Electrical Properties of High Tc Superconductors Using the Pyrolysis Method for Renewed Electric Power Energy

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Abstract - We have fabricated a superconducting YBCO system according to the pyrolysis method and low pressure apparatus. In our experiment, the X-ray diffraction pattern of the non doped YBaCuO layer indicated that the superconductor contained only 90K phase crystal. The critical temperature and critical current density for a thick layer at 650℃ were Tc=90 K and Jc=6 × 10^4 A/cm^2 at 90K. In low pressure apparatus, the 90 K phase YBaCuO was grown at a lower temperature compared with the normal system. Tc and Jc at 650 ℃ were Tc = 90 K and Jc= 6 × 10^4 A/cm^2 at 90K.

Keywords: YBaCuO, High Tc superconductor

1. Introduction

The recent worldwide success in applying high temperature superconductors to electric power components, such as motors, cables, and current limiters, has renewed the interest for this technology. These achievements were only possible due to the rapid worldwide progress in developing high Tc superconductor wire and tape with acceptable performance for these prototype demonstrations.

This talk will briefly highlight the performance of high Tc superconductor wire and tape related to the current and long-range objectives of these power system related applications. The major problems facing this technology will be discussed, as well as the prospects for comercialization and integration into the utility sector. The eventual widespread utility acceptance for superconducting power equipment will ultimately be based on several key factors; the system performance must be improved over conventional technology; the efficiency, reliability and maintenance must be comparable to conventional power equipment; the life cycle costs must be lower; and the installed cost must be highly competitive and justifiable to the utilities. The latter is impacted by the current high cost of high Tc superconductors

Significant effort has been directed towards developing high current superconducting wire technologies.

Much of this work has focused on achieving the crystallographic texture needed in high temperature superconductor (HTS) wire or tape in order to realize the high critical current density (Jc) at 77 K.

When compared to the first generation Bi based HTS tapes, $YBa_2Cu_3O_7$(YBCO) coated conductors have higher critical current densities of 1 MA/cm^2 at 77 K. Jc values of YBCO thin films grown epitaxially on single crystals exhibit above 1 MA/cm^2, while randomly oriented polycrystalline high Tc superconductors show a few hundred A/cm^2 .

This large difference is related to the weak link behavior due to the high misorientation angle above 10 at the grain boundaries. To obtain high Jc values, the high Tc superconductor tapes should posses high grain alignments both in-plane and out-of plane over the entire conductors.

High temperature superconductors (HTS) are of interest in electrical power applications where their unique properties can make them economical if they can be optimized and produced repeatedly.

Commercial applications of superconducting electric power devices and systems based on HTSC require long lengths of flexible, high current and high field tape conductors.

HTSC coated superconducting tapes hold out the promise of both a high zero field critical current density, Jc (77 K) 10^6A/cm^2, and excellent magnetic field performance [1-6].

Researchers have been studying the thin film growth of high-Tc superconducting materials using several methods such as RF diode sputtering, EB sputtering, ICB deposition, and various laser devices that operate at liquid-nitrogen temperature.

A high Tc superconductor consists of an aligned high Tc superconductor film and buffer layers on a metal substrate The buffer layers are needed to prevent chemical reaction and compensate for the lattice mismatch between the high Tc superconductor film and the metal substrate.

The degree of the alignment of the high Tc super-

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conductor film is dependent on the alignments of the buffer layers. A template with aligned buffer layers can be made by two well known processes, namely ion beam assisted deposition and rolling assisted bi-axially textured substrate. The metal substrate of the former process does not require a textured structure due to the directional oxide decomposition by the ion beam, while the metal substrate of the latter process should have a textured structure. In both processes, ceria and yttria stabilized zirconium are widely used as buffer layers for the high Tc superconductor tapes.

In the process, the textured Ni tape can be fabricated by rolling and recrystallization. The well known buffer layer structure is ceria/YSZ/CERIA/Ni tape.

Ceria is a good material to compensate for the lattice mismatch, and TSZ has been widely used as a diffusion barrier. Buffer layers like ceria and YSZ have been mainly deposited by physical vapor deposition methods using e-beam evaporation or sputtering for textured substrates, or the ion beam assisted deposition method for textured substrates.

Typically, a superconducting tape is fabricated depositing HTS film on base metal substrate that has been pre-coated with an oxide buffer layer.

The oxide buffer layer is biaxially aligned and acts as a diffusion barrier to the metal species and as a template to facilitate the epitaxial growth of the c-axis tape conductor.

High Jc (10^6 Acm^{-2}) values can be achieved if the in plane grain misalignment in the tape conductor film is 15.

Since this misalignment is controlled by the texture of the buffer layer, it is very important for the buffer layer to have a very high degree of biaxial alignment. Meng et al. have already reported the high Jc tape conductor.

We fabricated 90K phase YBaCuO superconducting as-grown film by high Jc as-grown film via low pressure. This paper discusses the characteristics of YBaCuO.

2. Experimental

The calcined powder of the nominal composition $YBa_2Cu_3O_y$ precursor, which was prepared from mixed powders of Ag_2O, was mixed with HgO, and then sintered at 900 ℃ for 20 h in a sealed quartz ampoule.

Obtained $YBa_2Cu_3O_y$ pellets were grounded and used as the starting powder for the thick film.

In the case of the Ni substrate, 123 thick film was formed on the substrate by a painting method utilizing a slurry containing calcined powder of 123.

The NiO layer was prepared by oxidizing the surface of the Ni foil at 900 ℃ in air.

The thick films were put into Al_2O_3 tubes, and then sintered at various temperatures in a sealed quartz ampoule together with Hg-containing pellets.

The microstructure of the tape surface was observed by a scanning electron microscope. The electrical trans-port properties of the tapes were measured by the conventional four probe method Tc.

3. Experimental Results and Discussion

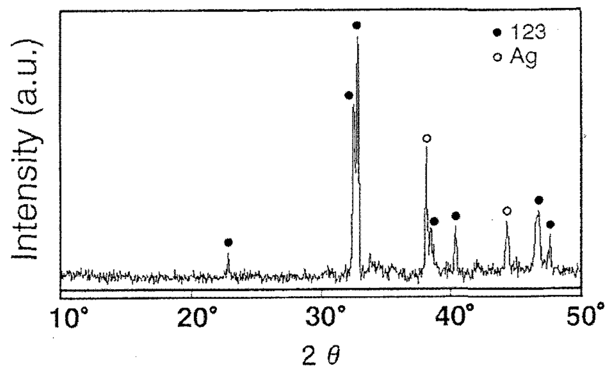

Fig. 1 X-ray diffraction pattern of the YBaCuO superconductor

$YBa_2Cu_3O_y$ 123 thick films were obtained with the Ni substrates, when pellets of $YBa_2Cu_3O_y$ were used as the Hg vapor source. In addition, platelet crystals of $YBa_2Cu_3O_y$ 123 were grown on the substrate by sintering at 650 ℃.

$YBa_2Cu_3O_y$ 123 tapes could be synthesized reproducibly and Fig. 1 shows a typical X-ray diffraction pattern of the tape. In the case of the Ni substrate, strongly c-axis oriented thick film was fabricated by sintering at 650 ℃ with an intermediate uniaxial pressing.

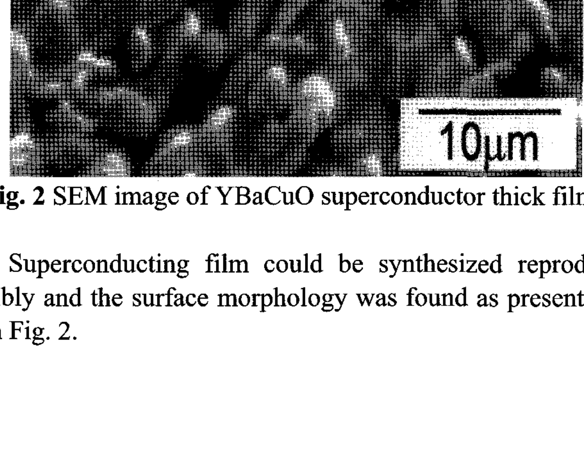

Fig. 2 SEM image of YBaCuO superconductor thick film

Superconducting film could be synthesized reproducibly and the surface morphology was found as presented in Fig. 2.

The oriented thick film exhibited Tc=90 K under zero magnetic field. These results indicate that the Ni substrate is more preferable for YBaCuO 123 thick film.

The compound growth apparatus consists of a quartz reactor tube, two source chambers, a substrate holder, a horizontal furnace with five separate heating zones, and a gas flow control system. The oxygen concentration in the carrier gas was about 8% concentration at about 500 ppm. The 90 K phase diffraction pattern could not be detected even under high magnification.

The critical temperature was 90 K for a 0.2 μm thick sample, 89 K for the 0.15 μm thick sample and 89 K for the 0.12 μm thick sample

Fig. 3 indicates the critical current densities for layers formed by photolithography on waters 1, 2, and 3 at 10 K for a width of 10 μm and a length of 20 μm.

The critical current densities were 1×10^4 to 8×10^4 $A/cm^{2.}$ The temperature dependence of the electrical resistance of YBaCuO on MgO and the sapphier substrates are shown in Fig. 4. The critical temperature for a 70 nm thick layer on MgO grown at 700℃. The temperature dependence of the critical density of the YBaCuO layer on the MgO is shown in Fig. 4. The critical current density was 8×10^4 A/cm^2 at 20K and $1 \times 10^4 A/cm^2$ at 60K.

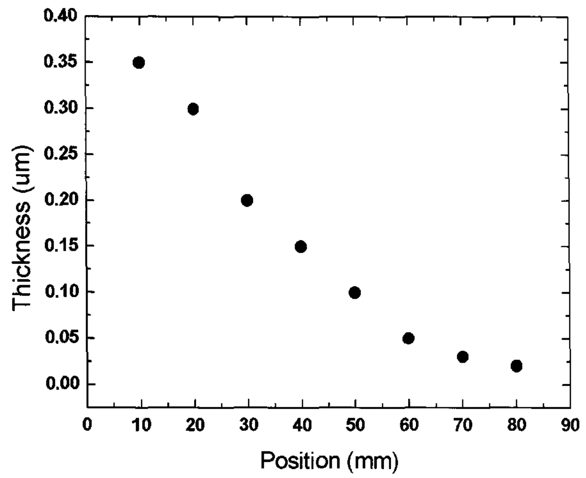

Fig. 3 Temperature dependence of the electrical resistance of the YBaCuO superconductor

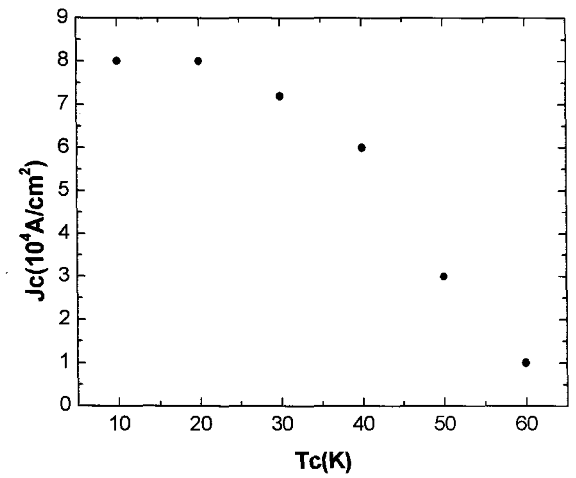

Fig. 4 Tenperature dependence of the critical current density for the 100 nm thick YBaCuO superconductor on MgO

4. Conclusion

We developed a technique for growing a 90K phase non doped as-grown YBaCuO thick film on an MgO substrate. The critical temperature and critical density for the layer were 90 K and 8×10^4 A/cm^2 at 10K respectively.

We obtained high-Jc as-grown YBaCuO on an MgO substrate by low pressure. The critical current density for the layer was 8×10^4 A/cm^2 at 20 K.

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