Rare-earth
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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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Superpermanent Magnet

Researchers at the Superconducting Research Laboratory, Tokyo, Japan [S. Gotoh, M. Murakami, H. Fujimoto and N. Koshizuka, **J. Appl. Phys., 72** (6), 2404, 15 September 1992] have described their success in preparing a superconducting $YBa_2Cu_3O_x$ (1:2:3) permanent magnet (-- a "superpermanent" magnet), with impressive permanent magnet properties (BH_{max} of 110 MGOe) while in the superconducting state at 5K. The possibility of a superconducting permanent magnet with trapped flux has been considered since the discovery of type-II superconductivity. However, in practice this has been difficult to realize because of flux jumping due to thermal instability and poor mechanical strength. A few years ago S. L. Wipf and H. L. Laquer proposed that these problems could be overcome by using high T_c ceramic superconductors with large J_c values because the thermal stability is quite high at high temperatures due to their large heat capacities **[IEEE Trans. Magn., Mag-25**, 1877 (1989)]. Gotoh *et al.* reasoned that melt processed 1:2:3 superconductors are potential candidates for superpermanent magnets because they have high J_c values and good mechanical properties. The melt processed Y-Ba-Cu oxide superconductor material contains Y_2BaCuO_5 (2:1:1) inclusions in the $YBa_2Cu_3O_x$ matrix, and these inclusions act as strong pinning centers, which prevent flux vortices from moving and as a result one obtains high J_c values. When superconductors have large pinning forces, large magnetic fields can be trapped in the samples, and thus these materials become ferromagnets.

Two different melt processed 1:2:3 samples were prepared and studied. One sample was prepared by a quench and melt growth process (QMG) and the second sample by a melt-powder-melt-growth process (MPMG). In both processes the starting composition is adjusted so that the 1:2:3 phase (matrix) will contain some 2:1:1 inclusions that can act a pinning centers which are dispersed in the 1:2:3 matrix during the melt processing procedures. In both cases the initial powders are heated to 1400°C and quenched by copper hammer plates. For the QMG process the sample is reheated to 1100°C, held for 20 min., cooled to 1000°C in one hour, and then further cooled at a rate of 5°C/hr. A final anneal at 600°C for 1 hr. was carried out in an oxygen atmosphere before slowly cooling in oxygen to room temperature. The MPMG samples were powdered, mixed and pressed after the initial quench step. This material was then melted at ~1100°C and slow cooled at several different rates depending upon the temperature regime to allow the 2:1:1 phase to precipitate out of solution.

The magnetic properties as one might expect were anisotropic with the best properties shown when the magnetic field was parallel to the *c*-axis of the sample (H||c). The best magnetic properties were obtained on the MPMG sample which had a thickness of 1.5 mm. The measurements were made at 5 K after field cooling in a field of 10 kOe (1 T) which trapped the

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Telephone: (515) 294-2272
Facsimile: (515) 294-3709

Telex: 283359
BITNET: RIC@ALISUVAX

flux in the 1:2:3 phase. The resultant properties are as follows: the residual flux densities B_r, are 9.6 kG ($H\parallel c$) and 8.5 kG ($H\perp c$); the coercive forces ${}_bH_c$ are 33 kOe ($H\parallel c$) and 17 kOe ($H\perp c$); and the maximum energy product, $(BH)_{max}$, are 110 MGOe ($H\parallel c$) and 49 MGOe ($H\perp c$). These numbers are quite impressive, generally comparable to (for the $H\perp c$ orientation) or much better than (for the $H\parallel c$ orientation) the best Nd-Fe-B or R-Co permanent magnet materials. Unfortunately, the values were obtained at 5K. So, until scientists and engineers obtain a room temperature superconductor, the permanent magnet producers do not need to worry about the high T_c ceramic conductors as a competing material at least at ambient temperatures.

IR Detector

Metal-silicides with low Schottky barriers are used as infrared (IR) detectors. In particular Pd, Pt and Ir silicides are the ones commonly used today in IR detector arrays, because they have sufficiently low barrier heights which are necessary to detect infrared photons. Since the barrier heights on p-type Si are much lower 0.35 vs. 0.72 for n-type Si, all of the IR detectors in use today are based on p-type Si. The rare earth silicides, however, exhibit the reverse behavior from the Pt, Pd and Ir silicides, the barrier heights are ~0.4 eV on n-type Si and ~0.7 eV on p-type Si. This would allow designers to build devices that would benefit from operating with electrons instead of holes. Recently, M. H. Unewisse and J. W. V. Storey from the University of New South Wales, Kensington, Australia, describe their work fabricating Er silicide on n-type Si Schottky diodes [**J. Appl. Phys., 72** (6), 2367, 15 September 1992]. The devices were fabricated by thermal evaporation onto <100> Si single crystals. They found an electrical barrier height of 0.28 eV and a phonon barrier height of nearly the same value (0.273 eV). The quantum efficiency at 2.0 μm is found to be 0.52% which is comparable to that of unenhanced PtSi, while the dark current is less than 10^{-7} A/cm^2 at 77 K. The authors have suggested several ways which could be utilized to improve their Er silicide n-type Si IR detector by about a factor of ten. Unewisse and Storey conclude that their work opens up the possibility of the whole new generation of IR detector array architectures with n-type Si based multiplexers but using n-type Si instead of p-type Si.

Brightest Solid State Laser

Scientists and engineers at TRW Space and Technology Group, Redondo Beach, California have tested a 100-W, diode-pumped, Nd:YAG master oscillator power amplifier. They obtained a 1 J per pulse output at a repetition rate of 100 Hz, which is the highest brightness reported for a solid state laser. TRW stated that the optical efficiency of 22% and the overall efficiency of 9.4% are also records for high-energy short-pulse lasers. Congratulations to the TRW team!

Karl A. Gschneidner, Jr.

K. A. Gschneidner, Jr.
Director, RIC