

Korea's Developmental Program for Superconductivity

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1. Introduction

Superconductivity research in Korea was firstly carried out in the late 70s by a research group in Seoul National University (SNU), who fabricated a small scale superconducting magnetic energy storage system under the financial support from Korea Electric Power Company(KEPCO). But a few researchers were involved in superconductivity research until the oxide high T_c superconductor was discovered by Bednorz and Mueller.¹⁾

After the discovery of YBaCuO superconductor operating above the boiling point of liquid nitrogen(77K)²⁾, Korean Ministry of Science and Technology(MOST) sponsored a special fund for the high T_c superconductivity research to universities and national research institutes by recognizing its importance. Scientists engaged in this project organized "High Temperature Superconductivity Research Association(HITSRA)" for effective conducting of research. Its major functions are to coordinate research activities on high T_c superconductivity and organize the workshop for active exchange of information. During last seven years the major superconductivity research has been carried out through the coordination of HITSRA. The major parts of the Korea's superconductivity research program were related to high temperature superconductor and only a few groups were carrying out research on conventional superconductor technology, and Korea Atomic Energy Research Institute(KAERI) and Korea Electrotechnology Research Institute(KERI) have led this research.

In this talk, the current status and future plans of superconductivity research in Korea will be reviewed based on the results presented in interim meeting of HITSRA, April 1-2, 1994, Taejeon, as well as the research activity of KAERI.

2. Research Activities in Korea

After the first workshop held on July 6, 1987, HITSRA has organized 18 workshops to promote research activities on high T_c superconductivity and share the results. Recent research results presented at interim meeting of HITSRA are summarized as follows:

(1) film : High quality YBCO thin films were reported by many groups using RF sputtering, laser ablation, chemical vapor deposition etc. But there was no report on Bi- and Tl-based thin film. Currently the research activities are concentrated on development of devices applying film such as HTSC dc SQUID, Josephson junction device, filter, resonator, antenna, flux transformer etc. Several research groups reported the successful fabrication of the HTSC dc SQUID and Josephson step edge junction. Korea Standards Research Institute(KSRI) and Goldstar central research laboratory lead the research in this field.

(2) bulk : Researches on fundamental properties of HTSC superconductor such as superconductivity theory, thermodynamics, kinetics, mechanical and magnetic properties etc were carried out for Y-, Bi- and Tl-base materials. Several groups are executing the research on Hg-base compound and KSRI and Pohang Institute of Science and Technology reported the successful formation of Hg-1212 and Hg-1223 oxides using ampoule method and obtained a T_c of about 130K. They are trying to fabricate Hg-base compound in thin film. The study on fabricating high magnetization YBCO material for application on fly wheel and current lead is also carried out by several groups with different techniques such as extrusion and laser melt pedestal growth,

isothermal peritectic process, quasi melt process, melt texture growth etc.

(3) wire/tape : There were several reports on the superconducting tape of Bi-2212/Ag and Bi-2223/Ag composites showing a relatively good critical current density in the order of 10^4 A/cm² in 1 m length and KAERI and KERI reported preliminary results on multi-filamentary wire of 7, 49 and 108 filaments. KERI also reported the preliminary result on TI-1223/Ag composite tape.

It was noticeable that trends of superconductivity research in Korea was changed from fundamental research to application technique and government emphasized the importance of joint R & D between industry and national research institute.

3. Superconductivity Research Activities in KAERI

Since the high T_c superconductivity research in Korea started in 1987, KAERI has played leading role by presenting several important results on material development and its application. In previous articles^{3,4)}, it was pointed out that 105K Pb-doped BiSrCaCuO, Bi-2223/Ag composite superconducting tape, high J_c YBaCuO film, high magnetization YBaCuO bulk superconductor and high speed rotating system(75,000 rpm in air) using superconducting bearing by melt processed YBCO superconductor were firstly fabricated by KAERI in Korea. Some important results were reported on characteristics of Bi-2223 compound formation⁵⁻⁸⁾, mechanisms of YBCO formation⁹⁻¹⁵⁾ and preparation of YBCO film by CVD process^{16,17)}. We reported the formation of high J_c YbBaCuO film on various substrates at 650 °C without using any other excitation source¹⁸⁻²⁰⁾

Very recently, we have developed new process for fabricating BSCCO/Ag composite using silver powder instead of silver tube²¹⁾, which has many advantages such as ; ability of fabricating large composite with high critical current density, ability of fabricating complicated shape with less difficulty than powder in tube method, possibility of changing silver sheath composition easily

by adding suitable alloying element powder to silver powder, good controllability of BSCCO powder packing density etc. Through repeated cold rolling and annealing at 840 °C in air, Ag/Bi-2223 composite with a thickness of 0.1 mm and a width of 40 mm was obtained. The Ag/Bi-2223 composite with large dimension was fabricated into complex H-patterned and helical shape having a high current carrying capacity ($J_c = 3,500 \text{ A/cm}^2$ at 77K, 0T, $I_c = 4.5 \text{ A}$ for a specimen with a width of 3 mm). Currently the test for applying this composite as antenna, magnetic shield and wire are being carried out together with the experiments for deciding optimum process condition.

For last several years, we also have put large effort to understand the flux pinning behavior and increase the quality of melt processed YBCO specimen for developing application device such as fly wheel, current lead and superconducting magnetic bearing. Some important result were reported : the behavior of 211 particle growth in different melt composition²²⁾, the abnormalous magnetization of 123²³⁾, and effect of various additives on the growth of 123 matrix.^{10,14)}

In order to develop the key technology in the field of nuclear energy, Korean government set up an long term national R&D program in 1992 and its major categories are as follows ;

- Nuclear fuel cycle technology
- Waste management
- Radiation and RI application through the use of KMRR
- Nuclear basic research
- Nuclear safety research.

The development of superconducting magnet for superconducting magnetic energy storage and nuclear fusion is classified as one of the important topics of nuclear basic research program. And superconductivity research team and fusion research team are responsible for that. From 1992, we have extended

our research activity to the development of superconducting magnet and fabricated a superconducting magnet with high homogeneity of 10 ppm in 5 cm diameter through cooperation with Kurchatov Institute of Atomic Energy(KIAE). The goals on the magnet technology in KAERI are summarized as follows:

1992 - 1995 : Magnet for basic research and preliminary design of magnet for medium size tokamak

1995 - 1998 : Fabrication of proto type magnet for medium size tokamak and SMES

1998 - 2005 : Fabrication of magnet for medium size tokamak.

To achieve the goals successfully, it is very important to have a wide international cooperation and we are willing to have a close relationship with any institute which keep the advanced magnet technology.

4. Superconductivity Research Program in Korea

The MOST recognized the importance of superconductivity research and decided to support its activities continuously. Therefore the third phase of three years base national program on superconductivity research started in 1993. In third phase program, the higher priority was given to the application techniques and joint research among national research institute, universities and industries are emphasized. It is planned that the technical bases for implementing the HTSC material to practical application is established in this period and next phase program is mostly oriented to industrialization of those techniques.

Until 1992, superconductivity research activities in Korea had been concentrated on high T_c superconductor and little attention was paid on conventional superconductor. But from 1992, the research on the application of conventional superconductor has been carried out intensively by KAERI and KERI. The major fields of interest are superconducting magnetic energy

storage, power transmission cable, superconducting motor and generator, superconducting magnet with high homogeneity and high field and superconducting magnet for medium size tokamak. MOST recognizes the importance of conventional superconductor technology for large scale application and KEPCO also shows deep interest to the application of superconductivity to electric power system and support related research. It is expected that the priority of superconductivity research will greatly increase as far as the development of application technique keeps current pace of improving.

5. Conclusion

Superconductivity research in Korea, which was initiated by the discovery of high T_c superconductor, is extending its area to the conventional superconductor and their application such as SMES, nuclear fusion, MRI etc. To achieve the research goals effectively, HITSRA coordinates the researches on HTSC materials and their applications continuously. To carry out the research successfully, Korean government encourages cooperation between national research institute and industry as well as international cooperation with foreign institution.

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