WB5-1-INV

10 years beyond the 30th ISS: History and future prospects of Bi-2223 wires development

*Kenichi Sato[1]

Japan Science and Technology Agency[1]

Since the discovery of Bi-Sr-Ca-Cu-O (BSCCO) high temperature superconductors on Christmas Eve, 24th December, 1987 by Dr. H. Maeda, Sumitomo Electric has developed Bi-2223 superconducting wires. Among the BSCCO system, Bi-2223 ($Bi_2Sr_2Ca_2Cu_3O_{10}$) has the highest critical temperature of around 110 K. Bi-2223 has many features; not only high critical temperature but also non rare earth elements and well aligned crystals through thermo-mechanical deformation.

Based on collaborations with academia, wire properties were improved very much. Now, 200 A carrying and high mechanical stress tolerant wires are available at commercial basis (see Fig.). There are many daily operating apparatus incorporated with Bi-2223 wires such as current leads, cables and high field magnets, due to their electro-magnetic, mechanical and thermal performance, and industrial productivity for long length wires with an affordable economic point of view [1,2]. Wire performance could be improved further by decreasing anisotropy of crystals and introducing pinning centers [3].

[1] K. Sato, S. Kobayashi, and T. Nakashima: *Jpn. J. Appl. Phys.* **51** (2012) 010006.
[2] see"*Research, Fabrication and Applications of Bi-2223 HTS wires*", Ed. by Kenichi Sato, World Scientific, (2016).
[3] T. Nakashima, ibid., p. 17.

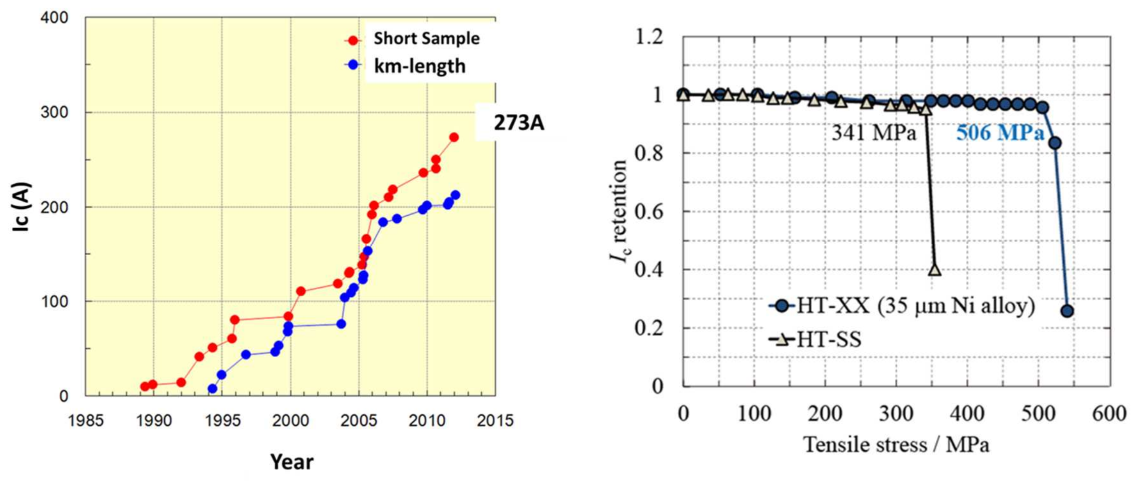

Fig. (a) Ic(77K, sf) improvements of Bi-2223 wire, (b) Mechanical strength of Bi-2223 wires.

Keywords: high temperature superconductor, Bi-2223, critical current, tensile strength

WB5-2-INV

10 Years Beyond the 30th ISS: History and Future Prospects of Bi-2212 Conductors

*Eric E. Hellstrom[1], Ernesto S. Bosque[1], Griffin Bradford[1], Michael Brown[1], Daniel S. Davis[1], Charles L. English[1], David K. Hilton[1], Imam S. Hossain[1], Jianyi Jiang[1], Fumitake Kametani[1], Youngjae Kim[1], David C. Larbalestier[1], Jun Lu[1], Evan Miller[1], George E. Miller[1], Yavuz Oz[1], Ulf P. Trociewitz[1]

Applied Superconductivity Center, National High Magnetic Field Laboratory, Florida State University, USA[1]

Bi-2212 was the first high temperature superconductor that demonstrated high-Jc in high-magnetic field. This was in 1989, but, it wasn't until 2014 that Bi-2212 became a viable long-length conductor when overpressure (OP) processing was applied. OP processing removes the large, current limiting bubbles in powder-in-tube round wire. Bi-2212 is the HTS material that can be produced as a round wire, which gives it many advantages, including: it can be made in long lengths (BOST has drawn 2400 m long 0.8 mm diameter single piece lengths), it can be used as a round wire, or it can rolled to a slightly aspected rectangular shape, which are both geometries magnet designers and builders prefer; it can be cabled (Rutherford and twist cables, such as 6-on-1), it can be made with a wide variety of multifilament wire architectures, it can be twisted and transposed, and it is electromagnetically isotropic. With OP processing, Jc in short length wire samples is now 6860 A/mm2 (4.2 K, 15 T). Challenges for using Bi-2212 wire in magnets are that it has to be used in a wind and react magnets, it requires an OP heat treatment (~900 °C, 50 atm total pressure), the wire is mechanically weak, and the wire is expensive. Methods to deal with these challenges are being developed. We have OP processed a variety of single strands, cabled conductors, and coils made with single strand and with Rutherford cable for the Bi-2212 community. Future applications for Bi-2212 coils are in high-field NMR magnets, in accelerators for high-energy physics, and as replacement inserts in existing LTS laboratory magnets to upgrade the field achievable in these magnets.

Keywords: Bi-2212, High temperature superconductors, High-field magnet, Round wire conductor

WB5-3-INV

History and future prospects of MgB_2 and iron based superconducting wires

*Hiroaki Kumakura[1]

National Institute for Materials Science[1]

MgB_2 wires have been developed by applying powder in tube(PIT) method and Internal Mg diffusion (IMD) method. One of the key factors that govern J_c values of MgB_2 wires is the MgB_2 core density. Applications of high pressure such as hot pressing, cold pressing and hot isostatic pressing have been successfully carried out to increase the MgB_2 core density and J_c values. However, these methods are not practical for large scale fabrication of MgB_2 wires. Other effective methods to increase MgB_2 core density and J_c values are mechanical milling of Mg and B powder mixture and mechanical working with swaging. IMD process has also been studied and higher MgB_2 layer density and higher J_c values than those of PIT wires are realized. However, $J_c(J_e)$ values of all these MgB_2 wires are still not high enough for applications at around 20K and ~5T. Much higher J_c values of MgB_2 thin films suggests that practical level $J_c(J_e)$ values can be realized by reducing the MgB_2 grain size, eliminating impurity phases and introducing pinning centers.

Among various iron-based superconductors, $(Ba(Sr),K)Fe_2As_2$(Ba(Sr)-122) are potentially useful for high field(>25T) applications due to their high B_{c2} over 50T and small anisotropy. Ba(Sr)-122 wires have been fabricated with *ex situ* PIT method. Besides Ba(Sr)-122 core density, c-axis grain orientation seems to be another key factor for high J_c values. Applications of high pressure improve the core density and c-axis grain orientation. Mechanical working with hard sheath materials is also effective in increasing the core density and c-axis grain orientation. However, present Ba(Sr)-122 wires show lower J_c-B properties than those of high-T_c oxide superconducting wires. Further increase of Ba(Sr)-122 core density, refinement of grain boundaries and introduction of pinning centers will realize practical level J_c values at high fields.