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S-U-P-E-R

Right now rare earth superconductivity is hot. It started with last month's issue of **RIC Insight** about a breakthrough in fabricating $YBa_2Cu_3O_{7-x}$ (YBCO) superconducting tapes which can carry large currents at 77K. Other important papers have just appeared in print — a possible above room temperature superconductor, applications of YBCO thin films, large size YBCO single crystals, and the first rare earth fulleride superconductor. These latest developments are described below, in the order of decreasing superconducting transition temperature. Unfortunately, because of the lack of space, the story on the rare earth fulleride superconductor is being postponed until the August 1, 1995 issue.

371K (98°C) Superconductor?

Russian scientists from the Central Scientific Research Experimental Institute , Ministry of Defense, in Mytishchi presented evidence for "superconductivity" at 371K in the selenide analogue of the famous Y-Ba-Cu-O 90K superconductor, namely $YBa_2Cu_3Se_7$. V. D. Shabetnik, *et al.* [**Pis'ma Zh. Tekh. Fiz. 21** 67-71 (May 26, 1995); Engl. transl. **Tech. Phys. Lett. 21** 382-284 (1995)] found that the magnetic susceptibility (χ) showed a sharp increase upon heating from a negative value to a positive value at ~372K, while the resistivity (ρ) showed a large increase at ~371K. They claim this is evidence for superconductivity because the χ vs. T and ρ vs. T curves are essentially identical to those for $YBa_2Cu_3O_{7-x}$ at ~93K. They estimate that about 12% of sample is superconducting. There is no doubt that Sabetnik *et al.* observed a transition at 371K, the main question is, is it due to superconductivity? There have been many reports by scientists claiming to have discovered superconductors with transitions above 150K, but none of these have been verified. So until the Russian results are verified by others, and the superconducting phase has been isolated and identified, one should remain skeptical about this claim. However, if it is correct, this discovery is just as big or even bigger than the original discovery of the high temperature oxide superconductors.

YBCO Thin Films in the Market Place

In an excellent article, G. B. Lubkin [**Physics Today 48** [3] 20-23 (March 1995)] summarized the state-of-the-art of technical developments of high temperature superconductors (high T_c), especially thin film applications. In her review she noted that some products are already in the market place and others are about to emerge. The market for high T_c superconducting electronics and medical applications are expected to reach the $100 billion per year level in 2020.

The YBCO superconductor is, by far, the leading material to date for these thin film devices, which includes SQUIDS, cellular telephone filters, NMR coils, and analog and digital electronics. The major problem

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that had to be solved was the fabrication of YBCO thin films such that the weak boundaries do not adversely affect the superconducting properties. This problem has been solved by various approaches, and the utilization of YBCO in these devices has become a commercial reality.

The commercial YBCO SQUIDS, that are sold today, have achieved low noise levels which are comparable to the best that researchers in a laboratory can build (usually commercial products lag by an order of magnitude behind those built by researchers). These high-T_c SQUIDS are now replacing low-T_c ones in some applications.

In the cellular phone market YBCO thin film filters are expected to replace conventional copper filter receivers in the cellular-phone base stations. The major problem has been in coating both sides of the substrate by a 1 μm thick YBCO film. Eventually the filters for transmitters are expected to be made of YBCO thin films. The complete high-T_c filter unit is ten times smaller than the conventional filters. Another rare earth material may also be used as the substrate for the YBCO superconducting filters — lanthanum aluminum oxide.

The use of a high-T_c superconducting YBCO film coils in nuclear magnetic resonance NMR devices, such as medical Magnetic Resonance Imaging (MRI) instruments, has reached the initial stage of commercialization with a premarket authorization from the Food and Drug Administration to set-up marketing agreements between the thin film producers and the MRI manufacturers.

Probably the furthest from the market place is the use of high-T_c thin films to interconnect digital circuits and multichip modules. The main problem here is to fabricate multilayer thin films to interconnect the individual devices. But work on YBCO multilayers is moving forward and scientists and engineers are optimistic that they will be successful.

Large YBCO Single Crystals

Japanese scientists at the Superconductivity Research Laboratory, International Superconductivity Technology Center, Tokyo, Japan, announced that they have been successful in producing high quality $YBa_2Cu_3O_{7-x}$(BYCO) single crystals 1.4 cm square cross-section by 1.3 cm long. The results were reported by Y. Namikawa, M. Egami and Y. Shiohara at the 7th International Symposium on Superconductivity. The crystals were grown by pulling and simultaneously rotating a small seed crystal from a solute rich liquid. They claim that their crystals are of substantially better quality than the small single crystals which had been prepared heretofore, and were only a few millimeters in size. The Japanese scientists/engineers had made a numerical simulation of the growth process to understand and optimize the physical variables. These data enabled them to precisely control the temperature, and other conditions and factors which affect the growth process. They are hoping to be able to double the size of the single crystals in the near future. An electrical resistivity vs. temperature plot (which showed a very sharp superconducting transition) and neutron diffraction rocking curves (which showed a spread of ± 0.2° of the (004) Bragg peak) were presented.

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