

Japanese Aerospace Literature This month: Superconductors

A93-18541 Studies on crystal growth and some physical properties of oxide superconductors. KUNIHICO OKA, *Electrotechnical Laboratory, Researches* (ISSN 0366-9106), No. 940, July 1992, 99 pp. 184 Refs.

A review is presented of the theory and technique of crystal growth from solution and superconductive oxides. Attention is focused on the phase diagrams, crystal growth, characterization and some physical measurements of high-Tc oxide superconductors. The phase diagram for crystal growth of superconductive oxides, which were determined using differential thermal analysis, a quenching technique and X-ray diffraction measurement are presented.

A93-18516 Flux creep characteristics after high-temperature magnetization in YBaCuO superconductor. NOBUYOSHI SAKAMOTO, TADAHIRO AKUNE, and TERUO MATSUSHITA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 10B, Oct. 15, 1992, pp. L1470-L1473. 9 Refs.

Flux creep characteristics at an operating temperature T_0 have been investigated experimentally after temperature changes from the critical state, which were created by cooling a YBaCuO superconductor magnetized at higher temperatures $T_0 + \Delta T$ (HTM). Drastic reduction in the creep rate by one order of magnitude was observed for ΔT greater than about 3 K at T_0 ranging from 40 to 77 K. A transient state with high HTM creep rate has also been observed at high operating temperature and is ascribed to flux profile variations induced by strengthened diamagnetic properties at low temperatures. (Author)

A93-18067 Hysteresis loops of modulated microwave absorption and flux distribution in granular Y1Ba2Cu3O(x). TAMIO ENDO and TAKASHI WADA, *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 10, Oct. 1992, pp. 3303-3310. 26 Refs.

Results of hysteresis measurements of the modulated microwave absorption (MA) and the magnetization made on granular Y1Ba2Cu3O(x) are presented. The mechanism of the modulated MA and the manner of change in the flux distribution in the sample with increasing and decreasing field are proposed, with the intergrain and intragrain flux distributions taken into account. The intergrain critical state (CS) is established at about 5 G, and it is virtually maintained to over 4 kG, and the inverse intergrain CS is maintained to below about 200 G. The transition widths of the hysteresis loop of the modulated MA increase with increasing H_a with small rates for H_a of less than 1700 G and larger rates for H_a of greater than 1700 G. This indicates that the depth and the height of the intergrain critical states for the upward and the downward field sweeps increase. The height increases at H_a of greater than 1700 G is maintained to the very low field of 50 G. The origin of this behavior is discussed in terms of the corrective pinning of intergrain and intragrain vortex glass.

A93-17604 Analysis on electric field effect in Al/SrTiO3/YBa2Cu3O(y) structure. KEN-ICHI MATSUI, TAKAHIRO AWAJI, TAKASHI HIRANO, TATSUHIKO FUJII, KEN SAKUTA, and TAKESHI KOBAYASHI, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 9B, Sept. 15, 1992, pp. L1342-L1344. 14 Refs.

Planar-type Al(100)/SrTiO3/(001)YBa2Cu3O(y) metal-insulator-superconductor field-effect transistors (MISFETs) were investigated experimentally and theoretically. The applied gate field induces the change of the carrier concentration in YBa2Cu3O(y) channel (or conducting layer thickness), which in turn modulates the critical current through the flux-creep model and flux-flows resistivity through the Bardeen-Stephen model. Theoretical results explained, to a certain extent, the observed field effect in the MISFET semiquantitatively. (Author)

A93-17603 Unit-by-unit process of Bi2Sr2CuO(y) film growth with molecular beam epitaxy by separated evaporation/oxidation/crystallization technique. KOUJI SUZUKI, TETSUYA KARAKI, KENJI IWASHIMA, MIKI SHIBATA, HIROYUKI OKADA, HIROYOSHI ONNAGAWA, and KAZUO MIYASHITA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 9B, Sept. 15, 1992, pp. L1339-L1341. 13 Refs.

Thin films of Bi2Sr2CuO(y) were grown with MBE by the separated evaporation/oxidation/crystallization technique on a MgO (100) substrate. The proposed technique is the unit-by-unit process consisting of three steps: multilayer deposition of (Bi-Sr-Cu-Sr-Bi) \times 2, low-temperature oxidation (300 C) in low concentration O3(O2/O3(0.3 pct)) atmosphere (5 \times 10 exp -5 Torr) and crystallization (750 C, 1 \times 10 exp -8 Torr). After growth of ten units, clear streaks on the RHEED pattern showing the twin structure and a fairly fine X-ray diffraction pattern were observed. (Author)

A93-17601 Zero-bias resistance peak in oxide-semiconductor junctions. KAZUAKI TAMURA, NOBUAKI MIYAKAWA, DAISUKE SHIMADA, TAKASHI AKAHANE, and NOBUO TSUDA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 9B, Sept. 15, 1992, pp. L1322-L1324. 24 Refs.

A zero-bias resistance peak appeared in the tunneling resistance curve of Bi-cuprates, Na(0.89)WO3 and ReO3, contacted with GaAs or SnO(2-x). Therefore the peak is not inherent to high-Tc superconductors and may not be relevant to the electronic properties in the bulk. (Author)

A93-17602 Distribution of oxygen atoms in a YBa2Cu3O(6.4) superconductor visualized by ultra-high-resolution electron microscopy. SHIGEO HORIUCHI, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 9B, Sept. 15, 1992, pp. L1335-L1338. 8 Refs.

Arrangements of oxygen atoms in a superconducting YBa2Cu3O(6.4) crystal ($T_c = 27$ K) have been visualized by ultra-high-resolution high-voltage electron microscopy. The crystal consists of major orthorhombic and minor pseudotetragonal regions. Oxygens in CuO(y) planes do not distribute homogeneously but are mostly concentrated in areas smaller than 100 Å in diameter, in which clusters of 8 to 30 Å are closely packed with an oxygen arrangement similar to that in YBa2Cu3O(6.9) or YBa2Cu3O(7.7) respectively. The volume ratio of these two types of clusters varies in each area, resulting in the local change of the crystal symmetry. The formation of these oxygen-rich areas as well as clusters must strongly affect the mechanism and properties of superconductivity. (Author)

A93-17559 Junction characteristics of an Au/Ba(1-x)K(x)BiO3/nio-bium-doped SrTiO3 structure. HIROSHI SUZUKI, MASAHIRO IYORI, TETSUYA YAMAMOTO, SEIJI SUZUKI, KAZUHIKO TAKAHASHI, TATSURO USUKI, and YORINOBU YOSHISATO, *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 9A, Sept. 1992, pp. 2716-2720. 23 Refs.

Au/Ba(1-x)K(x)BiO3 and Ba(1-x)K(x)BiO3/nio-bium-doped SrTiO3, two types of junctions which correspond to the emitter base and base collector in superconducting base transistors, respectively, have been fabricated and studied. The highest T_c end point (T_{c0}) of 28 K was obtained of thin film Ba(1-x)K(x)BiO3 by RF-sputtering method. The Au/Ba(1-x)K(x)BiO3 tunnel spectrum showed a clear gap structure and was very close to the ideal Bardeen Cooper Schrieffer theory's (BCS) form with $\Delta(0) = 3.19$ meV. The Ba(1-x)K(x)BiO3/SrTiO3(Nb) junction with heavy niobium doping (0.1 wt pct) showed tunnel-like I-V characteristics. The dI/dV spectrum for a high-Tc superconductor/semiconductor junction displayed the energy gap structure of a superconductor. (Author)

A93-17558 Production of YBa2Cu3O(7-x) thick films on Ag metal substrate controlled by oxygen. YOSHIO MASUDA, KAZUO MATSUBARA, RIKURO OGAWA, and YOSHIO KAWATE, *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 9A, Sept. 1992, pp. 2709-2715. 17 Refs.

YBa2Cu3O(7-x) superconducting thick films were formed on Ag substrate using the sol prepared from pertinent metal alkoxides. The firing conditions which cause incongruent melting and a peritectic reaction in the film were investigated. We call this the IMPERCO (incongruent melting and peritectic reaction controlled by oxygen) method. It has been found that films which undergo both reactions have excellent superconducting properties. Accordingly, the critical current density (J_c) of 1.18×10^4 A/sq cm at 77 K and zero magnetic field has been obtained. Roles of the boundary of the film and Ag substrate were also discussed. (Author)

A93-15720 Superconducting phase diagram of the two-band model investigated by the exact-diagonalization method. KUNIHICO YAMAJI, KIKUO HARIGAYA, TAKASHI YANAGISAWA, and YUKIHIRO SHIMOI, *Physical Society of Japan Journal* (ISSN 0031-9015), Vol. 61, No. 10, Oct. 1992, pp. 3689-3698. 30 Refs.

By means of the exact-diagonalization method we have studied the finite-size two-band model with the interband pair-transfer interaction by calculating the superconducting (SC) correlation function P_s , etc., in the ground state. Occurrence of SC was clearly indicated by the increase of P_s . The diagram of the observed SC region was constructed in the plane of the relative position of the second band versus on-site Coulomb energy U . In the low-density limit it proved close to the region where a negative- U situation is realized by the pair-transfer interaction. On the high-density side, the SC region was found to be more extended than the latter in accord with the previous interband-ladder-diagram results. Inclusion of the exchange interaction was found to reduce the SC region in a restricted region where two bands substantially share electrons. The two-band situations in cuprates are argued to be relevant to the high T_c through the present mechanism. (Author)

A92-54442 Photocurrent in thin YBa2Cu3O6 films on sapphire. BRUNO ULLRICH, IBRAHIM KULAC, HARALD PINT, GUENTHER LEISING, and HARTMUT KAHLERT, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 7A, July 1, 1992, pp. L856-L859. 19 Refs.

Photocurrents in thin YBa2Cu3O6 films were measured at 300 K and 77 K. It is demonstrated that the classical semiconductor theory holds for this kind of material. The photocurrent results are discussed and compared with luminescence and optical transmission measurements. A large energy shift (0.63 eV), to date not observed in other semiconductors, between the photocurrent and luminescence maxima was measured. An oxygen surplus in the bulk of the sample is assumed to be the reason. Furthermore, it is demonstrated that at the critical temperature ($T_c = 93$ K) of superconductive YBa2Cu3O7 a change in the dark conductance behavior of semiconducting YBa2Cu3O6 takes place. (Author)

A93-17557 Contact resistance of several metals on YBa₂Cu₃O_{7-δ}. KATSUTOSHI OKA and TAKEO IRI, *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 9A, Sept. 1992, pp. 2689-2691. 12 Refs.

The contact resistance of Au, Ag, Cu, Pb, Sb, and Al metal electrodes on a high-T_c superconductor YBa₂Cu₃O_{7-δ} was evaluated from the electrode resistivity defined by the inverse of the conductance per unit area of the electrode. It was found that the dominant parameter which determined the electrode resistivity is the free energy of oxide formation of a metal, which is a measure of the tendency of the metal to oxidize during the fabrication of the electrode. Electrodes of good quality were obtained with electrode resistivity less than 10 exp -6 ohm sq cm, using metals with high energy of oxidation, such as Au, Ag, and Cu. For these metals there will be no oxide layer and only a shallow oxygen-deficient region which recovers its superconducting nature with annealing during which oxygen is supplied to the deficient region from the superconducting bulk.

A93-15716 Conductance of normal-superconductor contacts due to the Andreev reflection. YOSITAKE TAKANE and HIROMICHI EBISAWA, *Physical Society of Japan Journal* (ISSN 0031-9015), Vol. 61, No. 10, Oct. 1992, pp. 3466-3469. 15 Refs.

Low-bias conductance of impure normal-superconductor contacts is studied theoretically in the limit of the small Andreev reflection probability. Its dependence on both magnetic field and temperature is obtained. In the calculation, we focus our attention on the interference effect between an electron and a hole that is suggested to be significant by van Wees et al. (1992). It is shown that the conductance is sensitively suppressed by a magnetic field or temperature. (Author)

A93-15659 Nuclear relaxation study in strong coupling superconductors—A comparison with high-T_c superconductors. SHIGEKI OHSUGI, YOSHIO KITAOKA, MASAFUMI KYOGAKU, KENJI ISHIDA, KUNISUKE ASAYAMA, and TSUKIO OHTANI, *Physical Society of Japan Journal* (ISSN 0031-9015), Vol. 61, No. 9, Sept. 1992, pp. 3054-3057. 22 Refs.

The paper investigates the nuclear relaxation behavior in s-wave superconductors such as Chevrel-phase superconductors TiMo₆Se_{7.5} and Sn_{1.1}Mo₆Se_{7.5}, with T_c = 12.2 and 4.2 K, respectively. The nuclear-spin-lattice-relaxation rate, 1/T₁, of Sn-119 in Sn_{1.1}Mo₆Se_{7.5} reveals a distinct coherence peak just below T_c, followed by an exponential decrease with the isotropic energy gap of 3.6 kBT_c in a weak coupling regime. By contrast, 1/T₁ of Ti-205 in TiMo₆Se_{7.5} possesses no coherence peak, although the exponential decrease of 1/T₁ was also observed with a larger isotropic energy gap value of 4.5 kBT_c in a strong coupling regime. The stronger electron-phonon coupling enhances the superconducting transition temperature and at the same time opens a decay channel to cause an intense damping of quasi-particles, resulting in the depression of the coherence peak.

A93-13474 Magnetization and anisotropy in single crystals of Ti-(1223) phase of Ti-Sr-Ca-Cu-O system. SHIN-PEI MATSUDA, ATSUKO SOETA, TOSHIYA DOI, KATSUZO AIHARA, and TOMOICHI KAMO, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 9A, Sept. 1, 1992, pp. L1229-L1231. 9 Refs.

Single crystals of the Ti-(1223) phase of Ti-Sr-Ca-Cu-O are prepared and studied by means of a SQUID, powder X-ray diffraction, and SEM energy-dispersive X-ray spectroscopy. Intragrain critical current density (J_c), anisotropy, and magnetization are studied in the single crystals, and J_c is found to be 20,000-80,000 A/sq cm at 77 K and 1 T. The irreversibility field is also determined to demonstrate where the superconducting current flows without incurring significant resistance.

N92-32746 Status of LHD control system design. K. YAMAZAKI, H. KANEKO, Y. TANIGUCHI, O. MOTOJIMA et al., *National Inst. for Fusion Science, Nagoya (Japan)*. 17 pp.

The Large Helical Device (LHD) fusion system, using 1.6 GJ superconducting (SC) magnets, is now under construction, and its plasma experiments will be started in April 1997. For this purpose, a new national institute (National Institute for Fusion Science) was established in May 1989, and a new site (Toki city) was prepared for these experiments. The main objectives of the LHD project are as follows: (1) the study of the behavior of high temperature/high density plasmas using a helical torus device for comprehensive understanding of toroidal plasmas; and (2) the investigation of the steady-state helical system reactor. The major plasma radius of the LHD is 3.9 m, and the magnetic field strength is 3 Tesla (4 Tesla in the second experimental phase). This makes the LHD the largest SC fusion machine now under construction. To maintain flexible and reliable operations of this SC machine, a new control concept is required. The present status of the control system design for the LHD system is presented. (Author)

A92-54433 Thickness dependence of levitation forces acting on magnets over a thin superconducting sheet. ZHONG J. YANG, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 7B, July 15, 1992, pp. L938-L941. 22 Refs.

The London theory of superconductivity is used here to calculate the thickness dependence of the levitation forces acting on magnets over a thin superconducting sheet. As an example, the point dipole results are applied to the theoretical estimation of the force acting on the tip of a magnetic force microscope.

A92-54440 Observation of Josephson junctionlike behavior in single-crystal (Bi, Pb)₂Sr₂CaCu₂O_{7-y}. GIN-ICHIRO OYA, NAOTO AOYAMA, AKINOBU IRIE, SATORU KISHIDA, and HEIZO TOKUTAKA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 7A, July 1, 1992, pp. L829-L831. 13 Refs.

The dependences of critical current on the temperature and magnetic field and the current-voltage characteristics in response to incident microwave radiation are measured in the direction of the c-axis of the 80 K superconducting phase (Bi, Pb)₂Sr₂CaCu₂O_{7-y} bulk single crystal. Josephson junctionlike behavior is successfully observed, and it shows that the single crystal itself is composed of Josephson junctions along the c-direction and that its electrical transport in this direction is limited by intrinsic tunnel barriers existing in the single crystal. (Author)

A92-54436 Fabrication of YBCO/CeO₂/YBCO multilayer junctions and their characteristics. TAKESHI KUSUMORI and IENARI IGUCHI, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 7B, July 15, 1992, pp. L956-L959. 15 Refs.

The fabrication of YBCO/CeO₂/YBCO multilayer junctions grown by the in situ vacuum deposition technique is reported. The measurements yield reproducible characteristics. The observed phenomena appear either in the tunneling regime or in the Andreev-reflection-like depending on the magnitude of the junction resistance. Prominent gaplike structures around 10 mV and 20 mV and additional structures are observed. Temperature dependence of the gap structures is nearly BCS-like. The results are discussed in terms of an anisotropic conduction model. (Author)

A92-54435 Molecular beam epitaxy fabrication of SrTiO₃ and Bi₂Sr₂CaCu₂O₈ heterostructures using a novel reflection high-energy electron diffraction monitoring technique. PETER BODIN, SHIGEKI SAKAI, and YUJI KASAI, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 7B, July 15, 1992, pp. L949-L952. 7 Refs.

SrTiO₃ and Bi₂Sr₂CaCu₂O₈ layered structures were continuously grown by the molecular beam epitaxy technique with in situ reflection high-energy electron diffraction (RHEED). By using a new RHEED picture subtraction technique, intensity changes due to only the topmost layer could be displayed. This method allows us to sensitively detect roughness on the atomic scale and excess phase formation. The SrTiO₃ layer could be grown by sequential shuttering as well as coevaporation. A heterostructure with a 60 Å Bi₂Sr₂CaCu₂O₈ film had a superconducting transition temperature of 53 K. (Author)

A92-54434 The superconducting properties of (001) twist boundaries in a Bi-Sr-Ca-Cu-O superconductor. NARUAKI TOMITA, YUTAKA TAKAHASHI, MINORU MORI, and YOICHI ISHIDA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 7B, July 15, 1992, pp. L942-L945. 11 Refs.

Critical temperature (T_c) and critical current density (J_c) of (001)-twist bicrystals of the Bi₂Sr₂CaCu₂O_x were measured as a function of twist angle. The resistivity-temperature curve of the bicrystal showed a long tail, which was enhanced as the applied current increased. The J_c values of the bicrystals are three to four orders of magnitude lower than that of single crystals but relatively high J_c values were obtained for bicrystals at Sigma5 and Sigma17 coincidence orientation relationships. It was indicated that the (001) twist boundary in Bi₂Sr₂CaCu₂O_x was the weak link, and it is suggested that there existed a less detrimental grain orientation. (Author)

A92-51837 Fabrication and properties of MgO/Bi₂Sr₂CaCu₂O_x interfaces using crystalline and amorphous MgO films grown by the MBE method. KOJI YAMANO, KAZUHIRO SHIMAOKA, KAZUHIKO TAKAHASHI, TATSURO USUKI, YORINOBU YOSHISATO, and SHOICHI NAKANO, *Japanese Journal of Applied Physics, Part 1* (ISSN 0021-4922), Vol. 31, No. 6A, June 1992, pp. 1765-1770. 24 Refs.

Tunnel-type junctions with pinhole-free crystalline and amorphous MgO barriers on the order of several nm were successfully fabricated on the cleavage plane of BSCCO single crystals. Both MgO films for the tunnel barriers were grown by the MBE method. The superconducting gap parameters of a BSCCO single crystal deposited with crystalline and amorphous tunnel barriers were estimated to be 25 meV and 38 meV, respectively, for the configuration of a Nb/MgO/BSCCO junction from dI/dV-V characteristics. The possibility of different surfaces superconductivities for BSCCO single crystals was determined by the characterization of the MgO/BSCCO interface. (Author)

A92-51445 Metal-insulator-superconductor field-effect-transistor using SrTiO₃/YBa₂Cu₃O_{7-y} heteroepitaxial films. TATSUHIKO FUJII, KEN SAKUTA, TAKAHIRO AWAJI, KEN-ICHI MATSUI, TAKASHI HIRANO, YASUYUKI OGAWA, and TAKESHI KOBAYASHI, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 31, No. 5B, May 15, 1992, pp. L612-L615. 13 Refs.

Planar-type metal-insulator-superconductor field-effect-transistors (MISFET) were fabricated and their current modulation characteristics were investigated. The FET had a structure of Al-gate metal/(100)SrTiO₃-gate insulator/(001)YBa₂Cu₃O_{7-y}-channel, where the oxide layers were grown by selective heteroepitaxy employing pulse ArF excimer laser deposition. The FET gate was 10 microns long and 100 microns wide. Apparent field-effect modulation of drain current was seen in both the normal and superconducting states. In the superconducting state, not only the critical current but also flux-flow resistance were appreciably changed according to the applied gate voltage. (Author)