PREPARATION OF MgB_2 AND BSCCO SUPERCONDUCTING THIN FILMS

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Contents

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PEMENANG Anugerah Kualiti Perdana Menteri 2008

Surat Kami : 600-RMI/ST/FRGS 5/3/Fst (56/2010)
Tarikh : 22 Mac 2010

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Y. Bhg. Prof/Prof. Madya/Dr./Tuan/Puan

KELULUSAN SKIM GERAN PENYELIDIKAN FRGS FASA 01/2010

Tajuk Projek	:	Preparation of Superconducting Thin Films
Kod Projek	:	600-RMI/ST/FRGS 5/3/Fst (56/2010)
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Dengan hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan pihak Kementerian Pengajian Tinggi melalui surat JPT.S(BPKI) 2000/011/010 Jilid. 2 (19) telah meluluskan cadangan penyelidikan Prof/Prof. Madya/Dr./Tuan/Puan untuk di biayai di bawah Skim Geran Penyelidikan Fundamental (FRGS) Fasa 1/2010.

Bagi pihak Universiti kami mengucapkan tahniah kepada Prof/Prof. Madya/Dr./Tuan/Puan kerana kejayaan ini dan seterusnya diharapkan berjaya menyiapkan projek ini dengan cemerlang.

Untuk tujuan mengemaskini, pihak Prof/Prof. Madya/Dr./Tuan/Puan adalah di minta untuk menyusun perancangan semula bajet yang baru seperti yang diluluskan. Sila lihat lampiran bagi tatacara tambahan untuk pengurusan projek.

Sekian, harap maklum.

"SELAMAT MENJALANKAN PENYELIDIKAN DENGAN JAYANYA"

Yang benar

MUSTAFAR KAMAL HAMZAH
Ketua INFOREC
Merangkap Ketua Penyelidikan (Sains & Teknologi)

/RS.

5.2 Enhanced Executive Summary

The main purpose of this project is to prepare MgB_2 and BSCCO superconductor bulk samples and thin films, and also to determine the highest critical temperature for MgB_2 and BSCCO superconductor. In order to prepare the MgB_2 and BSCCO superconductor, the solid state method will be applied which involve the process of grinding and sintering. The produced sample will be compress into pellet form before it is being sintered. The MgB_2 bulks were prepared by a pellet-in-sealed tube at different annealing temperatures of 650^0C, 700^0C, 750^0C and 800^0C. The superconducting thin films were prepared using sputtering technique. The bulk and thin film samples were then be characterized in various methods; electrical measurement, ac magnetic susceptibility measurement, Scanning Electron Microscopy (SEM) and also phase purity and composition by X-ray diffraction (XRD). For MgB_2 superconductor bulk samples, AC susceptibility measurements showed a sharp superconducting transition in all samples. The critical current density (J_c) was measured using ac magnetic susceptibility measurement method. The highest critical density in magnetic field, $J_c(T,H)$ from the magnetization measurements was recorded for the 650^0C annealed MgB_2. X-ray diffraction (XRD) analysis showed small quantities of MgO and unreacted Mg phases as impurities in the samples which act as effective pinning centres for vortices. Unreacted Mg decreased with increasing annealing temperature.

For BSCCO thin film samples, the superconducting transitions are sensitively affected by the annealing treatment temperature. At 850°C, the normal state exhibits a semiconducting behavior that is improved by increasing the temperature to 860°C - 880°C. There were very small drops in the resistance at 110 K and zero resistances were registered in the range of 46-60 K, strongly dependent on the annealed temperature. The x-ray diffraction plot of a film deposited for 1 hour and annealed at 850°C is *c*-axis oriented and film annealed at 860°C consists of low T_c phase as a major phase. An increase of annealed temperature to 870°C and 880°C led to increasing the intensity of low T_c phase and the appearance of semiconducting phase. SEM micrograph of the film shows densely packed fine grains of submicron size, which indicates low film density and poor connection between the grains, this leads to the poor superconducting properties of these film.

5.3 Introduction

Superconductor is an element, inter-metallic alloy or compound that will conduct electricity without resistance below a certain temperature. Resistance is undesirable because it produces losses in the energy flowing through the material. Once set in motion, electrical current will flow forever in a close loop of superconducting material-making it the closest thing to perpetual motion in nature. The main characteristic for a superconductor is it has no electrical resistance and thus it can carry the highest amount of current in the superconducting state. The application of high T_c superconductors in microelectronics depends on the availability of high quality superconducting thin films.

Accordingly, the discovery of high temperature superconductivity was followed by strong efforts by a large number of researchers to fabricate high quality films of superconductors began in 1986 with the observation of superconductivity above 30 K in $La_{2-x}(Ba,Sr)_xCuO_4$, $YBa_2Cu_3O_{7-x}$ (YBCO) with a superconducting transition (T_c) of 93 K, which was the first system to show superconductivity above the boiling temperature (77 K) of liquid nitrogen and $Bi_2Sr_2Ca_2Cu_3O_{7-x}$ with T_c~110K (Abd-Shukor, 2004). Since then, various other superconductors have been discovered with higher superconducting transition temperature and further efforts are continuing in discovering new materials which exhibit higher T_c. The highest critical temperature (T_c) among the borides is MgB_2 as it has the strong coupling of electrons within the boron layers as a result of an in-plane vibrational mode. MgB_2 is known as chemical compound but was discovered as a superconductor in 2001 and the critical temperature is 39 K. Contrasting from cuprates, the MgB_2 has larger coherent length, lower anisotropy and a transparency of the grain boundaries to current flow. Since the discovery of high-temperature superconductivity there have been intense efforts to synthesize thin films suitable for device applications and basic physics study. The most successful techniques at present is high-pressure single-target sputtering. However epitaxial growth of superconductor in thin film form was found to be challenging because the high T_c materials have characteristic properties which require growth conditions and growth techniques different from those used to deposit films of classical superconductors. Some of the difficulties associated with the fabrication of high-T_c thin films are the realization of correct elemental stoichiometry, proper oxygen content and optimum crystallographic alignment in the films.

In this work, the surface morphology, structure and electrical properties of the BSCCO and MgB_2 in bulk and thin films form will be investigated. The suitable conditions and parameters for producing a superconducting thin films will also be investigated at different annealing temperature. These samples will be characterized by ACS, SEM, EDAX, XRD, resistance measurement.