Rare-earth Information Center INSIGHT

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

Volume 8 | June 1, 1995 | No. 6

YBCO Takes the Lead

Scientists from the Los Alamos National Laboratory (Los Alamos, New Mexico, USA) announced at the Spring Materials Research Society meeting in San Francisco, mid-April, a breakthrough on the fabrication of $YBa_2Cu_3O_{7-x}$ (YBCO or Y-123) superconductor tapes which can carry large currents at liquid nitrogen temperatures (77K). The team of researchers led by S. R. Foltyn were able to fabricate a flexible tape that carries more than 1.3 x 10^6 amp/cm^2 at 77K, which is ~100 times larger than that of competing materials, especially the $Bi_2Sr_2Ca_2Cu_3O_{10}$ (Bi-2223) based materials. Furthermore, the Los Alamos YBCO tape retains much of its high current carrying capacity in high magnetic fields, which is not true for the Bi-2223 based materials.

The tape is 1-2 µm thick and is considered a "thick" film, which compares to 0.5 µm thick "thin" films. The thin film YBCO materials have been made which can carry 10 x 10^6 amp/cm^2 currents, but these are not suitable for many applications, such as transmission lines, superconducting solenoids, motors, generators, etc. The thick YBCO films are prepared by an ion-beam-assisted deposition process, where a textured cubic yttria-stabilized zirconia (YSZ) buffer layer is deposited on a Hastelloy (a nickel based alloy which has a coefficient of thermal expansion coefficient which matches that of YBCO) tape. The buffer layer is necessary to prevent the reaction of the YBCO with the nickel substrate tape, (which has a deleterious effect on the superconducting properties of YBCO), and to provide an orientated layer for the deposition of YBCO film in a quasi-epitaxial mode (which is important for the high current carrying characteristics). One of the critical steps in this process was the development of a two argon ion beam arrangement for the deposition of YSZ on the nickel tape. The first beam knocks (sandblasts) the YSZ particles from a target to deposit them on the Hastelloy substrate. The second beam is focused onto the metal at a specific angle which orients the YSZ crystal grains so that they are properly aligned as they grow. This is followed by a pulsed-laser technique to deposit the YBCO layer onto the YSZ.

The resulting tape is sufficiently flexible to wind it into coils with diameters as small as 2 cm. To date the Los Alamos team has made tapes as long as 5 cm by 1 cm wide. They are now gearing up to make longer lengths of materials and eventually develop a manufacturing process for making continuous lengths. The major obstacle is economic, it will require an expensive capital investment for a market that does not exist, but has a great promise of developing. The rare earth industry would benefit in two ways — the yttrium (oxide) for the superconductor itself and for the YSZ buffer layer. In addition, there is the possibility that the Hastelloy tape may contain lanthanum or yttrium metals (some of the alloys of the Hastelloy family contain small amounts of one of these rare earths — alloy N with 0.26 wt.% Y and alloy S with 0.05 wt.% La), but since sufficient details are not available to RIC we are not able to give a more definitive statement.

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Telephone: (515) 294-2272
Facsimile: (515) 294-3709
Telex: 269266
Internet: RIC@AMESLAB.GOV

As P. M. Grant notes in his review of this development, this was not an isolated quantum jump to this breakthrough, but was predicated on several other important advances as early as 1988 [**Nature 375**, 107 (May 11, 1995)]. His perspective is interesting reading. He also discussed the state-of-the-art with respect to the Bi-2223 tapes and wires, and why he believes that this material will not be a serious competitor to the YBCO material.

YSZ to Compete with Molten R to Polish C

No, this is not a Scrabble game [a game in which a player gets seven letters of the alphabet and tries to spell common words getting as many points possible on a game board; after all the letters are used the player with the highest point total wins]. The letters in the heading stand for yttria-stabilized zirconia (YSZ), rare earth metal (R), and carbon (C, more specifically diamond). Two years ago we reported that molten rare earth metals or alloys with transition metals could be used to polish diamonds for applications which needed a high quality finish, or for fabricating special shapes (**RIC Insight 6**, [6], June 1, 1993). Now, two IBM scientists, J. E. Yehoda and J. J. Cuomo (T. J. Watson Research Center, Yorktown Heights, New York), report that one can use YSZ to polish diamond [**Appl. Phys. Lett. 66**, 1750 (April 3, 1995)]. A 9.5 mol% yttria in zirconia material is placed on the surface of the diamond to be polished, and a 1 mA, 50 to 80 V dc current is applied to this composite, where the YSZ is the cathode and the diamond the anode. This polishing process is carried out at an elevated temperature (not specified, but an upper limit of 390°C was noted) to allow the O^{2-} ions to overcome the energy barrier between the anion sites in YSZ. The O^{2-} ions are transported to the interface by the applied electric field and react with the diamond forming CO_2 and some CO.

The polished diamond surface has a peak-to-valley surface of ≤50 Å which compares to a peak-to-valley distance of ≈400 Å of the unpolished diamond. Energy dispersive x-ray analysis indicates that no polishing residue is on the diamond surface. Furthermore, optical transmission studies indicate that the YSZ polished diamond transmits light at lower wavelengths (9% at 200 nm and >40% at 225 nm) than type IIa natural diamonds which have a near-ultraviolet cutoff of ~225 nm (i.e. <5% at 225 nm).

Shocking Sm Nitromagnet

Samarium-iron nitride, $Sm_2Fe_{17}N_3$, is one of the new permanent magnet materials which will find a niche in the rare earth permanent magnet family. It has favorable magnetic properties, such as a strong uniaxial anisotropy and a high Curie temperature. The major disadvantage is the fact that it decomposes into SmN and α-Fe at temperatures greater than 600°C and ambient pressure. Because of this, it is difficult to obtain in a monolithic bulk form. This problem may have been solved by the Japanese team of scientists at the Tokyo Institute of Technology and Tokai University, Kanagawa, who used a shock-consolidation method to prepare $Sm_2Fe_{17}N_3$. A propellant gun with a metal-plate impactor was used to prepare disk-like shaped magnets, 6 mm in diameter by 2 mm thick, with a density of 97% theoretical. The best material obtained to date had an energy product of 10.5 MGOe (84 kJ/m^3). The results were reported by H. Oda, *et al.* In the **Jpn. J. Appl. Phys. 43**, L35-L-35 (1995).

Karl A. Gschneidner, Jr.

K. A. Gschneidner, Jr.
Director, RIC