벌루닝 손상에 강한 Bi-2223 테이프의 기본적인 전기-기계적 특성

존얀 디존, 신 형섭[1], 하 동우[2], 조 전욱[2], 오 상수[2]
안동대학교 대학원 기계공학과, 안동대학교 기계공학부[1], 한국전기연구원[2]

Fundamental Electro-Mechanical Characteristics of Ballooning-Resistant Bi-2223 HTS Tapes

John Ryan C Dizon, Hyung-Seop Shin[1], Dong-Woo Ha[2], Jeon-Wook Cho[2], Sang-Soo Oh[2]
Graduate School, Andong National University, [1]Andong National University, [2]Korea Electrotechnology Research Institute

Abstract: The fundamental mechanical characteristics under tensile and bending deformations of hermetically-sealed reinforced Bi-2223 tape and CTOP processed Bi-2223 tape were examined at 77K. Also, the tensile strain dependence of the critical current, I_c, was obtained at 77K and self-field. The reinforced hermetic tape showed higher tensile strength and a better tensile strain tolerance than the CTOP processed tape. For bending tests, a rho-shaped sample holder was used giving multiple bending strains in increasing order. In the same case under bending deformation, the hermetic tape showed a higher bending strain tolerance than the CTOP processed tape. This higher strength of the hermetic tape can be attributed to the thick hardened copper reinforcement layer.

Key Words : Critical current, Ballooning, Hermeticity, Bi-2223 tapes, Bending strain, Tensile strain

1. Introduction

For practical applications to electrical devices adopting Bi-2223 tapes, the tapes are subjected to various stresses and strains during fabrication and operation [1,2]. The effects of stress and strain on the transport properties of BSCCO tapes have been studied because of their importance in practical applications [1]. It has been established that the Ic degradation is caused by the initiation of cracks in the superconducting filaments and the subsequent growth of these cracks. The improvement of the mechanical property and critical tolerance strain of BSCCO tapes have been achieved through various reinforcing processes such as adopting multi-filamentary tapes, by alloying the sheath material, and by reinforcing the tapes with metallic foil [3].

On the other hand, the rapid vaporization of LN_2 which diffuses through the defects of the sheath during operation when it was warmed up to RT causes a ballooning of the tape [3]. In order to prevent the ballooning damage, a densification method or a hermetic sealing of tapes have been used. In reference 4, the authors have reported on the accelerated pressurization tests of Bi-2223 tapes relating to the I_c degradation due to the ballooning.

In this paper, the electro-mechanical properties of ballooning-resistant BSCCO tapes have been fundamentally examined under tension and bending strains.

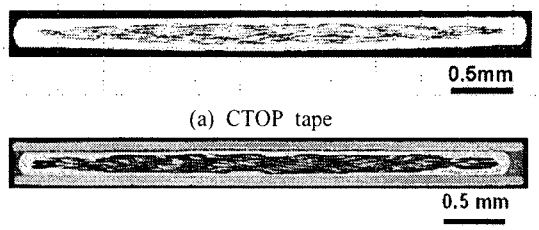
2. Experimental Procedure

Two kinds of commercially-available and ballooning-resistant Bi-2223 tapes were supplied which were fabricated using the powder-in-tube (PIT) process. The tape which has undergone the densification process by HIP has been designated as CTOP tape, and the one with hermetic sealing by soldering at both edges was designated as HST tape. Table 1 lists the properties of samples used and the cross-sections are shown in Fig. 1.

Tensile tests of both samples were conducted at 77K using a universal material testing machine (Shimadzu Autograph AG-IS: 5 kN) and Nyilas type double extensometers. Ref. 1 gives a full description on the test equipment used and procedures for the tensile tests and Ic measurements. For the bending tests, a ρ-shaped sample holder was used to apply bending strains at RT. The test procedures and set-up for the bending tests were described in Ref. [3].

Table 1 Specifications of Bi-2223 tapes

	CTOP	HST
Dimension (mm)	4.1 x 0.21	4.2 x 0.38
Ic at 77K (A)	123	147
Reinforcement material	Ag alloy	Brass
Reinforcement thickness (mm)	0.04	0.08
Multifilament bundle thickness	0.13	0.19



(a) CTOP tape

(b) HST tape

Fig. 1 Cross-sectional views of Bi-2223 tapes

3. Results and Discussion

Fig. 2 shows the tensile strain dependence of I_c. It can be seen that for the CTOP and HST tapes, the critical strain for 95% I_c retention are 0.36% and 0.43.%, respectively. The critical stress for 95% I_c retention, shown in Fig. 3, was derived for both tapes and it was 200 MPa for the CTOP tape and it was 245 MPa for the HST tape. The brass reinforcement of the HST tape made it possible to increase its critical stress and strains.

Fig. 4 shows the bending strain dependence of I_c. The HST tape showed a better bending strain tolerance as compared with the CTOP tape. The critical bending strain for 95% I_c retention are 0.9% and 0.51%. The bending strain at the outermost filament in both was also calculated. The critical strain at the outermost filament responsible for I_c degradation became lower for the HST tape and closer with that of the CTOP tape.

Even though it has been shown that the electro-mechanical properties of the CTOP tape was inferior to that of the HST tape, it should be noted that both these tapes are sufficient for practical applications because they have exceeded the mechanical requirements for the practical applications of these tape as given by Ref. [5].

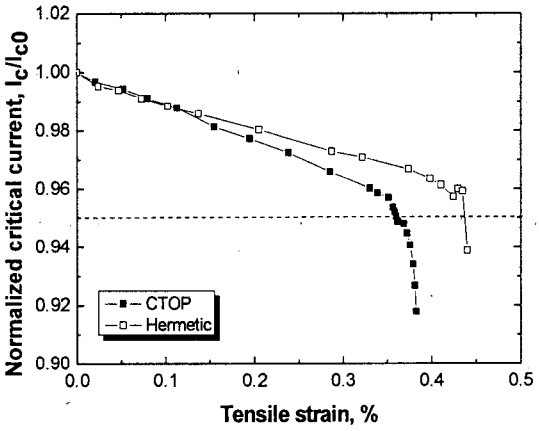


Fig. 2 I_c-ε_t dependence for both tapes.

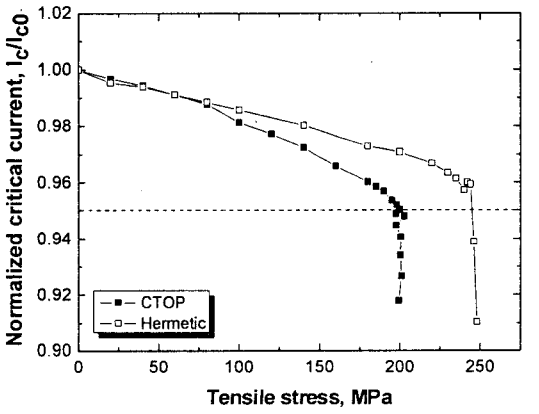


Fig. 3 I_c-σ_t dependence for both tapes.

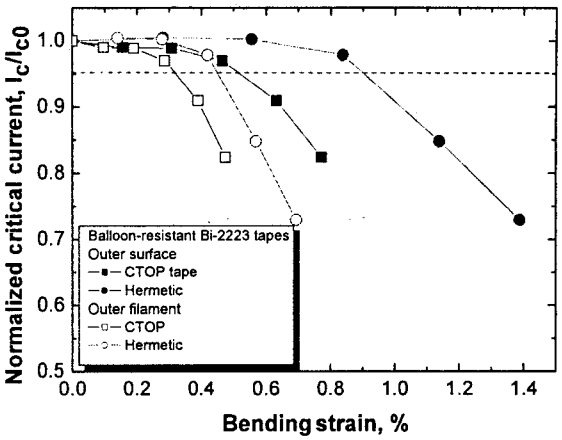


Fig. 4 I_c-ε_b dependence for both tapes.

4. Conclusion

The electro-mechanical properties of ballooning-resistant Bi-2223 have been examined. I_c-ε_b characteristics of Bi-2223 tapes were investigated. The reinforced hermetic tape showed higher tensile strength and better bending strain tolerance than the CTOP processed tape. In the same way under bending, the hermetic tape showed a higher bending strain tolerance than the CTOP tape. This higher strength of the hermetic tape can be attributed to the thick hardened copper reinforcement layer.

Acknowledgment

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 Science and Technology,

References

[1] H. S. Shin, and K. Katagiri, Supercond. Sci. Tech., vol. 16, p 1012, 2003.

[2] H. S. Shin, K. H. Kim, J. R. C. Dizon, T. H. Kim, R. K. Ko, S. S. Oh, Supercond. Sci. Tech., vol. 18, p S364, 2005.

[3] H. S. Shin, J. R. C. Dizon, H. Y. Choi, S. Kim, D. W. Ha, S. S. Oh, IEEE Trans. Appl. Supercond. Vol. 16, p.1051, 2006.

[4] H. S. Shin, J. R. C. Dizon, J. W. Cho, D. W. Ha, S. S. Oh, Proceedings of the KIEEME Annual Summer Conference, Vol. 7, 2006.

[5] J. Ekin, U.S. DOE, Annual Peer Review, Washington D.C., July 27-29 2004.