Preparation and Properties of Cu-based High-Tc Superconducting Thin Films

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We have adapted two different techniques namely, amorphous phase epitaxy (**APE**) and self assembling epitaxy(**SAE**)for the preparation of $(Cu_{1-x}Tl_x)Ba_2Ca_2Cu_3O_y$ (Cu,Tl-1223) and $(Cu_{1-x}Tl_x)Ba_2Ca_3Cu_4O_y$ (Cu,Tl-1234) superconductor thin films.

APE Method: In this method an amorphous film of compositions Cu,Tl-1223 and 1234 were prepared on $SrTiO_3$ substrate by RF magnetron sputtering. Later, the amorphous films were annealed at various temperatures in a silver capsule containing sintered pellets or a disc of composition similar to that of the film but with different thallium content. By this method nearly a single phase and biaxially oriented thin films of Cu,Tl-1223 and 1234 were obtained whose Tc's ranges between 105and 118 K. Their Jc values are 2×10^7 and 1.0×10^6 A/cm^2 at 77 K and 0T, 10T respectively. The magnetic field dependence of Jc for Cu,Tl-1223 is shown in Fig. 1 along with YBCO for comparison. It should be noted that the Tc and Jc values of these films are higher than those of YBCO.

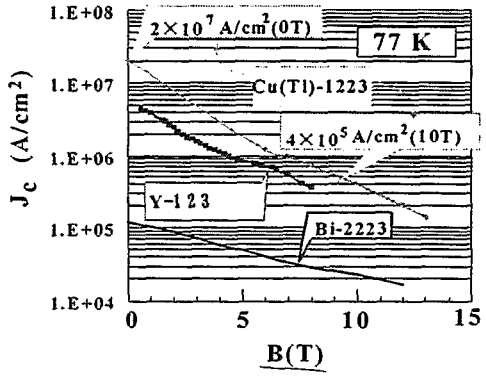

Fig.1 Magnetic field dependence of Jc for Cu,Tl-1223 thin films.

SAE Method: This method involves physical as well as chemical effect such as reactive sputtering, surface diffusion, lattice matching and structure stabilizers. Two targets with the compositions $TlBa_2CuO_{5-y}$(1201) and $CaCuO_2$, which form the charge reservoir and superconductive layers, respectively, were used. The former has a better lattice match (a=0.388nm) with SrTiO3 (a=0.390nm) compared to the latter (a=0.385nm). The superlattice was grown on $SrTiO_3$(100) substrate with 80nm of 1201 buffer layer at 510°C in a gas mixture (20 mT) of Ar and N_2O by alternatively depositing the charge reservoir layer and superconductive layer. XRD pattern (Fig.2) confirmed the superrlattice modulation with λ=1.868 nm which is close to that of bulk $(Cu_{1-x}Tl_x)Ba_2Ca_3Cu_4O_y$. EDX analysis showed that there was no thallium in the film and the formation of 1201 phase could be due to corbonate present in the chamber or in the target. Ac susceptibility measurements showed a diamagnetic signal at a temperature lower than that in the bulk material. Attempts are being made to prepare metallic 1201 charge reservoir layer with some transition metal ions and to improve the superconducting properties.

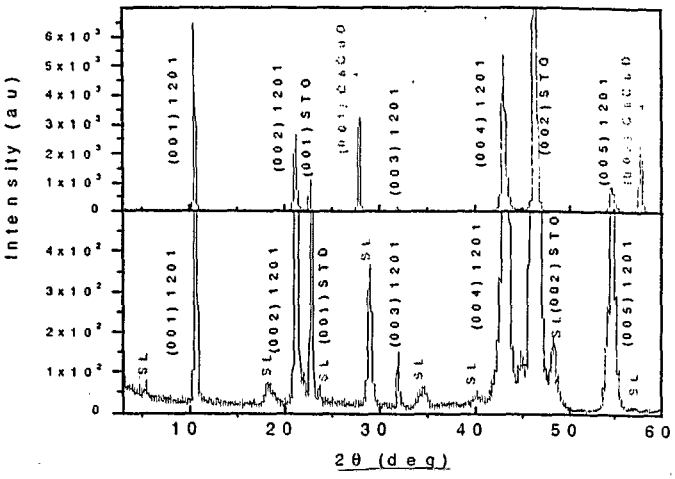

Fig.2 XRD patterns of 1201 , CaCuO2 (top) and superlattice thin film on $SrTiO_3$ prepared at 500°C.

Two compounds, $CaCuO_2$ and $Sr_xCa_{1-x}CuO_2$, which have better in-plane lattice match, could be also chosen as the building modules for the growth of $[CaCuO_2]_m/[Sr_xCa_{1-x}CuO_2]_n$ artificial superlattices. X-ray diffraction analyses had confirmed the formation of the tetragonal, infinite layer structure. The $Sr_xCa_{1-x}CuO_2$ thin films with x = 0.7 had remarkable resistive anomalies around 90 K and clear Meissner signals at temperature below 45 K. The superlattice chemical modulation was observed for structures with $CaCuO_2$ and $Sr_xCa_{1-x}CuO_2$ layers as thin as two unit cells.

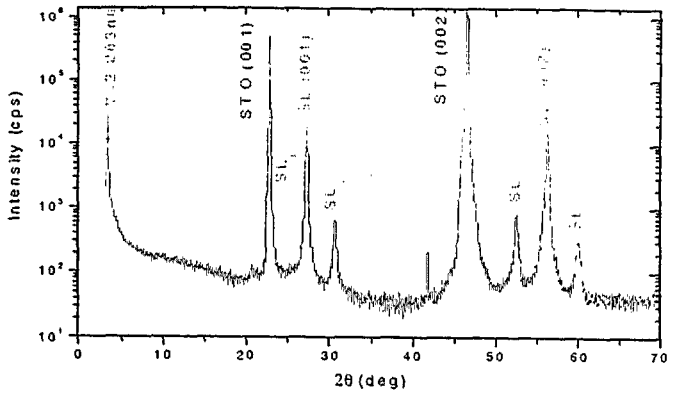

Fig.3 XRD spectra of $(SrCuO_2)_m/(CaCuO_2)_n$, for m=2 and n=5.