§16. Investigation of the Cross-sectional Configuration of Ag Sheath Material for High Strength Bi-2212 Superconducting Wire

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The key issues of the superconducting wire in the advanced fusion reactor beyond ITER are J_c improvement under the high magnetic field and higher mechanical strength for the large electromagnetic force. On the other hands, it is known that Y and Bi system high T_c oxide superconducting wires have higher J_c property under the high magnetic field above 20T compared with A15 compound superconducting wire as Nb_3Sn and Nb_3Al.

Especially, $Bi_2Sr_2CaCu_2O_x$ (Bi-2212) oxide superconducting wire is easy to make round-shape wire, so that Bi-2212 wire is easy to apply for the large Cable-in Condit (CIC) conductor of the fusion reactor. However, mechanical strength of the Bi-2212/Ag wire is remarkably lower than A15 compound superconducting wire because Bi-2212 compound is brittle material as a consequence of ceramic. In addition, the sheath material of the Bi-2212 superconducting wire must be used only Ag and/or Ag based alloy in order to obtain the high J_c performance.

In this study, we carried out reconsideration of the wire configuration of the Bi-2212 round wire to realize higher mechanical strength for the large electromagnetic force without decreasing of J_c performance.

Generally, mechanical strength of Bi-2212/Ag round wire can be improved by the making Ag-Cu and/or Ag-Mg alloy as sheath materials. Bi-2212/Ag round wire was heat-treated by the "partial melting-slow cooling process" because of the forming of highly c-axis oriented and dense microstructure. In the case of the investigation of the mechanical strength improvement in Bi-2212/Ag round wire, the composite material for high mechanical strength metal is required to higher melting point compared with Bi-2212 compound. We approached the higher mechanical strength of the Bi-2212/Ag round wire using the composite of the metal Ni-based alloy such as Cu-Ni. Furthermore, we also investigated the cross-sectional configuration to retain the Bi-2212 highly c-axis oriented structure using metal Ni composite. Fig.1 shows the conceptual wire configuration designs of the high mechanical strength Bi-2212/Ag round wire using Cu-Ni alloys. Sample A is the conventional Bi-2212/Ag round wire via Powder-In Tube (PIT) process. Sample B is the Bi-2212/Ag wire (Sample A) cladding the Cu-Ni alloy to the outer side of Ag sheath. Sample C is the multifilamentary wire composed of eight Sample B wires. Typical optical microscopic photographs of the cross-sectional area in Sample A and B are shown in Fig.2. These wires have 1.04 mm in diameter. In the both Samples A and B, it was suggested the good wire deformation without breaking of wire. Especially, we found that the abruption in the interface between Ag sheath and Cu-Ni clad material was not caused on Sample B. It suggested the good adhesion between Ag and Cu-Ni alloy. Fig. 3 shows that typical optical microscopic photographs of the cross-sectional area of Sample C. For the comparisons, Bi-2212/Ag round wires having eight filaments cladding metal Cu-Ni wire was also fabricated. We succeeded to fabricate Bi-2212 round wire having eight filaments cladding sample B. However, the irregular deformation of Bi-2212 oxide core was observed remarkably. This will be caused by the different criteria of stable wire deformation between Ag and Cu-Ni alloy.

In the future, we will investigate the change of the transport I_c property by the bending strain in the Bi-2212/Ag round wire cladding metal Ni and Cu-Ni.

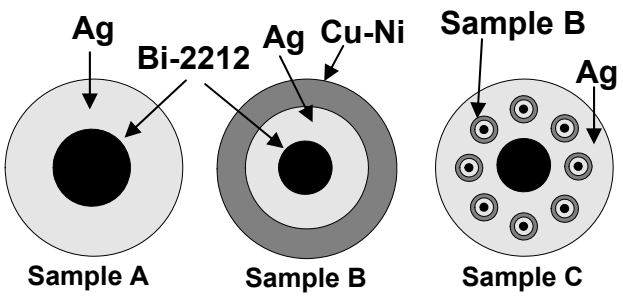

Fig. 1 Typical cross-sectional configuration of high mechanical strength Bi-2212 round wire using Cu-Ni alloys.

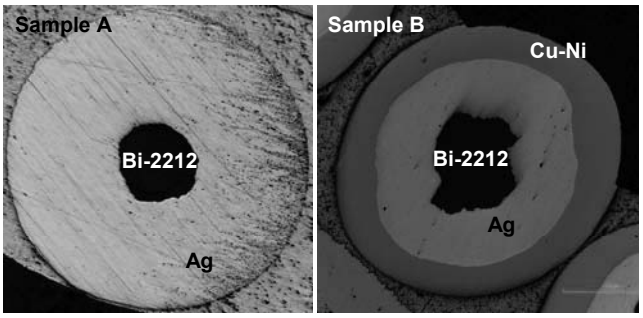

Fig.2 Typical optical microscopic photographs of the cross-sectional area on Bi-2212 mono-cored and Cu-Ni cladding round wires (Sample A and B).

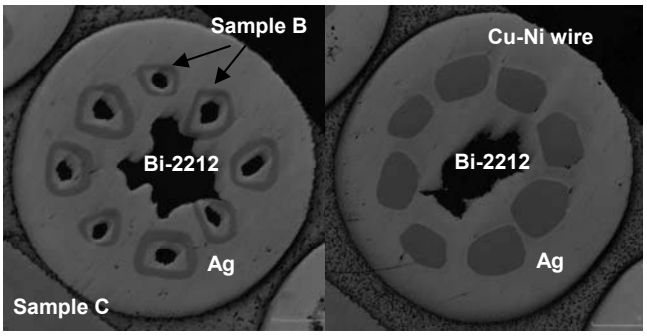

Fig.3 Typical optical microscopic photographs of the cross-sectional area on high mechanical strength Bi-2212 multifilamentary round wire using Ag/Cu-Ni and Cu-Ni wires.