

## On the addition of silver to high $T_c$ ( $Y_1Ba_2Cu_3O_{7-x}$ ) superconductor

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**Abstract.** The superconducting transition temperature of the high  $T_c$  compound  $Y_1Ba_2Cu_3O_{7-x}$  does not show degradation consequent upon the addition of metallic silver up to a concentration of 60 wt per cent. The X-ray diffraction data confirm that the oxygen deficient distorted orthorhombic perovskite structure of the pure compound stays intact as if silver does not enter the crystal lattice. SEM studies do show the presence of silver at the grain boundaries only. Silver is found to restrict the grain growth.

**Keywords.** High  $T_c$  superconductor;  $Y_1Ba_2Cu_3O_{7-x}$  compound; silver addition; X-ray diffraction.

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The enhancement of superconducting transition temperature to 92 K (Wu *et al* 1987) in the  $Y_1Ba_2Cu_3O_{7-x}$  compound and the subsequent large values of  $J_c$  ( $> 10^5 A cm^{-2}$  at 77 K) reported in epitaxial films (Chaudhari *et al* 1987) and in bulk single crystals (Dinger *et al* 1987) raised the hope that these materials can be produced with good  $J_c$  for practical applications. Yamada *et al* (1987) and Malik *et al* (1987) report  $J_c$  values of  $725 A cm^{-2}$  and  $90 A cm^{-2}$  at 77 K and zero field respectively for Y-Ba-Cu-O wires. Both the groups used copper sheath and the powder metallurgy technique. The copper sheath was however removed before the wire was oxygen reacted. Attempts have also been made to prepare superconducting tapes by reacting the mixture of  $Y_2O_3$  and  $BaCO_3$  powders with copper substrate (Kumakura *et al* 1987). The tape shows a wide superconducting transition between 93 and 40 K. No  $J_c$  is reported. A 3-hour reaction (at  $900^\circ C$ ) renders the tape brittle as the copper substrate reacts and disappears completely. On all accounts the most common matrix used in conventional superconductors, that is, copper has been found unsuitable for this high  $T_c$  material.

We therefore decided to use silver as the cladding material for the Y-Ba-Cu-O system. We, in fact, succeeded (Sharma *et al* 1987) in fabricating stabilized silver clad  $Y_1Ba_2Cu_3O_{7-x}$  wires even though the  $J_c$  ( $= 26.4 A cm^{-2}$  at 77 K) was quite low. The wire however turns completely normal at a current density of  $280 A cm^{-2}$ . Simultaneously we carried out studies on the effect of silver addition to the  $Y_1Ba_2Cu_3O_{7-x}$  compound and report our preliminary results here.

The compound  $Y_1Ba_2Cu_3O_{7-x}$  was prepared by the usual solid state ceramic technique. 20 mm diameter pellets were made from the powder as such and also after adding to it metallic silver powder (99.9 per cent) 1, 9, 17, 29 and 60 wt per cent. All the pellets were reacted at  $850^\circ C$  for 15 h under flowing oxygen and cooled down.