Gd Eu Tb Sm Dy Pm Ho RARVS Nd Er Pr Tm Ce Yb La Sc Y Lu ®

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Ames Laboratory
Institute for Physical Research and Technology
Iowa State University / Ames, Iowa 50011-3020 / U.S.A.

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Processing High T_c Superconductors

In the past few months several papers have appeared in print on processing high temperature superconductors (HTSC). In one paper [**Mater. Sci. Eng. B7**, 243 (1991)], various processing and fabrication methods for preparing HTSC were critically reviewed by S. Jin and J. E. Graebner keeping in mind the resultant properties and the likelihood of these techniques being commercially viable. Although the title indicates "bulk" HTSC, the authors discuss thin films (<3000Å) and thick films. However, the major portion of the paper deals with the bulk materials, such as bare wires and tapes, metal-clad composite wires and metal-core composite wires. Process techniques such as melt-texture processing, deformation texture processing, magnetic field alignment, and substrate-induced texture are evaluated. The last portion deals with methods for flux pinning enhancement, such as neutron or proton irradiation and phase decomposition.

The other recent papers were published as a group in the **J. Metals 43** [3] (March 1991). This set of four papers was organized by P. J. McGinn. The first paper is by S. Jin on processing techniques for bulk HTSC, and much of the material will also be found in the previous cited paper. The other papers deal with pulsed-laser deposition of thin films by R. K. Singh and J. Narayan, processing Bi-Sr-Ca-Cu oxide superconductors by K. H. Sandhage, G. N. Riley, Jr. and W. L. Carter, and texturing of the $YBa_2Cu_3O_{6+x}$ (1:2:3) HTSC by melt processing by P. J. McGinn, W. Chen and N. Zhu.

Except for the one paper on Bi-Sr-Ca-Cu oxides the major portion of each paper deals with 1:2:3 material, which is still the leading HTSC. While remarkable progress has been made processing these HTSC materials in the past few years, further processing innovations are needed in order to accelerate progress toward large current carrying capacities in the bulk HTSC. In addition, novel methods/or mechanisms for increasing the critical currents are also necessary to go hand-in-hand with improved processing techniques. Two recent advances are discussed in the next topic.

High T_c Superconductors Swirl and Pinch

Two research groups, C. Gerber, et al. from IBM, Zürich Research Laboratory [**Nature 350**, 279 (28 March 1991)] and M. Hawley et al. from Los Alamos National Laboratory [**Science 251**, 1587 (29 March 1991)], independently reported the observation of a new defect -- a screw dislocation -- in thin

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Telephone: (515) 294-2272
Facsimile: (515) 294-3226
Telex: 269266
BITNET: RIC@ALISUVAX

films of $YBa_2Cu_3O_7$ (1:2:3). These were detected by using scanning tunneling microscopes. The density of these spiral defects (>10^9 cm^2) is sufficiently high enough to account for the high currents found in sputtered thin films.

More recently, by a few days, H. Jiang et al. from Northeastern University plus other colleagues from Naval Research Laboratory and Micrion Corporation [**Phys. Rev. Lett. 66**, 1785 (1 April 1991)] made a 1:2:3 superconductor in which a 500Å bridge was milled into a 2000 to 5000Å thick film. They found that superconducting currents in the pinch area had critical current densities (J_c) of 1.3 x 10^9 A/cm^2, which is the highest value reported to date. Even at this narrow width the J_c had not reached a plateau, contrary to expectations. The authors put forth a new model for the current limit.

New Substrate for High T_C Superconductors

One of the common substrates for the high temperature $YBa_2Cu_3O_{7-x}$ (1:2:3) superconductors is $LaAlO_3$. But $LaAlO_3$ contains catastrophic twins caused by a structural phase transformation at ~400°C. Japanese scientists from the NTT LSI Laboratories suggest that $PrGaO_3$ would make a better substrate for an epitaxial film of the 1:2:3 superconductor. The authors state that there is a lattice mismatch of only 0.02% between the (001) of $PrGaO_3$ and the c-axis of the 1:2:3 phase at the deposition temperature, which makes $PrGaO_3$ the best lattice matching material known. The 1:2:3 phase was deposited by laser ablation. M. Sasaura et al. [**Appl. Phys. Lett. 57**, 2728 (1990)] found that the zero resistance transition temperature was 90K, even for films as thin as 500Å. The $PrGaO_3$ single crystals were grown by the Czochralski method, and were crack- and twin-free.

Y_2O_3 Coating for Protecting SiC

Researchers at Rensselaer Polytechnic Institute, headed by D. J. Larkin et al., have developed a chemical vapor deposition (CVD) process to coat a commercial SiC fiber (Textron-Avco SCS-6) with Y_2O_3 [**J. Mater. Res. 5**, 2706 (1990)]. The coated SiC fiber is used with the Ni_3Al intermetallic compound to form a SiC/Ni_3Al composite for applications in which high strength, toughness and good oxidation resistance is required. Both constituents separately have these desirable properties but when combined in a composite the strength is increased beyond that of the individual components. The main drawback is that above 700°C SiC reacts with Ni_3Al to form Ni_2Si which degrades the composite. The authors used the volatile yttrium compound $Y(thd)_3$ (where thd = 2,2,6,6-tetramethyl-3,5-heptanedionato) as the CVD precursor to form a 1-2 μm Y_2O_3 coating on the SiC fibers. The $Y(thd)_3$ compound was volatilized at 150°C and transported by dry N_2 gas into the hot zone (630°C) where it decomposed forming the Y_2O_3 coating on the SiC fibers. The Y_2O_3 deposit was found to be free of carbon and other impurities, and served as a stable barrier coating up to 1000°C for 100 hrs., preventing the reaction of the Ni_3Al with SiC.

Karl A. Gschneidner, Jr.

K. A. Gschneidner, Jr.
Editor and Director RIC