Rare-earth Information Center INSIGHT

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High Temperature Superconductor Advances

Work by IBM scientists at the T. J. Watson Research Center, Yorktown Heights, New York and Almaden Research Center, San Jose, California, have increased our knowledge and understanding of weak link behavior in high temperature superconductors. Weak link behavior in oxide superconductors is one of the outstanding problems facing scientists and engineers today, since these weak links have such a pronounced influence on the superconducting properties. The team of scientists headed by M. Kawasaki [**Appl. Phys. Lett. 62**, 417 (1993)] studied single-grain boundary junctions in Nd-, Bi- and Tl-cuprate superconductors, and they found that they all behave qualitatively similar to the 1:2:3, $YBa_2Cu_3O_{7-x}$, superconductor. They believe that the weak link, in addition to composition effects, is associated with the structure of the grain boundary and the dislocations present, which describe the topology of the boundary. Although we have a better understanding of the weak link behavior, no one has yet devised a way to overcome this problem. But this knowledge of the nature of the problem is the first step and eventually this will lead to a solution and improved superconducting properties.

In the meanwhile, scientists at the Superconductivity Industrial Research Laboratory of the International Superconductivity Industrial Research Center near Tokyo, have announced success in controlling the crystal orientations of the 1:2:3 superconductor. By controlling the orientation of the grains, one can overcome some of the weak link problems and thus improve the critical field and critical current values. The scientists have been able to produce crystals 8 cm in diameter by 3 cm thick with a repulsive force three times greater than that of conventionally processed 1:2:3 superconductors. Apparently, there are no size limits for making this directionally grown material. No details for the process were reported, nor did they present any quantitative values for the critical fields and currents, and their magnetic field dependences.

Neodymium as a Geochemical Hazard Indicator

An international team of earth scientists studying the composition and volume of erupted magna from volcanos have found that the ratio of neodymium isotopes ^{143}Nd to ^{144}Nd may be useful as an indicator of the size (volume) of an expected eruption. The scientific team from the U.S.A., Taiwan and Japan [C.-H. Chen *et al.* **Nature 362**, 831 (29 April 1993)] found significant differences in the neodymium isotope ratio for small and large eruptions from the Unzen volcano (25 miles east of Nagasaki on the island of Kyushu) over the past 300,000 years. They found that when the ^{143}Nd to ^{144}Nd ratio was between 1.5 and 2.0 large volumes (>0.1 km^3) of magna had been spewed from Mount Unzen, while for small volumes (~0. 01 km^3) the ratio was less than one. These results suggest that a measurement of the isotopic ratio from an early stage of an eruption would indicate the amount of magna still to be erupted. If this correlation had been

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known in May of 1991, geologists would have correctly predicted that Mount Unzen would continue to erupt for a few more months and spew out again about twice as much material. With this knowledge, it is quite possible that many of the 43 persons killed in the June 1991 eruption might be alive today.

The amount of ^{144}Nd in the earth's crust is higher than that of ^{143}Nd, while the opposite is true for the earth's deep interior. Thus, when the 143 and 144 ratio is high, it indicates that the lava is from deep in the earth's interior, and a much larger eruption can be expected. This correlation seems to hold true with volcanos in the western continental United States. The authors caution, however, that this neodymium isotope indicator may not work for island volcanos where there is no underlying continental-type crust, and that there may be no distinguishable difference in the isotopic ratio between the crust and mantle.

Er-Si an IR Detector

Rare earth disilicides have some of the lowest Schottky barrier heights known on n-type silicon. For $ErSi_2$ the barrier height is ~0.28 eV, which corresponds to an infrared (IR) wavelength cutoff of ~4.4 μm. Thus, $ErSi_2$ is well suited to take advantage of the atmospheric transmission window of 2 to 5 μm, and it could be used as an infrared detector. Other competing silicides are those of platinum (0.24 eV, 5.2 μm) and palladium (0.35 eV, 3.5 μm).

Recently, M. H. Unewisse and J. W. V. Storey from the University of New South Wales, Kensington, Australia [**J. Appl. Phys. 73**, 3873 (1993)], reported on their investigation of the conduction mechanism involved in allowing the electrons in the n-type substrate to move across the Schottky barrier in response to an applied voltage. Their studies were carried out over a temperature range of 25 to 160 K. The dominant carrier transport mechanism above 70 K was found to be thermionic emission. At low temperatures they found that recombination via tunneling through surface states became the dominant conduction mechanism. Many deviations from ideal behavior were observed, but they thought that these could be eliminated or greatly reduced by more careful processing, especially with regard to surface defects if low temperature operation is desired.

Rosy Outlook for Superconductors

The worldwide market for superconductors is expected to soar by 2020. The projections were made at the Second International Superconductivity Industry Summit (ISIS) held in Hakone, Japan in May, 1993. The current level of \$1.5 billion is predicted to rise to \$150-200 billion by 2020, an annual growth rate of 18 to 20%. The current market consists mainly of products made from low-temperature superconductors, but by 2020 the high-temperature ceramic superconductors, including $YBa_2Cu_3O_{7-x}$, will account for most of the market. In 2020, electronics (computers/circuits and microwaves) will account for 46%; energy (energy storage/generation and motors)—18%; other uses (primarily magnets and magnetic shields)—16%; medical/scientific (magnetic resonance imaging and spectroscopy, and squids)—11%; and transportation (levitated trains and electromagnetic propulsion)—9%. The rare earth ceramic superconductors are expected to play important roles in the electronic and medical/scientific areas.

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