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SOL-GEL INSULATION OF Cu/MgB_2 WIRES

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ABSTRACT
In this study, preparation and morphology of ceramic insulation coatings on Cu/MgB2 wires were investigated. Ceramic insulations were prepared using solutions of Y and Zr based organometallic compounds. Sol-gel Y_2O_3-ZrO_2 ceramic coating has been successfully applied to Cu/Mgb_2 wires by reel-to-reel continuous sol-gel dip coating system. The film thickness was controlled by number of coating, withdrawal speed and solution chemistry. The surface morphologies and microstructure of Cu/MgB_2 wires were characterized by Scanning Electron Microscope.

Keywords: MgB_2 wire, Sol-gel, Y_2O_3-ZrO_2, Insulation

1. INTRODUCTION
The interest of MgB_2 conductor is growing day by day due to its potential usage in numerous low field applications such as the Magnetic Resonance Imaging (MRI), transformers, generators, underground transmission cables and superconducting coil.

One of the most important parts of the low field applications is insulation, which is made from standard quartz by a vacuum impregnation with a resin, ZrO_2 and/or ZrO_2 based ceramic coating [1]–[3]. ZrO_2 based ceramic coating were studied by using various method such as spray pyrolysis, electron beam evaporation, plasma spray, sol-gel, and chemical vapour deposition. Among these methods the sol-gel methods have advantages which are low cost, long length, low temperature process, better homogeneity and simplicity.

In this study we have investigated processing, characterization and sol-gel parameters such as solution properties, withdrawal rate, drying, heat treatment, annealing condition of the Y_2O_3-ZrO_2 insulation coating on Cu/MgB_2 wires using reel-to-reel sol-gel system.

2. EXPERIMENTAL PART
The Y_2O_3-ZrO_2 (YSZ) solutions were synthesized by sol-gel process. Yttrium acetate was dissolved in isopropanol and glacial acetic acid, acetyl acetone and appropriate amount of Zirconium tetrabutoxide were added at room temperature to this solutions and then mixed with a magnetic stirrer.

The details of the preparation of YSZ solutions were discussed in the previous studies [2,3].

The monofilament MgB2 wires, 1m in length, 1 mm in diameter, which were manufactured from Mg and B powder by using PIT method. Cu/MgB2 samples were cleaned by using chemical method.

Y_2O_3-ZrO_2 insulation coating was grown with sol-gel continuous dip coating system by using vertical 3-zone furnaces as shown in figure 1.

Furnace zone temperatures can be adjusted to between 450 and 650 °C from bottom to the top.

Surface morphology, thickness and stochiometry of coating films were observed by using the Scanning Electron Microscope (SEM, Jeol-5910LV) and the Energy Dispersive Spectroscopy (EDS).

Figure 1. The sol-gel coating system.

3. RESULTS AND DISCUSSION

Short samples of about 10 cm in length were cut from Cu/MgB2 wire.

Short samples were cleaned by wiping them with a tissue paper containing dilute nitric acid solution and then cleaned again by wiping with a tissue paper soaked in acetone.

Figure 2 shows that cleaning treatment were removed all of contaminants successfully at the surface of Cu/MgB2 wire. These MgB_2 wire samples were dipped into the YSZ solution and then pulled through the three-zone vertical furnace as shown in the figure 1.

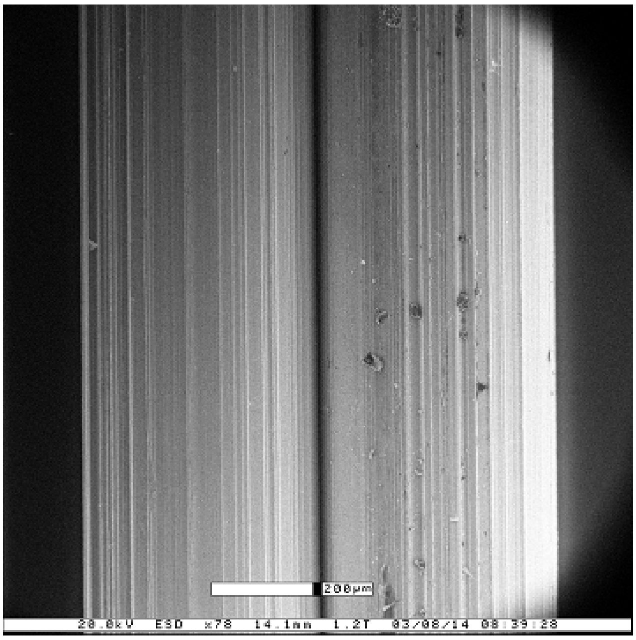

Figure 2. SEM micrographs as received (right)and after cleaned (left) MgB_2 wires

The film thickness was controlled by number of coating, withdrawal speed, and solution chemistry as in Table 1.

Figure 3 shows typical SEM micrograph of the surface of sol-gel insulated Cu/MgB2-4 wire sample.

The scale bars are 200 and 20 and 10 µm, in a, b and c respectively.

Table 1. Parameters of the sol-gel insulation experiment on MgB_2 wire samples as listed

Sample ID	Coating Material	Number of Coating	$T_{Furnace}$ (°C)	Withdrawal Speed(m/min)	$R_{Insulation}$ (Ω)
Cu/MgB2-1	Y_2O_3-ZrO_2	10	450,500,550	0.65	$3.2x10^{10}$
Cu/MgB2-2	Y_2O_3-ZrO_2	10	450,500,550	0.65	$4.0x10^{9}$
Cu/MgB2-3	Y_2O_3-ZrO_2	6	450,500,550	0.81	$2.94x10^{11}$
Cu-MgB2-4	Y_2O_3-ZrO_2	3 4 3	450,500,550 500,550,580 450,500,550	0.81	$3.6x10^{11}$

4. CONCLUSIONS

Cu/MgB_2 wires were coated by Yttrium-Stabilized Zirconia (Y_2O_3-ZrO_2) using reel-to-reel continuous sol-gel dip coating system.
The thickness of the film coating increases when the number of dipping, withdrawal speed, and insulation density are increased.
When the coating thickness is increased, cracks are started to occur.
To prevent cracks dilute solution and low withdrawal speed was used.

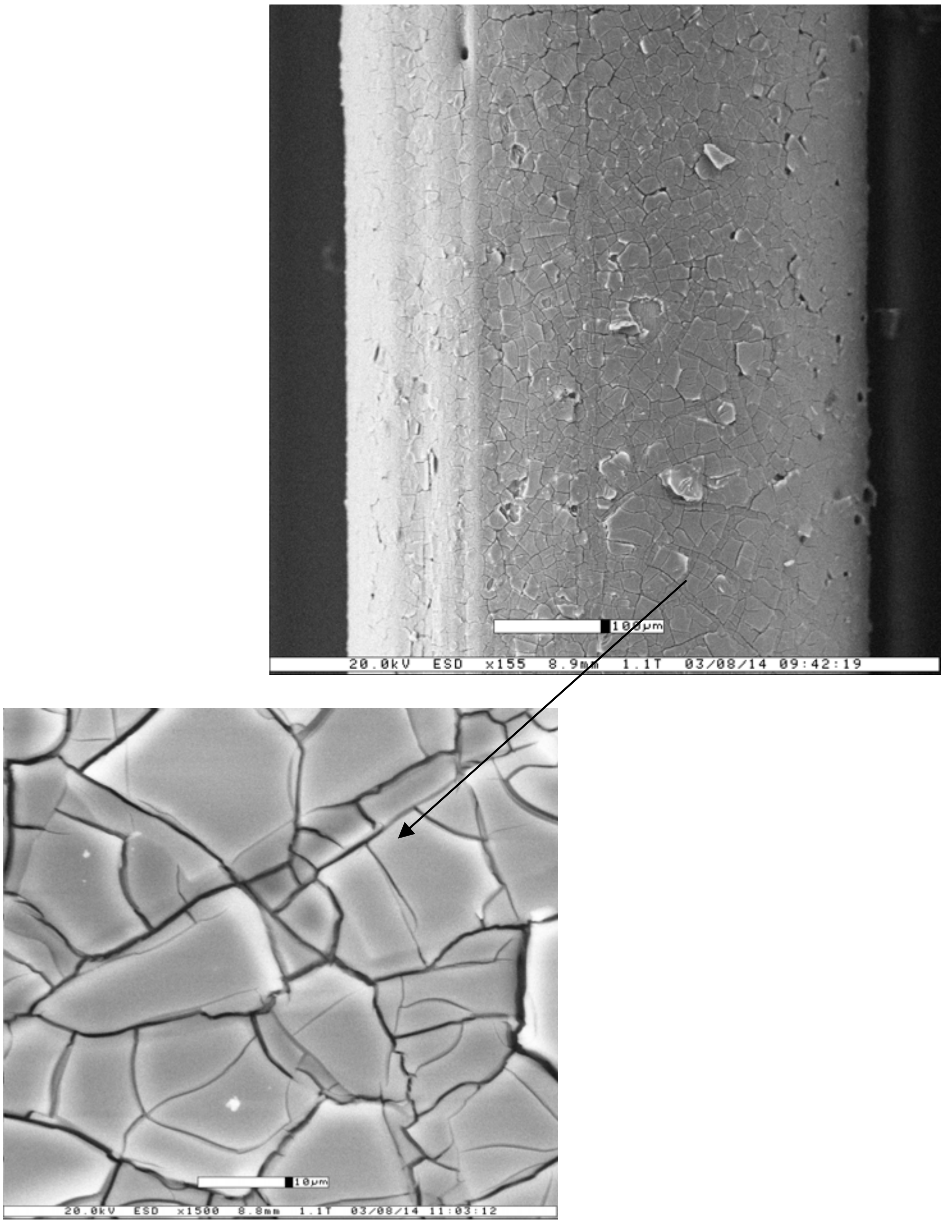

Figure 3. Typical SEM micrograph of the surface of sol-gel insulated Cu/MgB2-4 wire sample. The scale bars are 200 and 20 and 10 μm, in a, b and c respectively.

Acknowledgements
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5. REFERENCES

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