR-9158089.

THE SUPERCONDUCTING RESPONSE AND SCALING RELATIONS IN THE METASTABLE ALLOYS NEAR THE SUPERCONDUCTOR-INSULATOR TRANSITION.

V.F.Gantmakher, V.M.Teplinskii, and V.N.Zverev.
Institute of Solid State Physics RAS, 142432 Chernogolovka, Russia

The high-resistance metastable alloys Ga-Sb, Zn-Sb and Cd-Sb were obtained by quenching of high-pressure phases down to the liquid nitrogen temperature. They were superconductors with transition temperature about 10 K. At elevated temperatures (140-300 K), these metastable metals gradually transform into amorphous insulators. The sample becomes inhomogeneous in the course of this transformation: A disordered 3-D Josephson system appears with a mixture of different type of the "weak-superconducting" elements, such as tunnel junctions, confinements, thin wires, etc. The densities and the size scales of these elements change during transformation and lead to evolution of the superconducting response, the average resistivity of the material serving as a parameter. Peculiar temperature dependence of the critical current at different stages of transformation and scaling of the critical current with the resistivity were studied in detail. This reveals some common features in the behavior of different materials. When the resistivity becomes large, the Josephson currents are suppressed by the quantum fluctuations and exponential factor appears in the resistance determined by the ratio of the superconducting gap to the temperature. The magnetic field increases the conductivity enormously by destroying the gap. This leads to gigantic negative magnetoresistance.

SYNTHESIS OF NEW HTSC FOR PERSPECTIVE APPLICATIONS

A. ul Haq and M.N. Khan*
Metallurgy Division, Dr. A.Q. Khan Research Laboratories, Kahuta, P.O. Box 502, Rawalpindi, Pakistan.
*High Temperature Superconductivity Laboratory, Physics Department, University of Bahrain, P.O. Box 32038, Bahrain

The Phenomena of superconductivity is very exciting both for fundamental scientific interest and because of its many technical applications. Since 1986, a lot of work has been done by numerous authors from all over the world on various scientific aspects of the following systems: Y-Ba-Cu-O; Bi-Sr-Ca-Cu-O; Tl-Ca-Ba-Cu-O and Hg-Ba-Ca-Cu-O (either pure or doped with some suitable element to stabilize phase(s) of particular interest). These systems under suitable preparation conditions may produce phase(s) which become(s) superconducting between 80 and 130 K. Efforts are now being made to develop technologies to put these compounds into industrial applications.

In this paper we describe the superconducting properties of wires drawn from Bi-Sr-Ca-Cu-O system. These wires were produced in glass capillaries. It was found that the formation mechanism in the interior of the wire is different from that at the surface and the crystallization mechanism was affected by oxygen diffusion, thus altering the formation of Cu+ ions in the glass. The results are compared with new experimental data.

THIN-FILM DEVICES

Alex I. Braginski
Institut fur Schicht- und Ionentechnik (ISI) Forschungszentrum Julich,
D-52425 Julich, Germany

The purpose of this talk is an overview of electronic devices fabricated from high-temperature superconductor (HTS) thin films, and of their prospective applications. At present, almost all HTS device concepts are borrowed from the low-temperature superconductor (LTS) technology. However, the symmetry of the pairing state and the crystalline and electronic anisotropy of cuprates, their extremely short coherence lengths and long penetration depths impose severe device limitations while simultaneously offering new opportunities. The most characteristic example of both, a major limitation and an opportunity, is that a grain boundary usually exhibits Josephson weak-link properties. Also, the high temperatures required for cuprate synthesis, and the necessity of using high-crystalline-quality epitaxial film structures with a well-defined morphology, mandate different technological approaches to device fabrication than in the case of LTS. Electronic devices are grouped into categories of linear (passive) and nonlinear (active) elements which can be combined into integrated circuits. I will concentrate on nonlinear devices (since a separate talk gives a status report on the linear ones) and emphasize open material science problems with the aim to indicate what would make a difference. Nonlinear devices are predominantly planar patterned structures of epitaxial thin films of $YBa_2Cu_3O_{7-d}$ (YBCO) and YBCO (or other 123 cuprate) multilayers with epitaxial insulators and normal conductors. The recent discovery of the intrinsic Josephson effect in $Bi_2Sr_2Ca_1Cu_2O_8$ (BSCCO) and other quasi-two-dimensional superconductors is also leading to new devices without direct LTS equivalents. The (internally) resistively-shunted Josephson junction (RSJ) is the key nonlinear device for prospective applications. The main obstacle to their development originates from, thus far, excessive spreads of critical current and normal resistance in all types of HTS junctions fabricated in greater numbers on the same chip or wafer. The wafer-to-wafer reproducibility is also insufficient. Currently, superconducting quantum interference devices (SQUIDs) for magnetometry and metrology, and also junction arrays for voltage standards, suffer least from large critical parameter spreads and are in more advanced stage of practical development. At a large distance, these are trailed by arrays for submillimeter-wave oscillators and mixers, infrared detectors, three-terminal flux-flow "transistors", and single-flux-quantum (SFQ) digital logic circuits for high-speed signal processing and data switching. Simple demonstrations of these applications, at a low level of integration on chip, are usually possible in single-superconductor-layer technology. However, most require a sophisticated multilayer technology, and high integration levels, to attain the required competitive performance. SQUIDs and linear microwave devices are already commercially available and should be the first to penetrate potential niche markets for superconducting and cyogenic (hybrid with cooled semiconductors) electronics.

MICROSTRUCTURE OF ARTIFICIAL GRAIN BOUNDARIES IN THIN FILMS OF $YBA_2CU_3O_7$ AND $BI_2SR_2CACU_2O_8$

B. Kabius, J.W. Seo, J.L. Jia

Institut für Mikrostrukturforschung (IMF) Forschungszentrum Jülich, D-52425 Jülich

During the last decade electron microscopy has been proven to be a valuable tool for the characterization of the crystal structure and defects of high-temperature superconductors. Especially grain boundaries have attracted much interest because they can be used as weak links in microelectronic devices. Therefore the microstructure of artificial grain boundaries is important for the electrical properties of these junctions. Three different types of grain boundaries in thin films have been investigated by high-resolution microscopy (i) 90° grain boundaries on stepped subtrates (ii) bicrystralline and (iii) biepitaxial grain boundaries on planar substrates. A common structural feature is the facetting of the grain boundary. In general, these facets have low-index habit planes in common with one of the adjacent grains. The structural inhomogenity introduced by facets with different habit plane can be correlated electrical properties of grain boundary junctions.

PULSED LASER DEPOSITION OF THIN FILMS

Miroslav Jelinek
Institute of Physics, Czech Academy of Sciences Na Slovance 2, 180 40 Prague 8
Czech Republic

Principles of pulsed laser deposition (PLD) of thin films will be presented. Influence of laser parameters, such as laser- target interaction, working atmosphere, geometrical configuration of laser beam- target- substrate, substrate temperature, droplets mechanism and substrate parameters on the film properties will be explained. Problems of creation of superconductive thin films, buffer layers and multilayer structures, including characterization of film properties, and will be discussed.

HTS DIGITAL INTEGRATED CIRCUIT FABRICATION*

Martin G. Forrester
Northrop Grumman Corporation, Pittsburgh, PA, USA

Single Flux Quantum (SFQ) digital circuits based on High Temperature Superconductors (HTS) have the potential to perform logic operations at 10 GHz clock rates while dissipating only a microwatt per gate. In order to fully realize this potential, it is necessary to develop a circuit process which integrates reproducible Josephson junctions into epitaxial multilayers. In particular, since HTS circuits will require higher critical currents than comparable LTS circuits in order to be stable against thermal noise, maintaining low inductance becomes even more important, given that the LI_c product is constrained to be of order the flux quantum for SFQ logic. To maintain this low inductance while providing an extendible fabrication process it is important to integrate HTS junctions with an HTS ground plane. We have demonstrated two such processes, one incorporating step-edge grain boundary junctions fabricated using two epitaxial YBCO layers and one epitaxial insulator; and a second incorporating more reproducible edge-geometry SNS devices, fabricated by a process incorporating six epitaxial layers. Both processes have been used to demonstrate basic SFQ circuits operating at 65 K. We will discuss some key materials and fabrication issues involved in the development of these processes, including: development of edge-geometry SNS junctions; choice of epitaxial insulators; isolation integrity of insulators; diffusion of oxygen through multiple epitaxial layers; patterning issues for epitaxial layers; and cleaning measures required to maintain epitaxy through several patterning and growth steps.

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LOW-TEMPERATURE H-T PHASE DIAGRAM OF $Nd_{1.85}Ce_{0.15}CuO_{4-\delta}$ THIN FILMS

J. Herrmann[a], M. C. de Andrade[a], C. C. Almasan[b], R. P. Dickey[c], M. B. Maple[a,c], Wu Jiang[d], S. N. Mao[d], and R. L. Greene[d]

[a]Institute for Pure and Applied Physical Sciences, University of California, San Diego, La Jolla, CA 92093-0360, USA.

[b]Department of Physics, Kent State University, Kent, OH 44242, USA.

[c]Department of Physics, University of California, San Diego, La Jolla, CA 92093-0319, USA.

[d]Center for Superconductivity Research, University of Maryland, College Park, MD 20742, USA.

We report measurements of the magnetoresistance of $Nd_{1.85}Ce_{0.15}CuO_{4\pm\delta}$ epitaxial thin films with varying oxygen content in magnetic fields H applied parallel ($H\|c$) and perpendicular ($H\perp c$) to the tetragonal c-axis. We have observed critical scaling of the electrical resistivity that is consistent with a vortex-glass transition for a film with an optimum superconducting transition temperature T_c of $\approx$ 22 K and $H\|c$. The vortex-glass transition can be traced to temperatures as low as $\sim$ 150 mK, corresponding to $t \equiv T/T_c \approx 7 \times 10^{-3}$. At higher fields ($H \geq 50$ kOe) and low temperatures ($T \leq 0.5$ K), we observe indications of a magnetic field induced superconductor–insulator transition with an intermediate metallic state. The values of the zero-temperature upper critical field $H_{c_2}(0) = 80$ kOe and the in-plane zero-temperature coherence length $\xi_{ab}(0) = 64$ Å were obtained from an analysis of the fluctuation conductivity. For an over-oxygenated film with $T_c \approx 10$ K, an anomaly develops with increasing field for $H\|c$ and $T \leq 2$ K that is characterized by a minimum in the temperature dependence of the resistivity followed by a second resistive transition at a lower temperature, which is nearly independent of H. This behavior is similar to that previously observed in $Nd_{2-x}Ce_xCuO_{4-\delta}$ single crystals and may be associated with the magnetic ordering of the Nd^{3+} ions.

STRUCTURAL DISORDER INVESTIGATIONS OF YBCO 123 THIN FILMS USING RAMAN MICROSCOPY

G. Gibson, J.L. MacManus-Driscoll, L.F. Cohen & Y.B. Li

A number of 123 thin filmss grown by e-beam co-evaporation have been examined using Raman microscopy and X-Ray diffractometry. Different growth conditions were used when growing the films causing differing amounts of cation disorder. The films were examined in their as grown state and then the oxygenation of the films was altered using a coulometric titration unit. The effects of cation disorder and oxygenation on the 110cm^{-1} and 585cm^{-1} Raman lines shall be presented. The structural changes associated with cation disorder shall be discussed.

Material Science foundation for technical superconductors

A.D.Nikulin
Bochvar All-Russia Scientific and Research Institute of Inorganic Materials, Moscow, RUSSIA

Major technical requirements for superconductors of various purposes are presented. Technical superconductors are considered as the specific class of composite materials, which manufacturing demands the maintenance of a number of principles , based both on natural properties of individual materials - components of composite - and their mutual compartibility in the fabrication process and under testing.

The complex method of attack is considered regarding the design of multifilamentary high current LTS and HTS-superconductors and their manufacturing. The major findings of processing of the bulk ceramics and HTS-flexible conductors are discussed. Among them are the basic data on synthesys techniques of bismuth and yttrium oxides, the processing of bulk ceramics for elements of hysteresis cryomachine with output up to 500 W as well as the methods of composite conductors fabrication of various design with Jc up to 40 kA/cm^2 (77 K, OT).

Basic Tecnical characteristics of Russia superconductors complete the paper.

NOVEL SUPERCONDUCTING ELECTRICAL MACHINES

A. Leão Rodrigues
Department of Electrical Engineering
New University of Lisbon
2825 Monte de Caparica - PORTUGAL
Fax: + 351-1-294 85 32

Abstract
Recent developments in superconductors have raised the possibility of operating temperatures much higher than liquid helium and speculation on potential applications of these new materials has ranged across diverse fields of engineering. In power systems area, rotating electrical machines and transmission lines are frequently mentioned candidates.
The paper reports some progress made in possible application of high temperature superconductor (HTSC) materials to both linear and disc superconducting magnetohydrodynamic (MHD) generators for a coal-fired plant, large synchronous generators and the Meissner motor. Design aspects, both electrical and mechanical of these machines tailored to utilize HTSC materials are described. Electrical transient characteristics of a superconducting synchronous generator, tacking into account the influence of HTSC materials, are presented in the paper.

APPLICATIONS OF HIGH-TEMPERATURE SUPERCONDUCTORS (HTS) IN MICROWAVE TECHNOLOGY: A STATE-OF-THE-ART REPORT

Norbert Klein
Forschungszentrum Jülich, Institut für Festkörperforschung, D-52425 Jülich

Microwave technology has become one of the key areas for applications of high-temperature superconductors. This is mainly due to the low surface resistance of large area (up to 3 inches in diameter) HTS thin films on low-loss dielectric substrates at frequencies up to several hundred Gigahertz. Microwave devices based on HTS films are either planar or three dimensional. Planar devices are supposed to replace conventional cavity- or dielectric resonator devices in mobile and satellite communication and radar systems, in most cases for the sake of miniaturization. Examples are bandpass filter for input multiplexers in communication systems, which are based either on transmission line or lumped element resonators. The three dimensional devices are based on cavity or coaxial transmission line resonators fabricated from zirconia parts coated by granular HTS thick films, or single crystalline dielectric resonator devices with planar shields consisting of HTS thin films. For the latter quality factors in the 10^6 range were achieved, which make HTS shielded dielectric resonators favorable as frequency stabilizing elements in low-phase-noise oscillators for radar systems and high-bit-rate digital communication systems. The second type of applications of three dimensional resonators are narrow-band output filters with low insertion loss for the output multiplexers of satellite and mobile communication systems. Here the device has to operate at microwave power levels of 10-100 Watts, which requires high-quality HTS films with low microwave losses at high levels of the rf current density. In contrast to passive devices, where system implementation is already on the way, active devices based on the nonlinear properties of HTS films, HTS Josephson junctions, dielectric layers or magnetic materials are still in the state of basic research. Examples are voltage controlled phase shifters and tunable filters, which are considered to be important for advanced radar systems.

Abstracts of Poster Presentations
Session 1

ELECTRON DENSITY DISTRIBUTION AND VALENCE-BOND STRUCTURE IN HIGH-Tc SUPERCONDUCTORS AND RELATED COPPER OXIDES

Tetsuya IDA, Mitsuru IZUMI, Kenji NAKANISHI[1], Kei-ichi TANABE[1], Yoshitaka SASAGO[2] and Kunimistu UCHINOKURA[2]

Lab. of Applied Phys., Tokyo University of Merc. Marine, Etchu-jima, koto-ku, Tokyo 135, JAPAN, [1]Superconductivity Research Laboratory, International Superconductivity Technology Center, Shinonome, Koto-ku, Tokyo 135, JAPAN, [2]Dept. of Applied Phys., The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, JAPAN

On the appearance of the superconductivity in copper oxides, fruitful studies have been done to clarify the electronic state in the momentum space. Besides, the knowledge on the electron density distribution (EDD) in the real space shall give valuable informations on the electronic states and/or lattice instability. We report the EDD on $YBa_2Cu_3O_{6.9}$ from X-ray powder diffraction. Relatively intensified EDD was observed in the Cu(2)-O(3) plane, which is attributed to the fraction of $3d_{x^2-y^2}$ orbitals from Cu(2) atoms. The distorted $3d_{z^2}$ orbitals of Cu(2) atoms cause the antisymmetric EDD along the c axis. In addition, we report the valence structure of linear-chain compound $CuGeO_3$ which exhibits spin-Peierls transition at 14 K.

THE FULLY FRUSTRATED X-Y MODEL IN FOUR DIMENSIONS

S Jain
School of Mathematics & Computing
University of Derby, Kedleston Road, Derby DE22 1GB, UK

The results of Monte Carlo simulations of the fully frustrated X-Y model on a hypercubic lattice in four dimensions are presented. We compare and contrast the behaviour of this model with that of the planar spin glass and the vortex glass (also in four dimensions).

CORRELATIONS BETWEEN MAGNETOSTRICTION JUMPS AND FLUX INSTABILITIES IN $La_{1.85}Sr_{0.15}CuO_4$ SINGLE CRYSTAL

A.Nabiałek, V.Chabanenko*, N.D.Dung and H.Szymczak
Institute of Physics, Polish Academy of Sciences, Al.Lotników 32/46, 02-668 Warszawa, Poland
*Donetsk Physico-Technical Institute, Ukrainian Academy of Sciences, ul. R.Luxemburg,72, 340114 Donetsk, Ukraine

Giant magnetostriction in a large $La_{1.85}Sr_{0.15}CuO_4$ single crystal has been studied by the strain gauge technique in magnetic fields up to 12 T. For magnetic field B $\parallel$ c in the temperature range between 4.2 K and 8.5 K pronounced jumps of transverse magnetostriction have been observed. Different experimental techniques have been applied in order to study the correlations between the magnetostriction jumps and flux instabilities in the material under study. The observed instabilities are strongly dependent on experimental conditions. The simple adiabatic theory seems to be insufficient to describe magnetic instabilities in high temperature superconductors.

Charge carrier dynamics in HTSC materials: infrared optical results.

A.V. Puchkov[1], T. Timusk[1], P. Fournier[2], A. Kapitulnik[2], N.N. Kolesnikov[3]

[1] *Department of Physics and Astronomy, McMaster University, Hamilton, Ontario, Canada L8S4M1*

[2] *Edward L. Ginzton Laboratory, Stanford University, Stanford, CA 94305*

[3] *Institute of Solid State Physics, Chernogolovka, Russia, 142432*

We report on the doping dependence of infrared optical properties of Bi2212 and Tl2201 systems. Using sum-rule analysis for the optical conductivity we find that although the low-frequency conductivity spectral weight increases with doping in the underdoped regime, there is no increase in the overdoped regime. This suggests a non-monotonic dependence of the free carrier density on doping level. We also examine the doping and temperature dependence of the frequency-dependent scattering rate $1/\tau(\omega, T)$. In the high-quality underdoped Bi2212 single crystals we observe a pseudo-gap in the ab-plane $1/\tau(\omega, T)$ developing at low (but still above T_c) temperatures. In the overdoped regime the pseudogap is not observed.

PROXIMITY COUPLED SUPERCONDUCTOR-ANTIFERROMAGNETIC SUPERLATTICES

Vladimir N. Krivoruchko
Donetsk Physical & Technical Institute, Donetsk 340114 Ukraine

Nucleation of superconducting phase in short-period proximity coupled superconductor (SC) - antiferromagnetic (AF) metal multilayers have been studied theoretically. Describing a SC layer, we use the usual Usadel equations. As a AF layer we consider a normal metal, which undergo the magnetic phase transition associated with the nesting electron and hole Fermi surfaces. The basic formalism, suitable for the study of the SC phase of that AF metal is presented.

The transition temperature and the perpendicular upper critical field of SC/AF superlattices is calculated by solving exactly the Usadel equations. The existence of ground state with nontrivial phase difference between neighboring SC layers (so-called π-phase) is discussed. We obtained a nonmonotonic dependence of critical temperature and critical field on system parameters. A comparison of theoretical results with experimental data is given too.

EVALUATION OF THE MAGNETIC PROPERTIES OF ND-BASED SUPERCONDUCTORS

F. Frangi, V. Ottoboni, S. Zannella.
CISE SpA, P.O. Box 12081, I-20134 Milano, Italy.

The magnetic properties of Nd-Ba-Cu-O superconducting compounds, melt-grown in reduced oxygen atmosphere, were investigated using a SQUID magnetometer. A critical temperature above than 93 K was derived from magnetic susceptibility χ measurements. The anisotropic behaviour of the material was evidenced by magnetization cycles performed, at various temperatures, with the external magnetic field applied both parallel and perpendicular to the sample c axis. The magnetization critical current density J_{cm}, shows an anomalous peak (> 20 kA/cm^2 at 77 K) in the intermedium field region (1-2 T). From the magnetization and J_{cm} data other important parameters, such as the critical field H_{C1} and the irreversible field H_{irr}, were studied in the temperature range interesting for applications.

THE EXCITED FERROMAGNETIC STATE AND DYNAMIC STRUCTURE OF THE $Cu0_2$ PLANE IN HT_c SC.

A.E. Usachev, Yu.V. Yablokov

Kazan Physical-Technical Institute KSC RAS, 420029, Kazan, Sibirsky trakt, 10/7

In the present paper such phenomena in high-temperature superconductors as destruction of antiferromagnetic order and formation of a spin glass phase; phase separation phenomena; appearance of ferromagnetic domains and a number of others are interpreted within the frame of Jahn-Teller Effect. Studies of a continuous series of solid solutions (ceramics) $LaSrCu_{1-x}AlxO_4$ c x = 0 - 1 by means of EPR, charge transport and X-ray diffraction are reported. It is shown that when analysing properties of HT_c SC materials it is necessary to take into account the excited ferromagnetic state close to the ground state in which the orbital parts of the wave functions of Cu^{2+} ions are $|z^2-x^2>$ or $|z^2-y^2>$. The energy interval between the excited and the ground state of about 0.25ev per Cu^{2+} ion for pure La_2CuO_4 is evaluated. The mechanism of reduction of this interval due to the occurrence of carriers in the base plane CuO_2 and to the change in the density of their space distribution is considered. From this point of view the experiments on compressibility of $La_{1.7}Ba_{0.3}CuO_4$ under hydrostatic pressure are interpreted and the energy interval of about 25mev per Cu^{2+} ion for this composition is evaluated.

MAGNETOTRANSPORT STUDIES OF Bi - BASED SUPERCONDUCTORS

M. Pękała[1] and M. Ausloos[2]

[1]Department of Chemistry, University of Warsaw
Al. Żwirki i Wigury 101, PL-02-089 Warsaw, Poland
[2]SUPRAS, Institut de Physique, B5, Universite de Liege
Sart Tilman, B-4000 Liege, Belgium

The electrical resistivity, thermoelectric power and thermal conductivity probe the charge and heat currents caused by the electric and temperature gradients. A magnetic field additionally superimposed on the superconducting sample with an orientation perpendicular to the electric or temperature gradient, allows to observe phenomena called excess electrical resistivity, excess thermoelectric power, Nernst effect and magneto - thermal conductivity. These parameters supply the unique information on kinetics of vortices and of quasi particle scattering in the mixed state of the Bi based superconductors. The percolation line and other quantities like electrothermal conductivity, transport entropy, critical magnetic field H_{c2}, Ginzburg - Landau parameter, coherence length, mean activation energy of the thermally activated processes and the thermal Hall angle describing the vortex system are derived and discussed in relation to the layered structure of superconductors.

PENETRATION DEPTH MEASUREMENTS IN HIGHLY EPITAXIEL YBCO THIN FILMS

B. Aktaş
Physics Department Gebze Institute of Advanced Technology, 41400, Kocaeli.
H. Z. Durusoy
Department of Physics, Hacettepe University, Beytepe, 06532, Ankara.

High quality YBCO films were grown by off-axis RF sputtering technique in UHV. The films were characterized by means of R(T), XRD, Jc(H) and SEM measurements. Next, the electron spin resonance technique was used to obtain the Microwave penetration depth of $YBa_2Cu_3O_7$ thin films. An ESR-signal-generating marker was placed in between two high temperature superconducting films to probe the mw field penetrating through the films. Below the transition temperature the HTSC film started to screen the marker inside the sandwich. A meaningfully diminishing ESR signal was reproducibly recorded for various samples. Temperature dependence of ESR signal intensity above and below Tc has been studied to deduce the penetration depth from the measured signal intensity. A very rapid change of I just below Tc, slowed down later at lower temperatures and became smoothly changing.

THE ENERGY LEVEL IN THE BAND SPECTRUM OF HIGH TEMPERATURE SUPERCONDUCTORS.

Michael D. Medvedev
Theoretical Physics Department, Odessa University, 2 Petra Velikogo, 270100 Odessa, Ukraine.

The hybridization of band spectrum with the flat band located nearby Fermi level E_F [1,2] results in substantially high electronic states density $\rho(E_F)$ in the case of weak Coulomb correlations Δ between band electrons.

For $\Delta < 9W^2 / 14V$, where V and W are the constants of *p-p* and *p-d* hybridization, consequently, E_F represents a "pocket" situated in the vicinity of the point $(\pi/4, \pi/4)$ [3]. The last is a local maximum of conduction band.

$$\rho(E_F) = \left(\frac{V}{W}\right)^2 \left(1 + \left|\frac{9W^2}{2V\Delta} - 7\right|^{-1/2}\right) \rho_0(E_F)$$

($\rho_0(E_F)$ is density of states at Fermi level without band hybridization).

For $\Delta > 9W^2 / 14V$ the local maximum at $(\pi/4, \pi/4)$ goes over to a saddle point close to it E_F lies [4].

As a result, the broadening of the region of phase space of band electrons forming the superconducting state causes the superconducting temperature T_C to be high. It has the possible weak manifestation of an isotopic effect and increases when pressure grows. T_C as convex function of doping δ is defined. In particular

$$T_C\,max = \frac{W^2}{2V}\left(1 + \left|\frac{9W^2}{2V\Delta} - 7\right|^{-1/2} - 2\pi\delta_0\right)$$

where δ_0 is optimum doping of high-T_C cuprates. From this equation we can obtain Δ and, consequently, Coulomb repulsion U at cooper sites.

For $La_{1.85}Sr_{0.15}CuO_4$ V=1eV, W=0.4eV, $T_C\,max$=39K, Δ=0.06eV, $\Delta / T_C\,max$ ~20, U=0.18eV, $\rho(E_F) \sim 10\,\rho_0(E_F)$. $\Delta < 9W^2 / 14V$ ~0.1eV, therefore, Fermi level is the "pocket" in the neighborhood of the point $(\pi/4, \pi/4)$; $\partial^2 T_C(\delta = \delta_0) / \partial^2 \delta \sim$ -0.5.

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Abstracts of Poster Presentations
Session 2

STANDARD ENTHALPIES OF FORMATION OF SOME PHASES IN THE YBaCuO SYSTEM AUXILIARY TO SUPERCONDUCTORS

Jaroslav ŠESTÁK and German MOISEEV*

Division of Solid-State Physics, Institute of Physics of the Academy of Sciences, Cukrovarnická 10, 16200 Praha 6, Czech Republic

**Institute of Metallurgy, Ural Division of of the Russian Academy of Sciences, Amundsen 101, 620219 Ekaterinburg Russian Federation*

On bases of literature data, statistical treatment and empirical dependences the standard enthalpies of formation from oxides, $\{-\Delta_f H^\circ_{ox}(298)$ in *kJ/mol*$\}$, were estimated for the following compounds: $YBa_2Cu_3O_6$ {126 ∓7.9}, $YBa_2Cu_3O_{6.5}$ {130.8 ∓3.3}, $YBa_2Cu_3O_7$ {134.2 ∓2.4}, $YBa_2Cu_{3.5}O_{7.5}$ {144.6 ∓3.5}, $YBa_2Cu_4O_8$ {154 ∓5.7}, $YBa_4Cu_3O_{8.5}$ [190.2 ∓14.2}, $YBa_2Cu_5O_9$ {172.7 ∓10.5}, Y_2BaCuO_5 {84.6 ∓2.6}, $Y_2Cu_2O_5$ {14.5 ∓5.1}, $YCuO_2$ {4.5 ∓24.3}, $BaCuO_2$ {73.4 ∓21.4}, $BaCu_2O_2$ {30.1 ∓12.4}, Ba_2CuO_3 {108 ∓29}, Ba_3CuO_4 {138.7 ∓6.4}, $Ba_2Cu_3O_5$ {147.7 ∓18.5}, $Ba_3Cu_5O_8$ {210.9 ∓4.9}, Y_2BaO_4 }61.2 ∓0.7}, $Y_2Ba_4O_7$ {169.1 ∓7.5}, $Y_2Ba_2O_5$ {97.6 ∓6.4} and $Y_4Ba_3O_9$ {183.8 ∓9.3 kJ/mol}.

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INDUCED CURRENTS IN Bi-(2223) TAPES

L. Půst[1], M.R. Koblischka[2,3], A. Galkin[1], P. Nálevka[1]
[1] Institute of Physics, ASCR, Na Slovance 2, 180 40 Praha 8, Czech Republic
[2] Groupe de Physique appliquée, Univ. de Genève, CH-1211 Genève 4, Switzerland
[3] SRL/ISTEC, Division VII, 1-16-25 Shibaura, Minato-ku, Tokyo 105, Japan

Superconducting Ag-sheathed tapes with highly densified textured $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ were prepared by the "powder-in-tube" method with subsequent pressing or drawing and rolling [1]. The induced currents were studied by a PAR vibrating sample magnetometer and QD SQUID magnetometer. Magnetic hysteresis loops (MHL) were measured with external magnetic field B_e applied perpendicular to the tape plane. An anomalous position of the MHL maximum was observed similarly to [2] at temperatures up to about 60 K at positive field B_{max} for $dB_e/dt < 0$. Such a position of the MHL maximum indicates that the internal fields are apparently ahead of the external field. B_{max} increases steeply with the moment M_{max} at the MHL maximum as $B_{max} \propto M_{max}^{3.6}$.

This effect can be explained by local magnetic internal fields B_i at circumference of thin platelet-like grains. The induced moment is given in the Bi-2223 tapes mainly by the intergranular currents while their magnitude is limited by local fields at the grain contacts at the grain circumferences. Such fields are estimated from model calculations of internal fields [3] in superconducting disks with various dimensions representing grains of the polycrystalline material. Stray fields from large induced currents inside the grains cause that B_i changes sign in the area very close to the circumference of grains. Consequently, the shape of MHL indicates that the internal field B_i is apparently ahead of B_e while this is true only in very small, but crucial, areas close to the grain circumference.

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Ag ADDITIONS IN $LaBa_2Cu_3O_{(7-y)}$

E. Nazarova, A. Angelov, A. Zahariev, I. Iordanov
Inst. Sol. St. Physics, 72 Trackia Blvd., 1784 Sofia, BG

The observed linear temperature dependence of the critical current density ($J_c(T)$) near T_c confirms the domination of the S-I-S (superconductor - insulator - superconductor) weak links, through which the intergranular current flows in non-doped samples. Ag additions change the nature of the weak links from S-I-S to S-N-S (superconductor - normal metal - superconductor). Quadratic dependence $J_c(T)$, observed for the doped samples, shows the domination of normal metal connections between the superconducting grains. This is in agreement with the fact that Ag does not enter the crystallographic structure of the $LaBa_2Cu_3O_{(7-y)}$ and segregating on the grain boundary increases the J_c value.

MICROSTRUCTURE AND SUPERCONDUCTING CHARACTERISTICS OF $Hg_mPb_nBa_2Ca_2Cu_3O_{8+\delta}$.

I. Sargánková[1,2], W. König[2], M. Mair[2], G. Gritzner[2], J. Kováč[1], S. Longauer[3], P. Diko[1]

[1]Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 04353 Košice, Slovak Republic
[2]Institut für Chemische Technologie Anorganischer Stoffe, Johannes Kepler Universität, A-4040 Linz, Austria
[3]Technical University of Košice, Faculty of Metallurgy, Department of Materials Science, Komenského Park 11, 043 53 Košice, Slovak Republic

We have prepared Hg-based pure and Pb doped superconducting ceramics of nominal composition $Hg_mPb_nBa_2Ca_2Cu_3O_{8+\delta}$ (m = 1.0, 1.2, 1.4; n = 0, 0.1, 0.2, 0.3) by sealed quartz ampoules' method. The superconducting phase was synthesised at 860°C for 5 h in the case of n = 0 and at 830°C for 5 h in the case of Pb doped samples.

The superconducting transition temperatures were determined from resistivity and magnetisation measurements. The samples of these ceramics exhibit high-temperature superconductivity at temperatures falling in the range from 123 K to 133 K. We have studied the influence of post-annealing in oxygen flow at 300°C for 10 h on the superconducting properties.

The phase purity and lattice parameters were detected by XRD analysis. Type and volume fraction of secondary phases, porosity, grain size, grain shape and grain boundaries were investigated by optical microscopy, scanning electron microscopy and by EDAX microanalysis. Pb doping resulted in platelike crystallites.

P2-4

MICROSTRUCTURE OF $NdBa_2Cu_3O_{7-x}$ (Nd 123) - $Nd_4Ba_2Cu_2O_{10}$ (422) MELT-PROCESSED SUPERCONDUCTORS STUDIED BY POLARIZE LIGHT MICROSCOPY

P. Diko[1,2] H. Kojo[3], M. Murakami[2]

[2]Faculty of Engeneering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-01 Japan
[3]Superconductivity Research Laboratory, ISTEC, 10-13 Shinonome, 1-chome, Koto-ku, Tokyo 135, Japan

Microstructural features as 422 (or 211) particles, twins, twin complexes, subgrains, a-b microcracks and thermal microstresses are usual defects observable by polarized light microscopy in Re-Ba-Cu-O melt processed superconductors [1]. They can contribute to the pinning of flux lines mainly at lover magnetic fields (around 1 T), what is especially necessary in the case of Nd 123 bulk superconductors prepared by oxygen-controlled-melt-grown method [2], or they can be active as weak links. It is therefore important to study the possibilities how to influence the density of these defects in 123 matrix.
The samples with 10; 20;30 and 40 mol % of 422 phase were studied. Green pellets were pressed from 123 - 422 powder mixtures or from the powders obtained by melt quenched process. Melt processing was performed in reduced oxygen atmosphere (1 or 0.1 % O_2). Microstructure of the samples was studied in tetragonal and orthorhombic state.
Smaller 422 particles were observed in the samples prepared from the 123-422 powder mixtures. The a-b microcrack spacing increased with 422 volume fraction and refinement of 422 particles. Detwinning around 422 particles in <100> directions caused by thermal microstresses around 211 particles was observed. The twins and twin complexes were refined by shortening of the mean free distance between 422 particles. The formation of subgrain boundaries was related to the solidification process.

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[1]On leave from the Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 04353 Kosice, Slovakia.

STUDY OF A-AXIS ORIENTED $YBa_2Cu_3O_X$ SUPERCONDUCTING THIN FILMS ON Y_2O_3/ YSZ /Si SUBSTRATES

Š. Chromik[1], A.Rosová[1], Š. Gaži[1], Š. Beňačka[1] and B. Wuyts[2]
[1]Institute of Electrical Engineering, Slovak Academy of Sciences, Dúbravská cesta 9, 84239 Bratislava, Slovak Republic
[2]Laboratorium voor Vaste Stof-Fysika en Magnetisme Katholieke Universiteit Leuven, B-3001 Leuven, Belgium

A-axis $YBa_2Cu_3O_X$ (YBCO) thin films have been grown by DC magnetron sputtering on Y_2O_3 / YSZ / Si substrates with $PrBa_2Cu_3O_X$ (PBCO) seed layer prepared in the same vacuum cycle. X-ray diffraction has shown the maximum of a-axis YBCO volume fraction above 99%. A resistance-temperature dependence is influenced by "parasitic" c-axis volume fraction. A critical temperature T_c (at R=0) is often strongly dependent on value of measuring current. The epitaxial YBCO films are composed of a-axis oriented regions with YBCO orientations: YBCO (100) [010] / Y_2O_3 (100) [011] or YBCO (100) [001] /Y_2O_3 (100) [011]. The TEM observations show different distribution of "parasitic" c -axis oriented YBCO films for different volume fractions of a-axis oriented YBCO films. A low magnetic field microwave absorption has been applied for detection of the transition to superconducting state. Two different types of wave polarizations in microwave resonator were used for identification of intragranular and intergranular currents.

MATERIALS ASPECTS OF PROXIMITY JUNCTIONS ON CLEAVED SURFACES OF $Bi_2Sr_2CaCu_2O_8$ CRYSTALS

H. Z. Durusoy

Department of Physics, Hacettepe University , Beytepe, 06532 Ankara, Turkey.

M. R. Beasley,

Department Of Applied Physics, Stanford University , Stanford, CA. 94305, USA.

SNS' proximity junctions have been formed on cleavage steps of $Bi_2Sr_2CaCu_2O_8$ (BSCCO) single crystals. BSCCO/Ag/Pb junctions on such steps show RSJ type Josephson behavior with supercurrent densities as high as 10^4 A/cm^2. Typical Rn values vary between 50-100 mΩ at low temperatures, yielding IcRn products of several milivolts. Contact resistances for these junctions are measured to be 10^{-7} Ω-cm^2.

In contrast, c-axis junctions simultaneously formed on step-free, smooth areas of the same crystals exhibit no measurable Josephson coupling. A BCS like gap structure at 25 mV with a nonzero conductance at zero bias is observed for such junctions at low temperatures. Contact resistances for these, c-axis junctions are found to be 10^{-3} Ω-cm^2 .

SUPERCONDUCTIVITY IN $La_2CuO_{4.03}$ SINGLE CRYSTAL SYSTEM

Yuri Obukhov [a], V.Yu. Pomjakushin[a], A.A.Zakharov[b], A.A.Nikonov[b]

[a] Joint Institute for Nuclear Research, 141 980 Dubna, Russia

[b] Russian Scientific Center "Kurchatov Institute", 123182, Moscow, Russia

Abstract

The data of magnetisation of superconducting $La_2 CuO_{4.03}$ single crystal system are presented. The measurements was prepared using SQUID-susceptometer. Monocrystal has a high structure quality and T_c=13K. It demonstrates the superconducting grid like behaviour and can consider as a natural superconducting network. The data obtained are discussed.

P2-8

Dr. Andrei Galatanu
Physics & Technology of Materials
Institute of Atomic Physics
P. O. Box MG-06
76900 Bucharest-Magurel Romania
Tel:
FAX: +40.1.420.3700
e mail:
Paper #

Prof. Vsevolod Gantmacher
Inst. Solid State Physics, Chernogolovka
Russian Academy of Science
Moscow District
142432 Chenogolovka Russia
Tel: +7.096.517.1610
FAX: +7.096.517.1949
e mail: gantm@gantm.chg.free.net
Paper # O13

Mr. Gary Gibson
Department of Materials
Imperial College
Prince Consort Rd
London SW7 2BP UK
Tel: +44.171.589.5111
FAX: +44.171.584.3194
e mail: gg01@ic.ac.uk
Paper # O20

Dr. Ernst L. Haase
Physics
Forschungszentrum
IMF III, P.O.Box 3640
D-76021 Karlsruhe Germany
Tel: +49.7247.82.2807
FAX: +49.7247.82.3956
e mail: haase@hdi.kfk.de
Paper # O4

Dr. Jan Hermann
Physics Department
University of California, S.D.
IPAPS-0360, 9500 Gilman Drive
La Jolla CA 92093-0360 USA
Tel: +1.619.534.2493
FAX: +1.619.534.1241
e mail: hermann@sdphul.ucsd.edu
Paper # O19

Dr. Tajammul Hussain
Director
COMSATS
30, Ataturk Avenue G-6/4
44000 Islamabad Pakistan
Tel: +92.51.828.707
FAX: +92.51.216.539
e mail: comsats@infolink.net.pk
Paper #

Dr. Tetsuya Ida
Applied Physics Dept.
Tokyo Univ. of Mercantile Marine
2-1-6 Etchu-jima, Koto-ku
Tokyo 135 Japan
Tel: +81.3.5245.7462
FAX: +81.3.5245.7462
e mail: ida@zairyo.phys.tosho-u.ac.jp
Paper # P1.1

Dr. Mitsuro Izumi
Applied Physics Dept.
Tokyo Univ. of Mercantile Marine
2-1-6 Etchu-jima, Koto-ku
Tokyo 135 Japan
Tel: +81.3.5245.7462
FAX: +81.3.5245.7462
e mail: izumi@ipc.tosho-u.ac.jp
Paper #

Dr. Sudhir Jain
School of Mathematics & Computing
University of Derby
Kedlestone Road
Derby DE22 1GB UK
Tel: +44.1332.622.2222
FAX: +44.1332.622.745
e mail: s.jain@derby.ac.uk
Paper # P1.2

Prof. Miroslav Jelinek
Physics Institute
Czech Academy of Science
2 Na Slovance
18040 Prague 8 Czech Republic
Tel: +42.2.815.2733
FAX: +42.2.858.4569
e mail: jelinek@fzu.cz
Paper # 17

Dr. James D. Jorgensen
Neutron and X-Ray Scattering Dept.
Argonne National Lab
9700 S. Cass Avenue, Bldg. 223
Argonne IL 60439 USA
Tel: +1.708.252.5513
FAX: +1.708.252.777
e mail: jim_jorgensen@qmgate.anl.gov
Paper # O11

Dr. Victor Kabanov
Physics
University of Cambridge
Madingley Road
Cambridge CB3 0HE UK
Tel: +44.1.223.33.70.72
FAX: +44.1.223.33.70.74
e mail: vvk20@cus.cam.ac.uk
Paper # O10

Dr. Bernd Kabius
Institute fur Festkoerper Forschung
Forschungzentrum Julich
Postfach 1913
D 52428 Julich Germany
Tel: +49.2461.61.
FAX: +49.2461.61.
e mail: kabius@iff234.kfa-juelich-de
Paper # O16

Dr. Igor Khrebtov
S.I.Vavilov State Optical Inst.
199034 St.-Petersburg Russia
Tel:
FAX: +7.812. 350 9993
e mail: khrebtov@soi.spb.su
Paper # P2.1(

Prof. Kohji Kishio
Dept. of Applied Chemistry
University of Tokyo
Hongo, Bonkyo-ku
Tokyo 113 Japan
Tel: +81.3.3812.2111
FAX: +81.3.5689.0574
e mail: kishiok@tansei.cc.u-tokyo.ac.jp
Paper # O6

Dr. Norbert Klein
Inst. for Solid State Physics
KFA Julich
IFF
D-52425 Julich Germany
Tel: +49.2461.5722
FAX: +49.2461.6444
e mail: n.klein@kfa-juelich.de
Paper # O23

Dr. Ram Kossowsky
Emerging Technologies, Inc.
6327 Burchfield Avenue
Pittsburgh PA 15217 USA
Tel: +1-412.421.4408
FAX: +1-412.421.4342
e mail: ramkoss@ix.netcom.com
Paper #

Dr. Hanita Kossowsky
Emerging Technologies, Inc.
6327 Burchfield Avenue
Pittsburgh PA 15217 USA
Tel: +1-412.421.4408
FAX: +1-412.421.4342
e mail:
Paper #

Prof. Vladimir Krivoruchko
Physical & Technical Institute
Ukrainian Academy of Science
R. Luxemburg Str. 72
340114 Donetsk Ukraine
Tel: +38.622.55.68.74
FAX: +38.622.55.01.27
e mail: krivoruc @host.dipt.donetsk.ua
Paper # P1.5

Prof. John T. Markert
Dept. of Physics
University of Texas
Austin TX 78712 USA
Tel: +1.512.471.1039
FAX: +1.512.471.9637
e mail: market@physics.utexas.edu
Paper # O12

Mr. Michel M. Medvedev
Theoretical Physics Department
Odessa University
2 Petra Velikogo Street
270100 Odessa Ukraine
Tel: +38.482.206768
FAX:
e mail: mdm@dtp.odessa.ua
Paper # P1.1(

Ing. Peter Mraz
Pobocka/Subsidiary
AVANTEK
Piestanska 44
915 01 Nove Mesto n/V Slovak Republic
Tel: 42.834.71.5726
FAX: 42.834.5520
e mail: mraz@bb.sanet.sk
Paper #

Mr. Adam Nabialek
Institute of Physics
Al., Lotnikow 32/46
02668 Warszawa Poland
Tel: +48.22.435212
FAX: +48.22.430926
e mail: nabia@ifpan.edu.pl
Paper # P1.3

Dr. Elena K. Nazarova
Inst. Solis State Physics
Bulgarian Academy of Science
72 Trackia Blvd.
1784 Sofia Bulgaria
Tel: +359.2.743558
FAX: +359.2.757032
e mail: angelow@bgcict.acad.bg
Paper # P2.3

Dr. Sergey Nedilko
Department of Chemistry
Kiev University
Vladymyrskay 60
252033 Kiev Ukraine
Tel: +38.44.221.0206
FAX: +38.44.224.6166
e mail: zaitsev@chemuniv.kiev.ua
Paper #

Prof. Anatoli D. Nikulin
Vice Director
A. A. Bocvar, ARSRIIM
5, Rogova Street
123060 Moscow Russia
Tel: +7.095.196.6603
FAX: +7.095.196.6671
e mail: vica@vniinm402.msk.su
Paper # O21

Dr. Josef Novak
Institute of Electrical Engineering
Slovak Academy of Science
Dubravska Cesta 9
SK842 39 Bratislava Slovak Republic
Tel: 42.7.375.826
FAX: 42.7.375.816
e mail: eleknova@savba.sk
Paper #

Dr. Yuri Obukhov
Neutron Physics Laboratory
Joint Inst. Nuclear Research
FLNP, JINR
141980 Dubna Russia
Tel: +7.9621.62671
FAX: +7.9621.65882
e mail: obukov@nf.jinr.dubna.su
Paper # P2.8

Dr. V. G. Orlov
Kurchatov Institute, RRC
123182 Moscow Russia
Tel:
FAX: +7.095.882.5804
e mail: orlov@jbivn.kiae.su
Paper # P2.9

Dr. Vanni Ottoboni
CISE Spa
Via Reggio Emillia, 39
20090 Segrate, MI Italy
Tel: +39.2.2167.2303
FAX: +39.2.2167.2620
e mail: 0657otto@s1.cise.it
Paper # P1.6

Prof. Vladimir Pan
Department of Superconductivity
Institute for Metal Physics
Vernadsky Blvd.,36
Kiev 252142 Ukraine
Tel: +7.044.444.1031
FAX:
e mail: pan@d09imp.kiev.ua
Paper # O3

Dr. Marek Pekala
Department of Chemistry
University of Warsaw
Al Zwirki i Wiguri 101
PL02 089 Warsaw Poland
Tel: +48.22.224881
FAX: +48.22.225996
e mail: pekala@chem.uw.edu.pl
Paper # P1.8

Mr. Anton Puchov
Dept. of Physics
McMaster University
1280 Main W.
Hamilton Ont Canada
Tel: +1.905.525.9140
FAX: +1.905.546.1252
e mail: g9226012@mcmaster.ca
Paper # P1.4

Dr. Ladislav Pust
Superconductivity
Institute of Physics
Na Slovance 2
CZ18040 Prague 8 Czech Republic
Tel: +42.2.6605.2617
FAX: +42.2.821227
e mail: pust@fzu.cz
Paper # P2.2

Dr. Leoa Rodrigues
Electrotechnical Engineering
Universidade Nova de Lisboa
2825 Monte Caparicia Portugal
Tel: +351.1.295 4464
FAX: +351.1.295 7810
e mail:
Paper # O22

Dr. Irena Sargankova
Inst. of Experiment. Physics
Watsonova 47
04353 Kosice Slovak Republic
Tel: +42.95.622.5771
FAX: +42.95.36292
e mail: dikos@rs530h.iepsaske.sk
Paper # P2.4

Prof. Jaroslav Sestak
Institute of Physics
Cukrovarnicka 10
16200 Prague 6 Czech Republic
Tel: +42.2.522767
FAX: +42.2.312.3184
e mail: sestak@fzu.cz
Paper # P2.1

Prof. Donglu Shi
Dept. of Materials Science & Eng.
University of Cincinnati
Cincinnati OH 45211-0012 USA
Tel: +1.513.556.3100
FAX: +1.513.556.2569
e mail: dshi@uceng.uc.edu
Paper # O7

Prof. Thomas Timusk
McMaster University
Dept. of Physics
Hamilton ONT L8S 4M1 Canada
Tel: +1.905.525.9140
FAX: +1.905.546.1252
e mail: timusk@mcmail.cis.mcmaster.ca
Paper # O1

Dr. Anwar ul Haq
Metallurgy Division
A.Q.Khan Research Laboratory
Kahuta, P.O.Box 905
Rawalpindi Pakistan
Tel:
FAX: +92.51.452.487
e mail: 100074.172@compuserve.com
Paper # O14

Prof. Ann van Otterlo
Theoretische Physik
ETH - Konggerberg
CH-8093 Zurich Switzerland
Tel:
FAX:
e mail: blatterj@itp.phys.ethz.ch
Paper # O2

Dr. Valentin Shekhtman
President
EFL Ltd.
Orangereinaya ul. 67-50, Pushkin 8
189620 St. Petersburgh Russia
Tel: +7.812.476.2059
FAX: +7.812.238.9251
e mail: efl@shekhtman.spb.ru
Paper #

Dr. Viacheslav Solovjov
Superconductivity Dept.
Institute for Metal Physics
Vernadsky Boulevard, 36
Kiev 252142 Ukraine
Tel:
FAX: +38.44.444.1031
e mail: pan@d09imp.kiev.ua
Paper # O5

Dr. Vitezslav Trtik
Physics Institute
Czech Academy of Science
2 Na Slovance
18040 Prague 8 Czech Republic
Tel: +42.2.815.2733
FAX: +42.2.858.4569
e mail: trtik@fzu.cz
Paper #

Dr. Alexander Usachev
KSC RAS
Kazan Physical-Technical Inst.
Sibirsky trakt, 10/7
420029 Kazan-29 Tatars Russia
Tel: +7.8432.761221
FAX: +7.8432.765075
e mail: usachev@ksc.iasnet.com
Paper # P1.7

UNUSUAL PROPERTIES OF BISMUTH OXIDE α-Bi_2O_3. A SURVEY OF EXPERIMENTAL RESULTS

V.G. Orlov
Russian Research Center Kurchatov Institute, 123182 Moscow, Russia

The bismuth oxide alpha-Bi2O3, one of the parent compounds for the synthesis of HTSC, was traditionally regarded as a diamagnetic substance. However the results of recent studies have shown that the magnetic and electric properties of alpha-Bi2O3 are far more complex than it was thought of hitherto. We have investigated this compound using a number of experimental methods: NQR [1], SQUID-magnetometer [2], muSR [3], XPS, Inelastic Neutron Scattering, Infrared and Raman spectroscopies. The heat capacity, electrical resistivity, thermostimulated currents, dielectric permeability, X-ray diffraction and thermal expansion measurements have been also made on single crystal as well as polycrystalline samples in a wide temperature range.

A number of peculiarities have been observed:
1) the splitting of all 209Bi NQR lines [1], this fact was interpreted as an evidence of existence of internal magnetic fields in alpha-Bi2O3;
2) nonlinear magnetisation curves which at low temperatures had positive sign in weak external magnetic fields and demonstrated significant anisotropy and hysteresis [2];
3) the fast decay of the muon spin polarization [3];
4) the presence of longitudinal magnetoelectric effect on a single crystal at 4.2 K [2].

There have been also obtained evidences of a phase transition in alpha-Bi_2O_3 which presumably occurs in the temperature range 300-400 C: a small maximum in dielectric permeability, a sharp drop of electric resistivity, a jump of thermostimulated current, a narrow exothermal maximum in the heat capacity curve. The nature of the assumed phase transition and the origin of unusual properties of alpha-Bi2O3 are discussed in the report.

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HIGH-Tc SUPERCONDUCTING BOLOMETERS

I.A.Khrebtov, Vavilov State Optical Institute,
St.Petersburg, Russia

Detection of the radiation in a wide wavelength region is one of the most prospective applications of the high-Tc superconductors. The possibilities and the state-of-art of the development of bolometers based on HTSC-films are considered. Creative principles of various types of bolometers using a sharp change of resistance at superconducting transition, temperature dependence of magnetic susceptibility, critical current and kinetic inductance are formulated. Constructive and technological aspects of fabrication of the bolometric detector (composite and membrane types, antenna microbolometer, IR-arrays) are discussed.The factors determining the responsivity, response time and noise equivalent power are analysed. A special attention is paid to the consideration of the noise problem for HTSC-films and bolometers.In summary, the bolometric parameters achieved by different teams of researches and also by the author of this paper are reported.The future development of HTSC-bolometers is estimated.

P2-10

List of Participants

Dr. Nazeer Ahmad
Scientific & Tech. Cooperation Div.
Dr. A.Q.Khan Research Labs.
GPO Box 502
Rawalpindi Pakistan
Tel: +92.51.450734
FAX: +92.51.452.487
e mail: 100564.2717@compuserve.com
Paper #

Prof. Bekir Aktas
Physics Department
Gebze Inst. Advanced Technology
P. K. 41
41400 Gebze-Kocaeli Turkey
Tel: +90.262.653.8287
FAX: +90.262.653.8490
e mail: aktas@penta.gyte.edu.tr
Paper # P1.9

Dr. Elena V. Antipova
A. A. Bocvar, ARSRIIM
5, Rogova Street
123060 Moscow Russia
Tel: +7.095.196.6603
FAX: +7.095.196.6671
e mail: vica@vniinm402.msk.su
Paper #

Dr. Jom Beyer
Lab. fuer Kryoelektronik 9.33
PTB Institut
Abbestrasse 2-12
10587 Berlin Germany
Tel: +49.30.348.1426
FAX: +49.30.348.1490
e mail: jbeyer@chbrb.berlin.ptb.de
Paper #

Dr. Nicole Bontemps
Department of Physics
Ecole Normal Superior
24 Rue Lhomond
75231 Paris, Cedex 05 France
Tel: +33.1.44.32.35.04
FAX: +33.1.44.32.38.40
e mail: bontemps@physique.ens.fr
Paper # O9

Prof. Shyamalendu Bose
Physics Department
Drexel University
Philadelphia PA 19104 USA
Tel: +1.215.895.1706
FAX: +1.215.895.4999
e mail: bose@duvm.ocs.drexel.edu
Paper # O8

Dr. Alex Braginski
Direktor
Forschungszentrum, Juelich, KFA
Institut fuer Schicht und Ionentechnik (ISI)
D 52425 Juelich Germany
Tel: +49.2461.61.2330
FAX: +49.2461.61.2333
e mail: alexbrag@isitell.isi.kfa-juelich.de
Paper # O15

Dr. Stefan Chromik
Electrotechnical Ustav SAV
Dubraska cesta 9
842389 Bratislava Slovak Republic
Tel: +42.27.378.2339
FAX: +42.27.375816
e mail:
Paper # P2.6

Dr. Pavel Diko
Inst. of Experiment. Physics
Watsonova 47
04353 Kosice Slovak Republic
Tel: +42.95.622.5771
FAX: +42.95.36292
e mail: dikos@rs530h.iepsaske.sk
Paper # P2.5

Prof. Zafer Durusoy
Physics Department
Haccettepe University
06532 Ankara Turkey
Tel: +90.312.235.2551
FAX: +90.312.235.2550
e mail: fhzd@eti.cc.hun.edu.tr
Paper # P2.7

Dr. Andrei V. Eremenko
Low Temperature Physics
Institute for Single Crystals
60 Lenin Avenue
Kharkov 310001 Ukraine
Tel: +38.572.321042
FAX:
e mail: andrerem@ilt.kharkov.ua
Paper #

Dr. Martin Forrester
Northrop Grumman Corp.
1310 Beulah Road
Pittsburgh PA 15235 USA
Tel: +1.412.256.1468
FAX: +1.412.256.1331
e mail: forres@cis.pgh.wec.com
Paper # O18

Dr. Andrei Galatanu
Physics & Technology of Materials
Institute of Atomic Physics
P. O. Box MG-06
76900 Bucharest-Magurel Romania
Tel:
FAX: +40.1.420.3700
e mail:
Paper #

Prof. Vsevolod Gantmacher
Inst. Solid State Physics, Chernogolovka
Russian Academy of Science
Moscow District
142432 Chenogolovka Russia
Tel: +7.096.517.1610
FAX: +7.096.517.1949
e mail: gantm@gantm.chg.free.net
Paper # O13

Mr. Gary Gibson
Department of Materials
Imperial College
Prince Consort Rd
London SW7 2BP UK
Tel: +44.171.589.5111
FAX: +44.171.584.3194
e mail: gg01@ic.ac.uk
Paper # O20

Dr. Ernst L. Haase
Physics
Forschungszentrum
IMF III, P.O.Box 3640
D-76021 Karlsruhe Germany
Tel: +49.7247.82.2807
FAX: +49.7247.82.3956
e mail: haase@hdi.kfk.de
Paper # O4

Dr. Jan Hermann
Physics Department
University of California, S.D.
IPAPS-0360, 9500 Gilman Drive
La Jolla CA 92093-0360 USA
Tel: +1.619.534.2493
FAX: +1.619.534.1241
e mail: hermann@sdphul.ucsd.edu
Paper # O19

Dr. Tajammul Hussain
Director
COMSATS
30, Ataturk Avenue G-6/4
44000 Islamabad Pakistan
Tel: +92.51.828.707
FAX: +92.51.216.539
e mail: comsats@infolink.net.pk
Paper #

Dr. Tetsuya Ida
Applied Physics Dept.
Tokyo Univ. of Mercantile Marine
2-1-6 Etchu-jima, Koto-ku
Tokyo 135 Japan
Tel: +81.3.5245.7462
FAX: +81.3.5245.7462
e mail: ida@zairyo.phys.tosho-u.ac.jp
Paper # P1.1

Dr. Mitsuro Izumi
Applied Physics Dept.
Tokyo Univ. of Mercantile Marine
2-1-6 Etchu-jima, Koto-ku
Tokyo 135 Japan
Tel: +81.3.5245.7462
FAX: +81.3.5245.7462
e mail: izumi@ipc.tosho-u.ac.jp
Paper #

Dr. Sudhir Jain
School of Mathematics & Computing
University of Derby
Kedlestone Road
Derby DE22 1GB UK
Tel: +44.1332.622.2222
FAX: +44.1332.622.745
e mail: s.jain@derby.ac.uk
Paper # P1.2

Prof. Miroslav Jelinek
Physics Institute
Czech Academy of Science
2 Na Slovance
18040 Prague 8 Czech Republic
Tel: +42.2.815.2733
FAX: +42.2.858.4569
e mail: jelinek@fzu.cz
Paper # 17

Dr. James D. Jorgensen
Neutron and X-Ray Scattering Dept.
Argonne National Lab
9700 S. Cass Avenue, Bldg. 223
Argonne IL 60439 USA
Tel: +1.708.252.5513
FAX: +1.708.252.777
e mail: jim_jorgensen@qmgate.anl.gov
Paper # O11

Dr. Victor Kabanov
Physics
University of Cambridge
Madingley Road
Cambridge CB3 0HE UK
Tel: +44.1.223.33.70.72
FAX: +44.1.223.33.70.74
e mail: vvk20@cus.cam.ac.uk
Paper # O10

Dr. Bernd Kabius
Institute fur Festkoerper Forschung
Forschungzentrum Julich
Postfach 1913
D 52428 Julich Germany
Tel: +49.2461.61.
FAX: +49.2461.61.
e mail: kabius@iff234.kfa-juelich-de
Paper # O16

Dr. Igor Khrebtov
S.I.Vavilov State Optical Inst.
199034 St.-Petersburg Russia
Tel:
FAX: +7.812. 350 9993
e mail: khrebtov@soi.spb.su
Paper # P2.1(

Prof. Kohji Kishio
Dept. of Applied Chemistry
University of Tokyo
Hongo, Bonkyo-ku
Tokyo 113 Japan
Tel: +81.3.3812.2111
FAX: +81.3.5689.0574
e mail: kishiok@tansei.cc.u-tokyo.ac.jp
Paper # O6

Dr. Norbert Klein
Inst. for Solid State Physics
KFA Julich
IFF
D-52425 Julich Germany
Tel: +49.2461.5722
FAX: +49.2461.6444
e mail: n.klein@kfa-juelich.de
Paper # O23

Dr. Ram Kossowsky
Emerging Technologies, Inc.
6327 Burchfield Avenue
Pittsburgh PA 15217 USA
Tel: +1-412.421.4408
FAX: +1-412.421.4342
e mail: ramkoss@ix.netcom.com
Paper #

Dr. Hanita Kossowsky
Emerging Technologies, Inc.
6327 Burchfield Avenue
Pittsburgh PA 15217 USA
Tel: +1-412.421.4408
FAX: +1-412.421.4342
e mail:
Paper #

Prof. Vladimir Krivoruchko
Physical & Technical Institute
Ukrainian Academy of Science
R. Luxemburg Str. 72
340114 Donetsk Ukraine
Tel: +38.622.55.68.74
FAX: +38.622.55.01.27
e mail: krivoruc @host.dipt.donetsk.ua
Paper # P1.5

Prof. John T. Markert
Dept. of Physics
University of Texas
Austin TX 78712 USA
Tel: +1.512.471.1039
FAX: +1.512.471.9637
e mail: market@physics.utexas.edu
Paper # O12

Mr. Michel M. Medvedev
Theoretical Physics Department
Odessa University
2 Petra Velikogo Street
270100 Odessa Ukraine
Tel: +38.482.206768
FAX:
e mail: mdm@dtp.odessa.ua
Paper # P1.1(

Ing. Peter Mraz
Pobocka/Subsidiary
AVANTEK
Piestanska 44
915 01 Nove Mesto n/V Slovak Republic
Tel: 42.834.71.5726
FAX: 42.834.5520
e mail: mraz@bb.sanet.sk
Paper #

Mr. Adam Nabialek
Institute of Physics
Al., Lotnikow 32/46
02668 Warszawa Poland
Tel: +48.22.435212
FAX: +48.22.430926
e mail: nabia@ifpan.edu.pl
Paper # P1.3

Dr. Elena K. Nazarova
Inst. Solis State Physics
Bulgarian Academy of Science
72 Trackia Blvd.
1784 Sofia Bulgaria
Tel: +359.2.743558
FAX: +359.2.757032
e mail: angelow@bgcict.acad.bg
Paper # P2.3

Dr. Sergey Nedilko
Department of Chemistry
Kiev University
Vladymyrskay 60
252033 Kiev Ukraine
Tel: +38.44.221.0206
FAX: +38.44.224.6166
e mail: zaitsev@chemuniv.kiev.ua
Paper #

Prof. Anatoli D. Nikulin
Vice Director
A. A. Bocvar, ARSRIIM
5, Rogova Street
123060 Moscow Russia
Tel: +7.095.196.6603
FAX: +7.095.196.6671
e mail: vica@vniinm402.msk.su
Paper # O21

Dr. Josef Novak
Institute of Electrical Engineering
Slovak Academy of Science
Dubravska Cesta 9
SK842 39 Bratislava Slovak Republic
Tel: 42.7.375.826
FAX: 42.7.375.816
e mail: eleknova@savba.sk
Paper #

Dr. Yuri Obukhov
Neutron Physics Laboratory
Joint Inst. Nuclear Research
FLNP, JINR
141980 Dubna Russia
Tel: +7.9621.62671
FAX: +7.9621.65882
e mail: obukov@nf.jinr.dubna.su
Paper # P2.8

Dr. V. G. Orlov
Kurchatov Institute, RRC
123182 Moscow Russia
Tel:
FAX: +7.095.882.5804
e mail: orlov@jbivn.kiae.su
Paper # P2.9

Dr. Vanni Ottoboni
CISE Spa
Via Reggio Emillia, 39
20090 Segrate, MI Italy
Tel: +39.2.2167.2303
FAX: +39.2.2167.2620
e mail: 0657otto@s1.cise.it
Paper # P1.6

Prof. Vladimir Pan
Department of Superconductivity
Institute for Metal Physics
Vernadsky Blvd.,36
Kiev 252142 Ukraine
Tel: +7.044.444.1031
FAX:
e mail: pan@d09imp.kiev.ua
Paper # O3

Dr. Marek Pekala
Department of Chemistry
University of Warsaw
Al Zwirki i Wiguri 101
PL02 089 Warsaw Poland
Tel: +48.22.224881
FAX: +48.22.225996
e mail: pekala@chem.uw.edu.pl
Paper # P1.8

Mr. Anton Puchov
Dept. of Physics
McMaster University
1280 Main W.
Hamilton Ont Canada
Tel: +1.905.525.9140
FAX: +1.905.546.1252
e mail: g9226012@mcmaster.ca
Paper # P1.4

Dr. Ladislav Pust
Superconductivity
Institute of Physics
Na Slovance 2
CZ18040 Prague 8 Czech Republic
Tel: +42.2.6605.2617
FAX: +42.2.821227
e mail: pust@fzu.cz
Paper # P2.2

Dr. Leoa Rodrigues
Electrotechnical Engineering
Universidade Nova de Lisboa
2825 Monte Caparicia Portugal
Tel: +351.1.295 4464
FAX: +351.1.295 7810
e mail:
Paper # O22

Dr. Irena Sargankova
Inst. of Experiment. Physics
Watsonova 47
04353 Kosice Slovak Republic
Tel: +42.95.622.5771
FAX: +42.95.36292
e mail: dikos@rs530h.iepsaske.sk
Paper # P2.4

Prof. Jaroslav Sestak
Institute of Physics
Cukrovarnicka 10
16200 Prague 6 Czech Republic
Tel: +42.2.522767
FAX: +42.2.312.3184
e mail: sestak@fzu.cz
Paper # P2.1

Prof. Donglu Shi
Dept. of Materials Science & Eng.
University of Cincinnati
Cincinnati OH 45211-0012 USA
Tel: +1.513.556.3100
FAX: +1.513.556.2569
e mail: dshi@uceng.uc.edu
Paper # O7

Prof. Thomas Timusk
McMaster University
Dept. of Physics
Hamilton ONT L8S 4M1 Canada
Tel: +1.905.525.9140
FAX: +1.905.546.1252
e mail: timusk@mcmail.cis.mcmaster.ca
Paper # O1

Dr. Anwar ul Haq
Metallurgy Division
A.Q.Khan Research Laboratory
Kahuta, P.O.Box 905
Rawalpindi Pakistan
Tel:
FAX: +92.51.452.487
e mail: 100074.172@compuserve.com
Paper # O14

Prof. Ann van Otterlo
Theoretische Physik
ETH - Konggerberg
CH-8093 Zurich Switzerland
Tel:
FAX:
e mail: blatterj@itp.phys.ethz.ch
Paper # O2

Dr. Valentin Shekhtman
President
EFL Ltd.
Orangereinaya ul. 67-50, Pushkin 8
189620 St. Petersburgh Russia
Tel: +7.812.476.2059
FAX: +7.812.238.9251
e mail: efl@shekhtman.spb.ru
Paper #

Dr. Viacheslav Solovjov
Superconductivity Dept.
Institute for Metal Physics
Vernadsky Boulevard, 36
Kiev 252142 Ukraine
Tel:
FAX: +38.44.444.1031
e mail: pan@d09imp.kiev.ua
Paper # O5

Dr. Vitezslav Trtik
Physics Institute
Czech Academy of Science
2 Na Slovance
18040 Prague 8 Czech Republic
Tel: +42.2.815.2733
FAX: +42.2.858.4569
e mail: trtik@fzu.cz
Paper #

Dr. Alexander Usachev
KSC RAS
Kazan Physical-Technical Inst.
Sibirsky trakt, 10/7
420029 Kazan-29 Tatars Russia
Tel: +7.8432.761221
FAX: +7.8432.765075
e mail: usachev@ksc.iasnet.com
Paper # P1.7