ABSTRACT

The present research work elucidates the synthesis, sintering characteristics and fabrication of high temperature ceramic superconducting materials.

A new technique called pyrophoric process has been developed to synthesise ultrafine powders of Y-Ba-Cu-oxide. The ultrafine powders require minimum processing parameters (temperature and time) for calcination and sintering, compared to the other processes as, conventional ceramic process or coprecipitaion technique, to fabricate high density YBCO superconductors.

Rate of densification decreases with the increase of pO_2 and initial particle size of the green compacts. The activation energy for sintering and sintering kinetic parameter is dependent on the particle size of the compacts and pO_2. With the increase of particle sizes in compacts and pO_2, the mechanism of mass transport changes from volume/grain boundary diffusion to surface diffusion, which leads to lower activation energy as well as lower rate of densification. The sintering behaviour of the YBCO powder compacts under different pO_2's and in the presence of excess cations i.e. Y^{3+}, Ba^{2+} and Cu^{2+} suggest that a complex diffusion mechanism of Cu and O may be the rate controlling factor for sintering. Sintering of unreacted stoichiometric mixture exhibits low activation energies due to coalescence of the grains and reaction aided densification. The weak link nature between grain boundaries has been observed to be S-I-S type when sintered in argon, S-I-N-S type for the air sintered samples and S-N-S type for the oxygen sintered samples. The variation of the nature of the weak links is due to formation of oxygen deficient grain boundaries.

Addition of silver lowers the sintering temperature and formation of Ag layer between the YBCO grains controls the sintering and superconducting behaviour of YBCO-Ag composites. Increased rate of grain growth has been observed after a certain densification, 80% of the theoretical density, in $YBaCuO-Ag_{0.1}$ tape cast by doctor blade technique.

C-axis oriented YBCO (123) whiskers has been synthesised to

fabricate whisker reinforced YBCO composite, which show partial c-axis orientation after sintering and a J_c value of 1440 A/cm^2 at 77K.

Laser beam irradiation of 124 pellets cause melting of the surface upto a depth of ≈ 30 μm with precipitation of CuO and 123 phase. This layer on heating to 1173 K and subsequent oxygenation at 773 K for 20 hrs. become superconducting and exhibit a J_c of 3000 A/cm^2 at 77 K.

Acicular growth has been observed in 123 samples after laser beam irradiation. The size of the acicular grains increases with the power of the incident laser beam. The acicular growth has been observed around the pores which have led us to conclude that the directional melting and solidification occur as the pore surfaces act as efficient heat sinks. Superconducting properties of the specimen are improved after laser irradiation and oxygenation due to the acicular growth.

Evaporation of Bi, Sr and Pb has been observed during sintering of BPSCCO superconductors, which has been minimised by covering the pellets with the same powder of BPSCCO during sintering. Presence of Ag in BPSCCO matrix lowers the melting point and hence enhances the rate of evaporation. This lowering of melting point is due to formation of CuO-PbO-Ag eutectic which melts at about 993 K. The inter-reaction between Ag cladding and BPSCCO at the interface has been minimised by reducing sintering time and temperature to fabricate Ag sheathed BPSCCO tapes, with J_c values > 3000 A/cm^2 at 77 K.

A new orthorhombic phase with lattice constants a = 4.28 Å, b = 4.34 Å and c = 12.84 Å has been found to be co-existing with the conventional yttrium cuprate phase (123) in the $YBa_2Cu_2PbO_x$ superconductor. The presence of Pb increases Cu^{2+} valence state and is possibly responsible for a lower T_c (R=0) (80 K).