RARE-EARTH INFORMATION CENTER INSIGHT

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

Volume 1 September 1, 1988 No. 7

High T_c 1:2:3 Films

In the past few weeks several groups have reported important advances in preparing films of the $YBa_2Cu_3O_{7-x}$ (1:2:3) high temperature superconductor on silicon substrates. This advance is probably just as important as finding another material which has a higher superconducting transition temperature, but it does not have the typical media hype or aura associated with this advance. One of the most important potential applications of these high T_c superconducting films is their use in integrated circuits and computers. The main problem has been to form reliable superconducting films on silicon which is the main semiconductor material upon which these integrated and computer technologies are based.

One of the critical steps in processing the 1:2:3 material is that it had to be annealed at 700 to 900°C to increase the oxygen content so that it superconducts below 90K. At these temperatures, however, the 1:2:3 reacts with the silicon and the reaction product was no longer a superconductor. At the time of writing this article we are aware of three groups which have successfully formed a 1:2:3/Si interface which is superconducting and does not require post annealing after the 1:2:3 material has been deposited on the silicon.

One group, University of Texas, used electron beam evaporation to deposit the 1:2:3 superconductor on a silicon substrate at 540°C. They report that the superconductor lost all resistance at 68K. The second group, IBM at Almaden, used magnetron sputtering to deposit the 1:2:3 material on silicon, which was heated to 650°C. The film became fully superconducting at 76K. The third group, Bell Communications (Red Bank, NJ), used a pulsed laser method to coat the silicon, which was at ~600°C, with $YBa_2Cu_3O_{7-x}$. The 1:2:3 phase lost all its resistance at 67K. Of these three groups, only the Bell Communication team has published their results (T. Venkatesan, et al., Appl. Phys Lett. **53**, 243, July 18, 1988).

The Bell group was able to raise the superconducting transition temperature to 80K by depositing a 50nm thick amorphous ZrO_2 buffer layer onto the silicon by using an electron beam gun.

Other workers have been quite successful in getting 90K superconducting 1:2:3 films on other substrates, especially $SrTiO_3$. The main reason for the

(over)

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

higher superconducting transition temperature is that there is a good epitaxial match between the substrate ($SrTiO_3$) and the superconducting film. This is not the case for silicon substrates and the 1:2:3 phase. For example, the State University of New York at Buffalo group have prepared a 90K superconducting 1:2:3 film which was deposited by a plasma-assisted laser method on the (110) plane of single crystal $SrTiO_3$ substrate which was held at 400°C. (S. Witanachchi et al., Appl. Phys. Lett. **53**, 234, July 18, 1988).

Another problem associated with the $YBa_2Cu_3O_{7-x}$ superconductor is its stability in moist air, which is extremely important in thin film technology. Japanese workers at Toshiba Corp. have made progress in this regard by coating the 1:2:3 thin film by a layer of silver. After the silver is deposited it is annealed in oxygen at ~500°C. Since the oxygen diffuses through the silver layer the oxygen will react with the 1:2:3 layer to restore any of the oxygen deficient areas in the film. Furthermore, the silver oxidizes and this silver oxide film protects the superconductor from attack by the water vapor in the air. These scientists found that the silver layer also superconducts via the proximity effect.

There are still a number of problems that need to be solved before useful integrated circuits containing the $YBa_2Cu_3O_{7-x}$ superconductor become a commercial reality. The superconducting transition temperature and critical current capacity both need to be increased. Finally the problem of epitaxial mismatch needs to be addressed. Since the crystalline phases do not align well and their thermal expansions are different, strains develop when the samples are cooled and could lead to cracking during thermal cycling. Solution of this latter problem will undoubtedly help to raise the critical current density and perhaps T_c.

High T_c 1:2:3 Flexible Tapes

Scientists at the Argonne National Laboratory have succeeded in fabricating a composite tape of $YBa_2Cu_3O_{7-x}$ on a silver substrate. The superconducting tape can be bent into an arc of a 27mm (~1 inch) diameter circle without breaking. This bend amounts to a strain of ~2%, which is a factor of ten greater than that of single phase 1:2:3 materials, which fracture at a strain of ~0.1%. The authors (J. P. Singh, et al., Appl. Phys. Lett. **53**, 237, July 18, 1988) claim that the superconducting properties of the composite tape are typical of bulk $YBa_2Cu_3O_{7-x}$ superconductors.

Karl Gschneidner, Jr.

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