**Ceramic Insulation of Bi-2212 Round Wire for High-Field Magnet Applications**

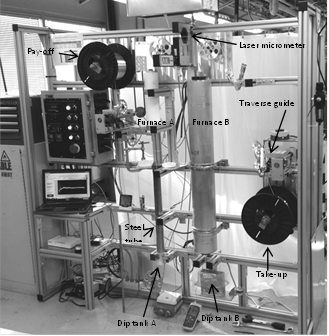
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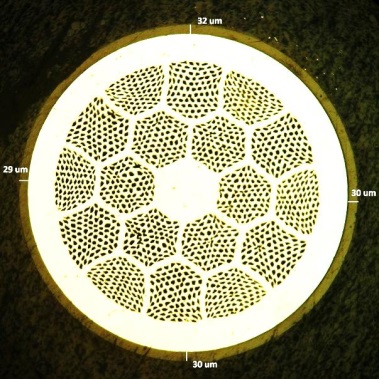
**Introduction**

Among technologies necessary for Bi-2212 application in magnets, development of insulation technology is critically important and particularly challenging because, in the wind-and-react process, the insulation has to be applied before heat treatment and it must maintain its integrity during heat treatment up to 890 °C in 1 bar oxygen. Compared with the conventional insulation, ceramic coating insulation is preferred due to its achievable thin thickness [1]. In this work, we developed a ceramic dip-coating slurry as the coating application method and built a facility to coat several hundred meter lengths. We faced significant technical challenges but overcame them.

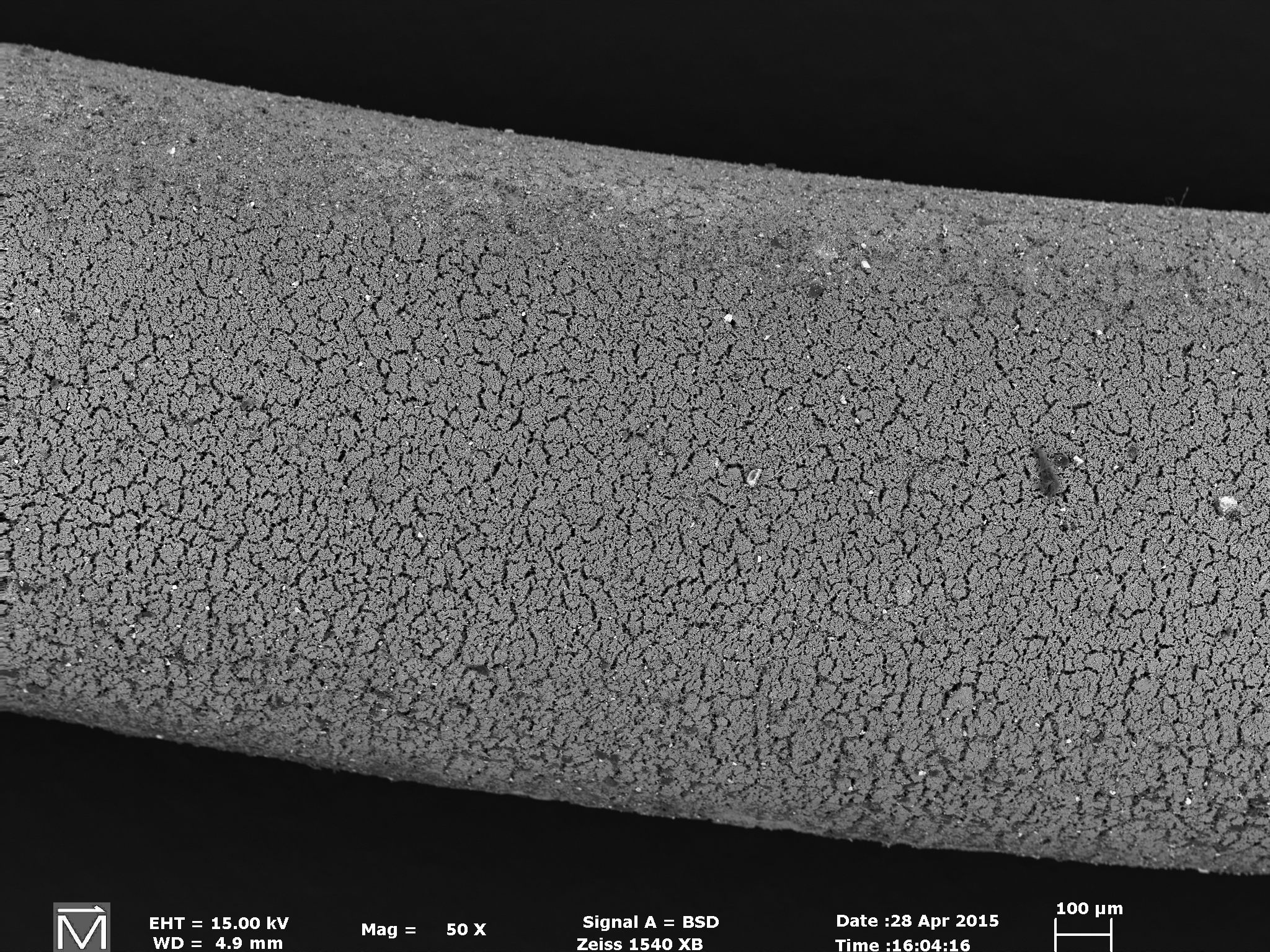
**Experimental and Results**

The ceramic dip coating consists of TiO2 nano-powder, polymer binders and other additives. It is applied by machine (Fig. 1) with a controlled, uniform thickness between 10 and 30 m (Fig. 2). The coating is strongly bonded to the wire and reasonably flexible in the as-applied (green) state, so magnet coils can be wound without cracks or spalling. The Bi-2212 heat treatment allows the coating to sinter which provides reliable ceramic insulation (Fig. 3). A few lengths of Bi-2212 wire including one over 750 m were insulated for our Bi-2212 high-field magnet development program.





200 m



200 m

Fig. 3 Insulated wire surface after heat treatment. The small cracks help oxygen permeation during heat treatment which is beneficial to wire properties.

Fig. 1 Ceramic insulation dip-coating system developed in this work

Fig. 2 Insulated green wire cross-section

**Discussion**

We observed that freshly coated wires are significantly more flexible than those stored for a week or two, which tend to age and to crack. We do not yet understand this aging effect. After heat treatment, a wire with 25 - 30 m green coating densifies to 15 - 20 m coating with a typical breakdown voltage of 300 - 400 V. This is consistent with our previous results [1], and sufficient for a magnet coil turn-to-turn insulation. However, there is some evidence that insulation integrity can be compromised after a heat treatment during which wires are under large contact pressure. This issue is still under investigation.

**Conclusions**

We developed a ceramic formulation suitable for dip coating insulation of Bi-2212 round wire. Over 1.5 km of Bi-2212 wires have been insulated using this technique.

**Acknowledgements**

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**References**

[1] H. Kandel, et al., Supercond. Sci. Technol. **28**, 035010, (2015).

[2] J. Lu, et al., Oral presentation, MT-24 conference, Seoul, Korea, Sept. 2015.