HIGH TEMPERATURE SUPERCONDUCTING MATERIALS AND DEVICE STRUCTURES

Abdul Halim Shaari, Kaida Khalid, Jamil Suradi, Mansor Hashim, Sidek Hj. A. Aziz, Senin Hassan, Zainul Abidin Hassan and Tan Wee Tee

Department of Physics, Faculty of Science and Environmental Studies
Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Keywords: high t_c superconductors, YBCO, BSCCO, Sol-Gel, A.C susceptibility, magnetic levitation, solid state sintering.

Introduction

Studies on the Superconducting Ceramics for Bismuth- and Yttrium-based systems have been performed (Al-Khawaldeh, 1998; Azahan et al. 1998). The role of barium and copper sites in the Y-Ba-Cu-O and calcium and copper sites in the Bi-Sr-Ca-Cu-O systems were studied (Hashim et al. 1998; Halim et al. 1999). A comparison between Bi-Sr-Ca-Cu-O superconductors prepared via sol-gel technique and conventional oxide-route was made. Sol-gel route assists in improving the formation of high T_c (2223) phase (Al-Khawaldeh, 1998).

Materials and Methods

Conventional Oxide-route and Sol-gel techniques have been used to derive the starting powders. Oxide powders are normally of micron-sized, while submicron-sized particles are obtained through sol-gel processing. High Temperature Superconducting Materials based on the Bi-Pb-Sr-Ca-Cu-O(BSCCO) system have been prepared using both approach. Via sol-gel techniques (Al-Khawaldeh, 1998), starting powders have been derived using different precursors, namely; acetates, oxide-carbonate and nitrate. Doping effect of various elements, such as Sn, Zn, Ba, Si, Y, Sn-Nb, Dy, Gd, Pr, Sm and Nd, on the calcium and copper sites have also been studied on the system (Hashim et al. 1998). In the Y-Ba-Cu-O(YBCO) system the effect of Indium and Gadolinium doping in Yttrium sites have been studied (Azahan et al. 1998). Solid state sintering process has been used to synthesise the final products. New superconducting materials based on the Y-Ba-Ca-Cu-O(YBCCO) have also been studied. Ceramics having a formula R-Ca-Cu-O where R=Y, Gd, Sm, Pr, Mg, Dy, Ho, Nd and Eu, were also prepared. An automated experimental rigs was also set up to study the levitation force, magnetic stiffness and other related properties of the superconductors.

Results and Discussion

Superconducting properties of BSCCO systems prepared via Sol-Gel method are superior to that of the conventional-oxide route. The transition width from normal to superconducting state is narrower. The grains connectivity are improved (Al-Khawaldeh, 1998). These are observed from a) the a.c. susceptibility data, where the coupling losses are close to the T_c and b) the magnetic levitation studies, where the levitation force is maximum. High T_c phase(2223) are higher in the samples prepared via sol-gel.

In YBCO system, the effect of indium doping in the yttrium site is more detrimental than gadolinium doping (Azahan et al. 1998). This could be due to the ionic size effect where the smaller size ion has reduces the internal pressure effect due to the yttrium ions.

The effect of Sn doping in the BSCCO system, at Ca site alone is much more sensitive than disturbing both Ca and Cu sites at the same time, indicating that the local environment around Ca site is crucial to the formation of high T_c phase (Halim et al. 1999b). However, ceramics having a formula R-Ca-Cu-O where R=Y, Gd, Sm, Pr, Mg, Dy, Ho, Nd and Eu, were found not superconducting. Levitation force and magnetic stiffness measurements revealed the role of the superconducting grains and also the effect of doping.

Conclusions

The substitution of both magnetic and non-magnetic impurities in the oxide superconductors displays detrimental effect on T_c. Incorporation of Ba, Zn, V, Y, and Sn in the calcium sites has resulted in the reduction of Tc as follows; $Ba^{2+} < Zn^{2+} < V^{3+} < Y^{3+} < Sn^{4+}$. This reflects the influence of the valence of the dopants. This also agrees with the assumption by other workers that the pair breaking effect is due to the non-magnetic disorder or to an indirect Abrikosov-Gorkov process by the local magnetic moments of Cu induced by the dopants. A series of compounds having a formula Y-Ba-Ca-Cu-O was found superconducting, while R-Ca-Cu-O were not. This concludes that barium environment is very crucial to the electron pairing mechanism. In general, the magnitude of the levitation force due to sintered samples are much smaller than the reported values of samples prepared via melt growth technique.

References

Al-Khawaldeh, S.A. 1998. Superconducting Properties of Sol-gel Derived Bi-Pb-Sr-Ca-Cu-O System, Thesis M.Sc.

Azahan, H., Halim, S.A., Mohamed, S.B., Khawaldeh, S., Khalid, K. and Sidek, H.A.A. 1998. Studies on New YBaCaCuO Ceramics. J. Solid St. Sci. Technol. 6(1): 15-20.

Halim, S.A., Mohamed, S.B., Azhan, H., Khawaldeh, S.A. 1999a. Effect of Ba and Zn doping in Bi-Pb-Sr-Ca-Cu-O Superconductors using Ac Susceptibility measurements. Accepted for publication in J. Material Science, U.K.

Halim, S.A., Mohamed, S.B., Azhan, H., Khawaldeh, S.A. and Sidek, H.A.A. 1999b. Effect of Barium Doping in Bi-Pb-Sr-Ca-Cu-O Ceramics Superconductors. *Physica.* C 312: 78-84.

Hashim, A., Halim, S.A., Mohamed, S.B., Jamil, S. and Sidek, H.A.A. 1998. The Effect of simultaneous doping of Sn on Ca and Cu sites in $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_\delta$ superconducting ceramics, Presented at MASS conference, Dec 12-14, 1998.

Supported by IRPA Grant 03-02-04-0010