Bi-2223테이프 겹치기 접합부(Lap-Joint)의 전기-기계적 특성

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Electro-mechanical properties of lap-jointed Bi-2223 tapes

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Abstract : In practical applications of HTS tapes for electric devices such as coils and power cables, the jointing of HTS tapes is needed. In magnet applications superconducting joints are needed to achieve very low resistance at the joint, but for power device applications, a slightly higher joint resistance may be acceptable. In this study, an economical joint with good mechanical and electrical integrity could be achieved for Bi-2223 tapes which can be applicable to electric power applications. A lap joint method has been used. The joint resistance and strength of the jointed Bi2223 tapes have been evaluated. Electro-mechanical properties of the joint sample under tension have been examined and compared with the case of the single tapes.

Key Words : Bi-2223 tape; Lap-joint; Electro-mechanical property; Joint-resistance

1. Introduction

Bi2223 tapes are now being used for device applications such as coils, motors, power cables and magnets. For these applications, the jointing of tapes is needed (e.g. during device manufacturing, installation and field repair). These joints should have good mechanical and electrical integrity. In the fabrication and operation of electric devices, the superconducting tapes will be subjected to various kinds of stresses/strains. In this study, an economical and practical jointing procedure, which could achieve good electrical performance is presented. Also, the electromechanical properties under tensile deformation is discussed.

2. Experimental Procedures

A commercially-available PIT-processed Ag-alloy sheathed Bi2223 tape has been used. It has a dimension of 4.1 x 0.21mm. For the jointing experiments, Bi2223 tapes were joined using two methods, namely, 1) manually and 2) by controlled jointing. The sample lengths were varied depending on the joint length. For the controlled jointing, a universal test machine was used to apply the compressive load. InBi solder which has a eutectic temperature of ~72°C was used. Tensile tests were performed, and the test procedures are given in [1]. The schematic view of the jointing and voltage tap configurations on Bi2223 tapes is shown in Fig. 1. The direction of axial load is also shown.

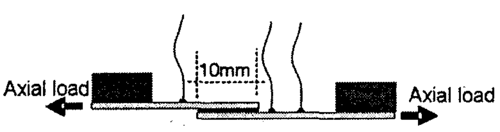

Fig. 1 Schematic view of the jointing and voltage tap configurations of Bi2223 tapes.

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3. Results and Discussions

Fig. 2 shows the joint resistance – joint length relationship in jointed Bi2223 tapes. For the Bi2223 sample, the joint resistance could be reduced from 10 nΩ to 0.8 nΩ with a 10mm and 100mm joint, respectively. Low resistance joints could be achieved due to the low resistivity of Ag used as the sheath material. The Ag-sheathed Bi2223 tapes show an exponential behavior of the joint resistance. Although a very low joint resistance could be achieved using manual jointing, scattering of measured resistance values may occur depending on the manually applied compressive pressure during jointing. For this reason, the optimum compressive pressure during jointing, having the lowest joint resistance, should be determined. This is the reason why jointing method 2 (controlled jointing) was devised and performed. Fig. 3 shows the joint resistance vs. compressive pressure during jointing in jointed Bi2223 tapes. When a 0.1MPa compressive pressure was applied, the joint resistance measured was ~ 25 nΩ. When a 1MPa jointing pressure was applied, the resistance dropped to 12 nΩ. Also from the plot, the joint resistance could be reduced below 20 nΩ if the applied pressure is 1-15MPa. The scattering at 4-5 MPa resulted from the uneven solder thickness, quality of joint, etc. Higher compressive stress may be applied but it should not exceed the yield strength of Ag (~16MPa). The joint resistance may still be reduced when the joint length was increased. For example, 20 and 30mm joints could reduce the resistance to 8 and 4 nΩ, respectively. For design purposes, a joint length of 20-30mm, and a joint pressure of

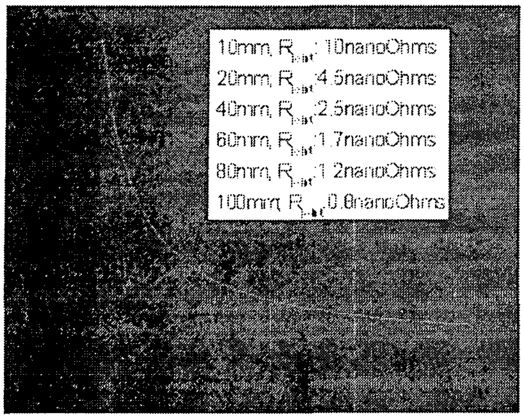

Fig. 2 Joint resistance - Joint length relationship in jointed Bi2223 tapes

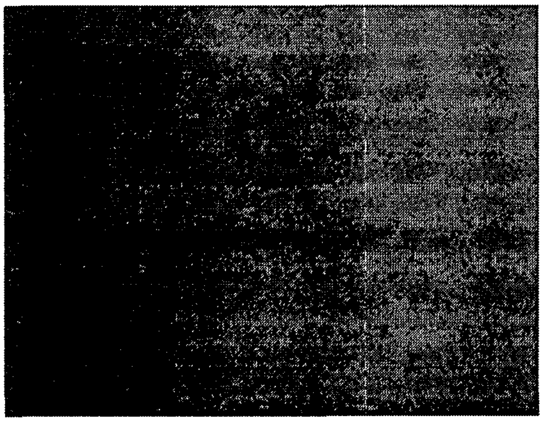

Fig. 3 Joint resistance – compressive stress relationship in jointed Bi2223 tapes (controlled jointing).

~1MPa is recommended.

Fig. 4 shows the load-displacement curves obtained from tensile tests of jointed Bi2223 tapes. All load-displacement curves of manually jointed Bi2223 tapes showed similar behavior with the single tape's curves. The tensile properties of lap-jointed stabilized CC tapes depend on the properties of the single tapes. Fracture always occurred at the unjointed parts of the sample. This observation would be valuable for device designers considering that they need the strength of jointed tapes to be similar with single tapes.

Fig. 5 shows the variation of V-I curves of samples with 10 mm joint length with the increase of tensile load. The slopes of the linear region in V-I curves (i.e. intrinsic resistance at the joint) did not change even after significant Ic degradation occurred as the applied load increased. The 95% Ic retention load is 156N for this Bi2223 tape.

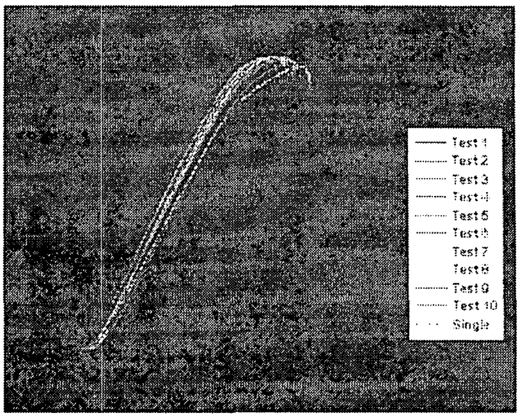

Fig. 4 Load-displacement curves obtained from tensile tests of Bi2223 tapes.

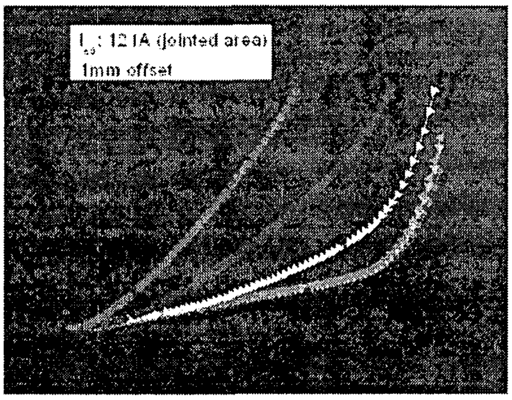

Fig. 5 Variation of V-I curves at the joint under tension.

4. Conclusions

Resistance in Bi2223 tape joints could be reduced by applying compressive pressure (~1 MPa) during jointing. Also, scattering of joint resistance values could be minimized by controlling the applied compressive pressure during jointing. The intrinsic joint resistance did not change even after large Ic degradation occurred at higher applied tensile loads. The electro-mechanical properties of lap-jointed CC tapes depended on the properties of single tapes.

Acknowledgments

This work was supported by a grant from the Center for Applied Superconductivity Technology under the 21st Century Frontier R & D Program funded by the Ministry of Education, Science and Technology, Republic of Korea. JRC Dizon was supported by the Korea Research Foundation funded by the Korean Government (MOEHRD) (KRF-225-D00182)

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