초전도 한류기를 이용한 Bi-2223/Ag 선재의 퀜치 보호를 위한 기초 연구

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Preliminary study on the quench protection of Bi-2223/Ag tape using superconducting fault current limiter

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Abstract : As an preliminary study for the quench protection of high temperature superconducting (HTS) cable using superconducting fault current limiter (SFCL), experimental research was carried out. The test circuit was composed of Bi-2223/Ag HTS tape and a SFCL made of YBCO thin films. In the normal state, the applied current of 56 A, which was critical current of HTS tape, could be flown through the circuit without resistive loss. Increasing the currents, the quench development of both materials was investigated from the voltage signal acquired from the resistance of the quenched superconductor. Up to around 10 times of the critical current was applied to the HTS tape and the current limiting characteristics of SFCL were investigated. In addition, for the finding out the optimal operating condition of SFCL such as the numbers of elements, a shunt resistor was applied to the SFCL and quench characteristics were analyzed as well.

Key Words : Bi-2223/Ag tape, quench protection, YBCO resistive type SFCL

1. Introduction

HTS tape and its applications demand special devices for the protection against a fault accident due to their large current capacity and peculiar electrical characteristics referred to as quench. In addition, considering high installation cost and complicate operation technology of HTS applications, they should be operated safely and protected perfectly not to be damaged. On the other hand, SFCL, which is a promising superconducting device for the protection of power grid, has been expected to be available for protecting HTS applications as well. In the normal state, SFCL can operate without resistive loss. However, if an fault accident happens, it limits the unexpected fault current rapidly within the safe current flowing range. In this study, we carried out the preliminary experiments for the investigation of the possibility to apply the SFCL to the protection of HTS applications as follows.

2. Experimental set-up

For the experiments, a Bi-2223/Ag tape and a resistive type SFCL composed of 3 piece of YBCO thin films were prepared. The HTS tape has a 56 A critical current and a

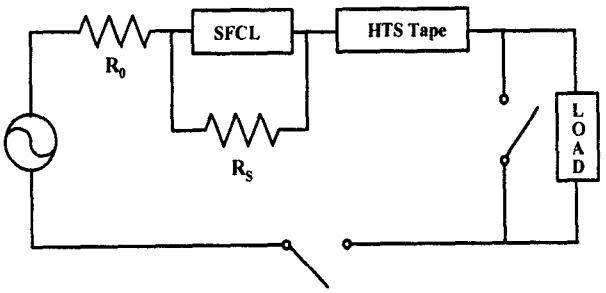

Fig. 1. Experimental set up consists of HTS tape and SFCL.

106 K critical temperature. The experimental circuit was setup as shown in Fig. 1. The critical current of the SFCL was adjusted to have the same value as that of the HTS tape. Applying the currents, which is beyond the critical current, to the circuit, the voltages generated by the resistance in both superconductor was measured simultaneously. Since the physical properties of both materials are quietly different, the quench development was investigated and analyzed separately from the V-I curves. Considering the voltage rating of SFCL acquired from the previous study, less than 100 V_{rms} was applied to the circuit [1]. In order to find out the appropriate condition for the application of SFCL to HTS tape, additional devices such as shunt resistors were applied and examined under various situation.

3. Results and discussion

Fig. 2 shows the quench development of the Bi-2223/Ag tape tested in this study. As the magnitudes of the AC currents increase, the resistance also increases fast. From the result of Fig. 2, the temperature increase due to Joule heating can be acquired. Moreover, the safe current flowing range of HTS tape that should be kept by SFCL can be identified from Fig. 2 as well.

When 40 V_{rms} was applied to the circuit in Fig. 3, the SFCL suppressed the fault current perfectly below the critical current of the HTS tape, therefore, the voltage signal was not detected at all in the HTS tape. However, according to the results acquired in Fig. 2, it can be considered that HTS tape is allowed to be safe with applied the over current which is even around ten times of the critical current. If this would be possible, the voltage rating of SFCL is also able to increase with adopted additional shunt resistor.

For confirming this assumption, a shunt resistor was added across the SFCL in parallel, and the fault currents were fed to the circuit. In Fig. 4, the V-I curves when 100 V_{rms} was applied to the circuit are presented. The fault current was suppressed below 256 A_p, however, it can be seen that HTS tape still maintains the safe operation according to the safety margin presented in Fig. 2.

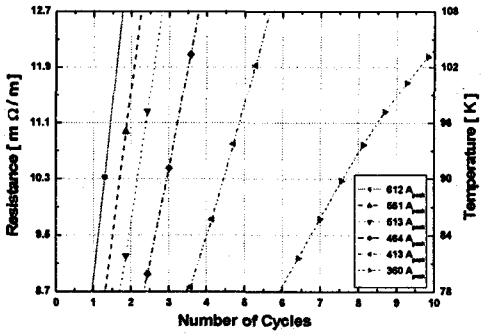

Fig. 2. Resistance increase with applied alternating over-current to the Bi-2223/Ag tape.

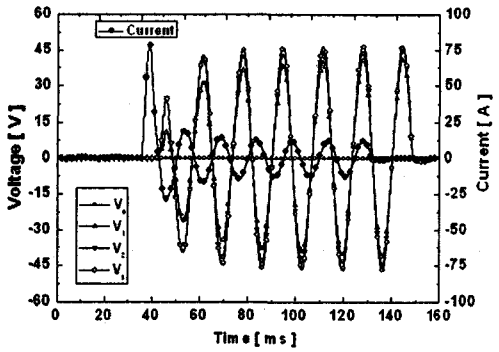

Fig. 3. Voltage-Current variation when 40 Vrms was applied to the circuit consist of HTS tape and SFCL

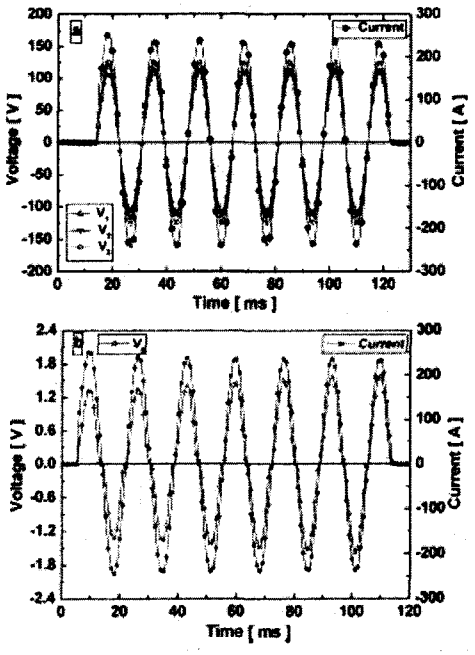

Fig. 4. V-I variation when 100 V_{rms} was applied to the circuit consist of HTS tape and SFCL with a shunt resistor. a) voltage variation of SFCL and b) that of HTS tape.

4. Conclusion

From the experiments of this study, it was concluded that SFCL will be available to protect the HTS tape against a fault current. In addition, according to the safety margin of a HTS tape, the voltage rating of SFCL could increase as well. Applying the results in this study, the power capacity of a SFCL would be able to be adjusted in the practical application. With the further study, the optimal value of a shunt resistor and the number of SFCL elements will be investigated in detail.

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References

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