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Magnetic microscopy for NbTi-Bi2223 superconducting joints impregnated with different PbSn-based solders

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LTSs have been widely used in superconducting magnet application such as NMR spectroscopy and MRI. For a breakthrough in high magnetic field generation, HTSs are inevitable. However, to realize a practical high field magnet system, a superconducting joint between LTS and HTS is a key component to realize persistent mode operation. It was reported that a superconducting joint between NbTi wire and Bi2223 tape can be fabricated via the in-situ sheath-dissolution method using PbSn-based solder. Critical current (I_c) of the joint was measured by four probe method, which is dependent on the solder composition [1]. However, the influence of the local superconducting property and a limiting factor of the joint are not yet clear from such macroscopic measurement. Furthermore, it should be clarified the superconducting property at extremely low electric field criterion equivalent to the persistent mode operation. In this study, we have investigated spatial distribution of local critical current density (J_c) in the joint based on magnetic microscopy, to clarify the influence with different solder composition.

The magnetization current distribution of two superconducting joints impregnated with $Pb_{0.7}Sn_{0.3}$ and $(Pb_{0.7}Sn_{0.3})Bi_{0.4}$ was evaluated respectively. As a result, J_c around the NbTi shows high performance, while the J_c of Bi2223 is low in both samples. Difference between the two samples can be observed as follows. Firstly, the J_c of $Pb_{0.7}Sn_{0.3}$ solder is lower than that of $(Pb_{0.7}Sn_{0.3})Bi_{0.4}$ solder. Secondly, the magnetization current can flow across both edges of the Bi2223 impregnated with $(Pb_{0.7}Sn_{0.3})Bi_{0.4}$, while there is almost no current observed in the Bi2223 impregnated with $Pb_{0.7}Sn_{0.3}$. In addition, we measure the J_c distribution along the longitudinal direction of the Bi2223, showing low J_c and poor joint with the $Pb_{0.7}Sn_{0.3}$ solder similar to the in-plane distribution.

In summary, by visualizing the J_c distribution based on magnetic microscopy, we can conclude that the difference between two samples comes from the different superconducting property of the solders and the performance of Bi2223-solder joint. Furthermore, Bi2223 tape is the limiting factor of I_c in both samples.

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[1] R. Matsumoto et al., Appl. Phys. Express, 10, 093102 (2017).