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TWISTED MgB_2 SUPERCONDUCTING WIRE FOR POWER TRANSMISSION APPLICATIONS

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ABSTRACT
Cu/MgB2 superconducting wire which was 500 mm in length, 0.5mm in diameter was insulated by using reel-to-reel sol-gel dip coating system for underground transmission cables. After coating the Cu/MgB_2 superconducting wire, three 120 mm long samples were cut from it. These samples were loosely braded and then twisted by applying different forces to the cable to investigate microstructural properties of the twisted Cu/MgB_2 superconducting underground transmission cables. Microstructure properties of prepared samples were observed by using environmental scanning electron microscope. The surface morphologies of Cu/MgB_2 wires before ~~twisting~~ and after twisting are presented.
Keywords: Insulation, MgB_2 wire, twisted transmission cable

1. INTRODUCTION
The high temperature and low temperature superconductors are promising candidate for Magnetic Resonance Imaging (MRI), transformers, generators and underground transmission cables. Especially for the transformers and generators which are used on the board of vessels and aircrafts. In these applications, the weight of the cable is a concern, as is the lightest practical superconductor [1]–[3]. Various superconducting and standard high voltage DC materials are used for underground transmission cables. Among them, the binary compound magnesium diboride (MgB_2) have a lot of advantages, such as: the lack of resistive power losses, low visual impact on the landscape, low electromagnetic fields and smaller environmental footprint.
The aims of the present work are: to grow crack free, pinhole-free, uniform ceramic insulation coating on the Cu/MgB_2 wires by using reel-to-reel continuous sol-gel dip coating system; to prepare twisted Cu/MgB_2 superconducting underground transmission cable without damaging insulation coating.

2. EXPERIMENTAL PART
Cu/MgB_2 superconducting wire, 500 mm in length, 0.5mm in diameter which was manufactured from pure Mg and B powder with the stochiometric composition using Cu sheet metal, was cleaned by using ultrasonic cleaner in dilute HNO_3 solution and then pure acetone. Figure 1 shows SEM micrographs of the surface of samples as received and after cleaned. The Y_2O_3-ZrO_2 solutions were synthesized by sol-gel process as explained in ref. [3]

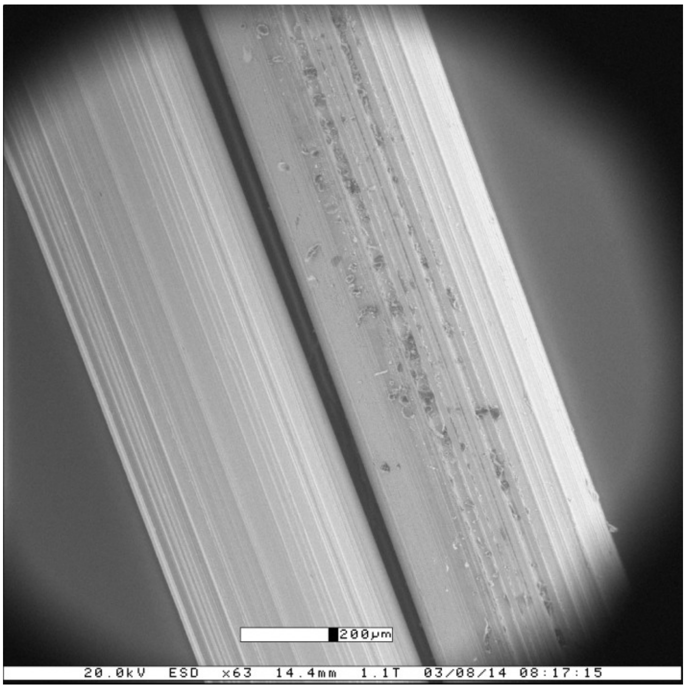

Figure 1: ESEM micrographs as received (right) and after cleaned (left) MgB_2 wires

Y_2O_3-ZrO_2 insulation coating was grown with continuous sol-gel dip system by using vertical three-zone furnace. The insulation coating thickness on the wire was controlled by the withdrawal speed, the number of dipping and the dilution of the solution. Process was repeated several times in order to achieve a dense and uniform insulation coating for the desired thickness.
Surface morphology, thickness and stoichiometry of insulation coating were observed by using the Environmental Scanning Electron Microscope (ESEM, electro scan model E-3 and Jeol-5910LV), and the Energy Dispersive Spectroscopy (EDS).

3. RESULTS AND DISCUSSION

Figure 2 depicts surface morphologies of sol-gel insulated before twisted Cu/MgB_2 wire. Sizeable grooves were observed on the wires probably as a result of wire drawing process. The insulation coating looks uniform over the grooves and ridges. Some of the ridges appear to be sharp even after the coating as shown in the Figure 2. This may cause problems during the twisting of the cabled MgB_2 conductors.

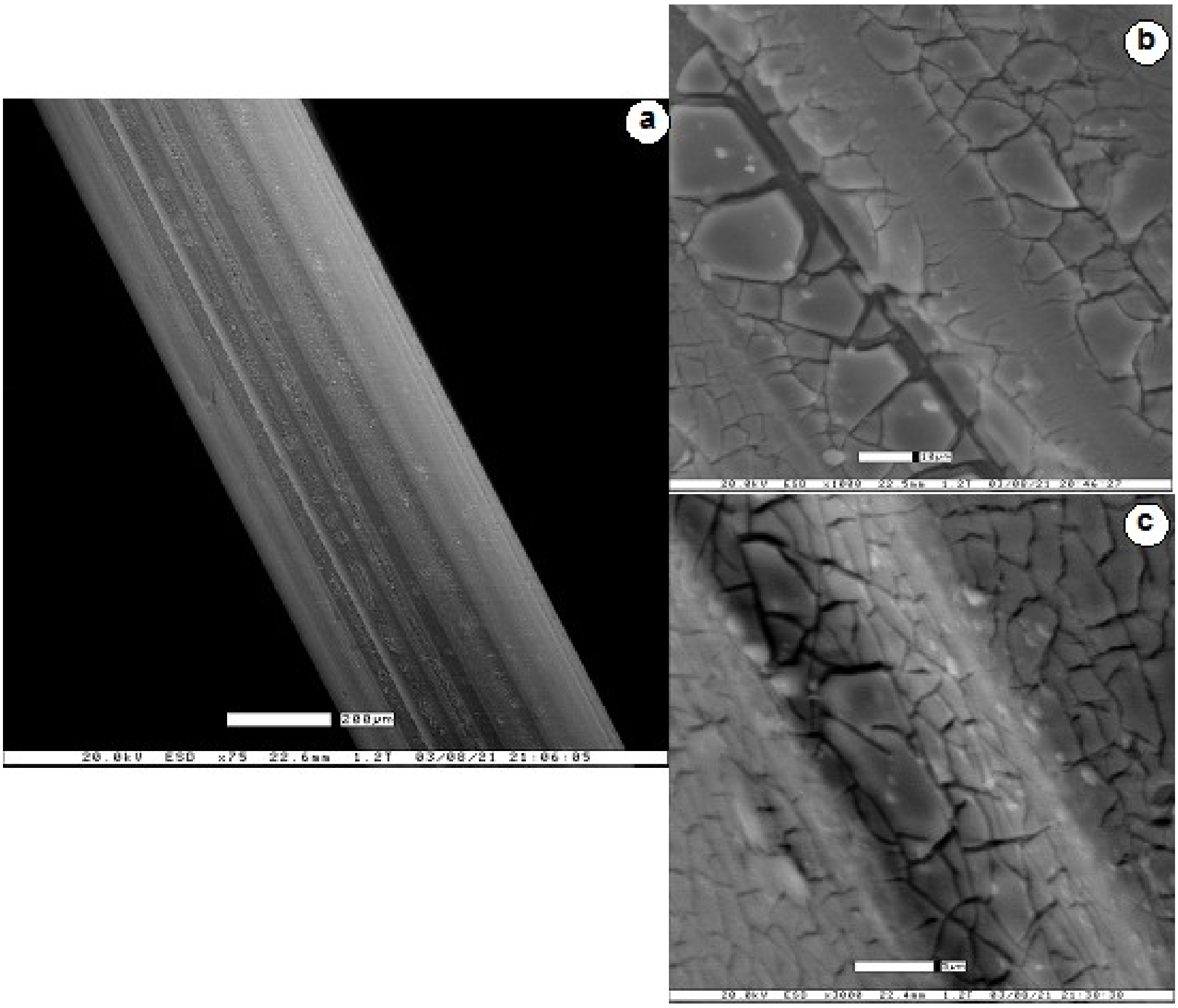

Figure 2: ESEM micrographs of the surface of sol-gel insulated before twisted wire. The scale bars are 200, 10, and 5 µm, in a, b and c respectively.

Figure 3 shows the ESEM micrographs of twisted Cu/MgB_2 wires.
As it is seen from the figure 3b as twisted right wires, surface is fairly smooth and there are maze of cracks running through the surface most likely due to drying stresses.
In figure 3c (as twisted left wires) and 3d (as twisted middle wires) the insulation was damaged.

4. CONCLUSIONS

Yttrium-Stabilized Zirconia (YSZ) ceramic insulation was coated on the Cu/MgB_2 superconducting wire using reel-to-reel sol-gel dip coating system.
The thickness of the insulation coating increases by increasing the number of dipping and withdrawal speed.
When the applying force is increased to twisted Cu/MgB_2 wire, cracks are started to occur and insulation coating is damaged. To prevent cracks and damage dilute solution was used and applied forces was decreased.

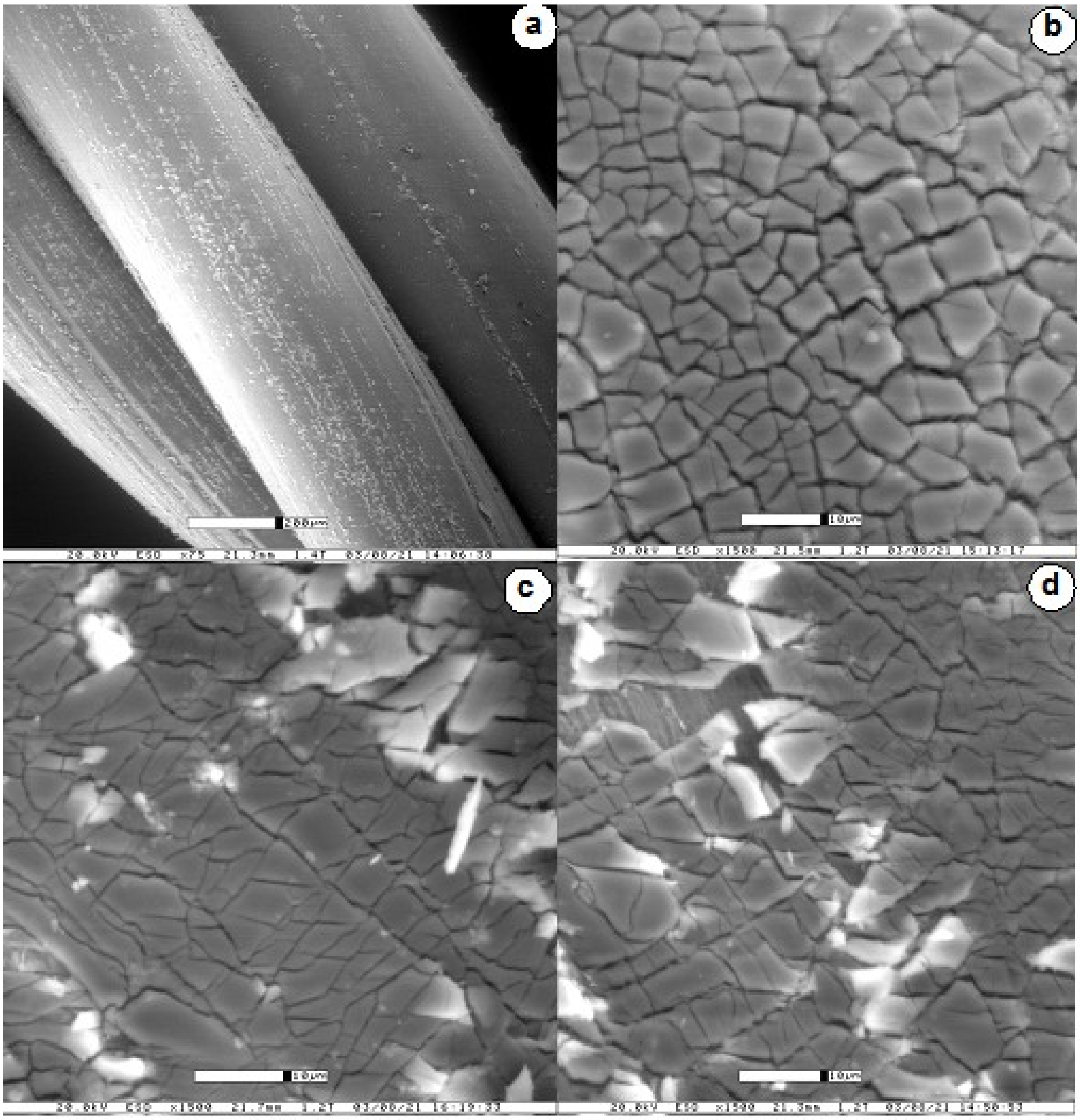

Figure 3. ESEM micrographs a) as twisted MgB_2 wires, b) high magnification of as twisted right wires, c) high magnification of as twisted left wires, d) high magnification of as twisted middle wires. The scale bars are 200, 10, 10 and 10 μm, in a, b, c and d respectively.

Acknowledgements
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5. REFERENCES

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