R&D Status of HTS Coated conductors in Korea

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Abstract - **In Korea, HTS coated conductors (CC) are developed under DAPAS program. In the CC project of the program, we selected the reactive co-evaporation (RCE) technique as the main fabrication process to deposit ReBCO superconductor on IBAD substrates. After the modification of EDDC which is a batch type RCE equipment, we fabricated long length SmBCO CC tapes and investigated the relationship between critical currents and deposition parameters of oxygen partial pressure, composition, etc. The fabrication length is limited to 100 m when we use the EDDC. So, we have manufactured the reel-to-reel RCE equipment for research use and will develop high Ic CC tapes.**

I. INTRODUCTION

Recently, R&D for HTS coated conductors and their applications are vigorously conducted in Korea. The DAPAS program is one of Korean frontier programs, which is supported by Ministry of Education, Science and Technology. Major application items of this program are power cable, motor, fault current limiter and transformer. High performance HTS CCs are needed for the developments of these devices. So, R&D for fabrication of CCs is recognized to be very important in the DAPAS program.

Under the DAPAS program, KERI is a key institute and has developed various fundamental technologies cooperating with universities and industry for the development of ReBCO CC.

Reactive Co-Evaporation(RCE) was selected as a deposition process for the superconducting layer. Long length SmBCO was successfully deposited using batch type RCE equipment on IBAD-MgO substrate.

In 3rd phase of DAPAS program, SuNAM Co. was joined as an industrial partner for commercialization of CCs. Various facilities for km length fabrication are designed and will be installed next year. University research groups contribute to CC project in the fields of fundamental technologies and evaluation of CC.

In the workshop, current status of CC fabrication and major results in the evaluation of various properties of CC in DAPAS will be presented.

II. R&D FOR COATED CONDUCTOR

A. Fabrication of SmBCO Coated Conductor.

We employed IBAD-MgO and RCE processes for the fabrication of high performance CC tapes in DAPAS-CC project. We manufactured EDDC (Evaporation using Drum in Dual Chambers) system for the deposition of SmBCO superconducting layer [1]. The system is batch type equipment based on RCE process, and the main parts of the equipment were recently modified. We changed the drum material from SUS to inconel. The discrepancy of thermal expansion between drum and the tape was reduced. We also improved the structure of gap part between the reaction and evaporation chamber. According to this, the deposition rate was stabilized and the reproducibility for optimum composition was enhanced.

Optimization research has been carried out changing the substrate temperature and oxygen partial pressure. A critical current density, Jc over 3 MA/cm^2 at 77 K in self-field was achieved for short SmBCO-CC tape with the layer thickness of less than 1 micron.

Fig. 1 shows the surface morphology of SmBCO layer.

SmBCO grains are observed to be well textured like scales of fish, and impurity phases were not observed in high Jc samples.

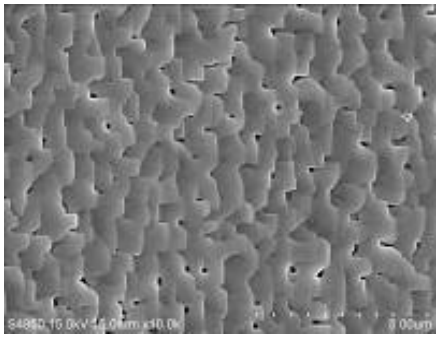

Fig. 1 SEM photograph of SmBCO surface

100 m-long SmBCO CC tapes have been fabricated, and the critical current was evaluated using the hall probe system. Ic distribution in short region along the tape length can be visualized. Some defects were found along the length, but the most part indicated high critical currents.

The EDDC system is not suitable for scale-up of the tape to over 100 m. Therefore, a reel-to-reel RCE system is needed for the production of long length. Recently, we manufactured new RCE equipment which can produce longer than 100 m. Fig. 2 shows a photo of the RCE equipment which was recently installed at KERI. Its basic structure is same as for the EDDC

system, and the multi-turn tape moving part was installed in the reaction chamber.

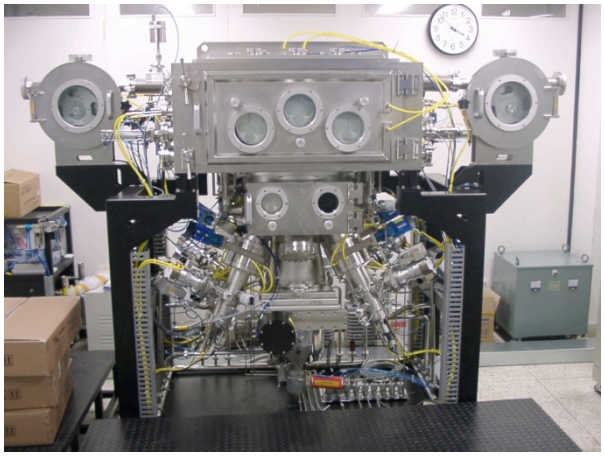

Fig. 2 Reel to reel type RCE equipment at KERI

The deposition conditions of $LaMnO_3$ (LMO) buffer layers on IBAD-MgO template by reactive DC sputtering were investigated. We developed a specially designed chamber for reactive DC magnetron sputtering. We investigated the effect of substrate temperature on the texturing of LMO layer. Four samples were prepared and the deposition conditions were same except for the substrate temperatures of 700 ℃, 750 ℃, 800 ℃, and 850 ℃. The samples deposited at low temperatures of 700 ℃ and 750 ℃ showed LMO(110) peak and LMO(00l) peak in XRD θ-2θ scan, while the others showed only LMO (00l) peak. The FWHM values for the LMO(110) pole of those samples were 13.5°, 10.7°, 9.7°, and 8.7° respectively. The texturing of LMO layer was improved by increasing the substrate temperature.

A SmBCO superconducting layer was deposited on the LMO(reactive)/IBAD-MgO template. Ic and Jc were 204 A/cm and 1 MA/cm^2.

B. Property Evaluation of Coated Conductor

Electro-mechanical properties of CC tapes are evaluated by Andong university group. Shin et al. reported [2] that the influences of bending strain on the critical current, Ic, in stabilized YBCO and SmBCO CC tapes in different modes of easy and hard bending were investigated at 77K and self-field. Under tensile bending strain, when the Ic was plotted against the strain on the YBCO film layer, the 95% Ic retention strain limit under bending was comparable to the value obtained in the axial-tension test.

Under the hard bending of YBCO CC tape, Ic started to degrade when the bending strain exceeded 0.6% and the recovery of Ic did not occur when the bending strain applied was released. The SmBCO CC tape showed a superior strain tolerance under hard bending resulted from its flexibility to in-plane deformation due to its thin geometry compared to other copper stabilized YBCO CC tapes.

The CCs are expected to be used in the conductor part of a fault current limiter (SFCL) in the DAPAS program. Generally, CC involves the stabilizer part which bypasses the fault current and heat when the SFCL is in fault mode. The thickness of the stabilizer in CC is important factor for improving the performance of the SFCL. Kwon *et al*. in Korea university group investigated [3] the quench/recovery characteristics of YBCO CC tapes having stabilizers with various thicknesses. The test results showed that as the thickness of the stabilizer decreased both the final approach temperature and the recovery time decreased.

The Korea Polytechnic university group is developing a HTS transformer within the DAPAS program. AC loss is one of important issues in HTS transformer. Kim *et al.* [4] reported the results of AC loss in YBCO cable. They manufactured continuous transposed cable with striated strand tapes to achieve a lower AC loss as well as higher critical current. They measured AC loss of the sample cable and found that magnetization loss of YBCO CC by alternative external magnetic field can be reduced by striation. However, the striation was no longer effective in reducing the magnetization loss with current lead connection to both end of the striated conductor. The experimental results showed that the striation effect may be sustained by transposition despite of the end connection on both end of the conductor for current leads.

III. CONCLUSION

Using the modified EDDC system, long SmBCO CC tapes on IBAD-MgO substrate were fabricated, and hgh Ic and Jc were confirmed in most part of the tape. But, defects which may be caused by metal substrate tape should be resolved. Reactive sputtering was tried in order to explore a lower cost process for buffer layer. It turned out to be effective for textured LMO layer. R&D efforts in 3rd phase of DAPAS CC-project will be focused on reel-to-reel RCE process.

Various researches on evaluation of CC tapes are also carried out in Korea. Use of CC is positively considered in power cable, motor, fault current limiters and transformers in 3rd phase of DAPAS program. A stable supply of reliable CC tapes is very important for the success of DAPAS program.

REFERENCES

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