STRESS-STRAIN RELATION OF Bi2Sr2CaCu2Ox/AgMg SUPERCONDUCTING ROUND WIRES BASED ON FRACTAL CHARACTERIZATION OF THE ROUGH SURFACES OF INDIVIDUAL FILAMENTS

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Summary Bi2Sr2CaCu2Ox/AgMg (Bi2212) multi filamentary superconducting round wires (RWs) can be only potential candidate for constructing the superconducting magnet with higher magnetic field (>25T). Very complicated microstructure of Bi2212 RWs has been found by recent SEM studies, and then the vital problems of Characterization of this unique microstructure and further exploration of the correlation of macro electromechanical properties with this microstructure arise. In this paper, it is firstly found that the rough surface of individual filaments can be well characterized by fractals. On the geometrical model with the fractal simulation of the rough surface, stress-strain relation of Bi2212 RWs has been investigated. The modeling result with considering the rough surface has a better agreement to the experimental data.

FRACTAL CHARACTERIZATION OF THE ROUGH SURFACES OF INDIVIDUAL FILAMENTS

As we know, Bi2212 multi-filaments round wires are composed of Bi2212 superconducting filaments, Ag matrix, and Ag alloy sheath. As shown in Fig.1, after heat treatment, the microstructure of Bi2212 RWs is very irregular. For an individual filament, its surface is changed to be very irregular and jagged [1, 2].

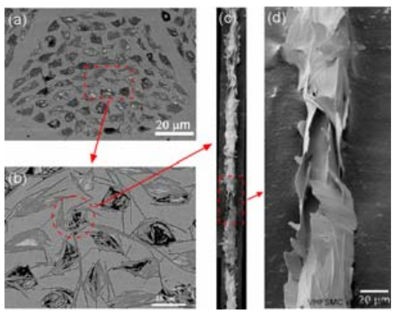

Fig. 1. The representative SEM images of the microstructure of Bi2Sr2CaCu2Ox/AgMg multi-filaments after heat treatment. (a) A small part from the cross-section of Bi2212 Round wires; (b) A smaller local part enlarged from the (a) (surrounded by a red rectangle); (c) A whole individual Bi2212 filament extracted from the Bi2212 composite structure (marked by a red circle); (d) A small part enlarged from the (c) (also surrounded by a red rectangle).

Pre-processing of the SEM images of an individual Bi2212 filament

For the SEM image of an individual Bi2212 filament, to obtain the distinct boundary outline of the filament, some image pre-processes are conducted (Fig. 2).

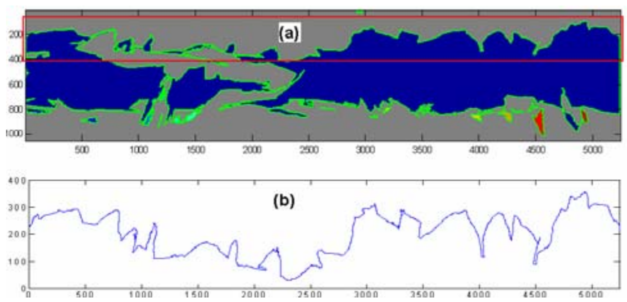

Fig. 2. The pre-process of the SEM image of an individual Bi2212 filament and extraction of its boundary profiles. (a) The whole boundary profile of the Bi2212 filament (green line); (b) Just the upper boundary profile is picked up (surrounded by a red rectangle in (b)).

Power spectrums of the profile of the rough surface of an individual Bi2212 filament

For a rough surface, the height distribution can be statistically characterized by its power spectrum [4]. If the relation of the power spectrum with the frequency follows the power-law relation (or the log-log plot of the power spectrum versus the frequency follows linear relation), one can conclude that the height distribution of this rough surface is scale

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invariance, or fractal. Further, the fractal dimension can be calculated from the relation of the power spectrum with the frequency [5].

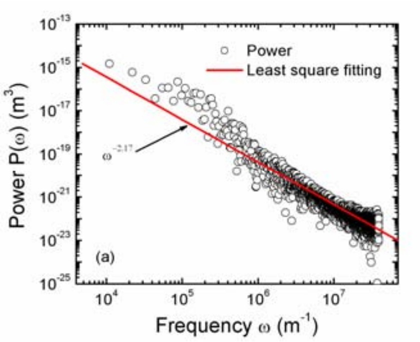
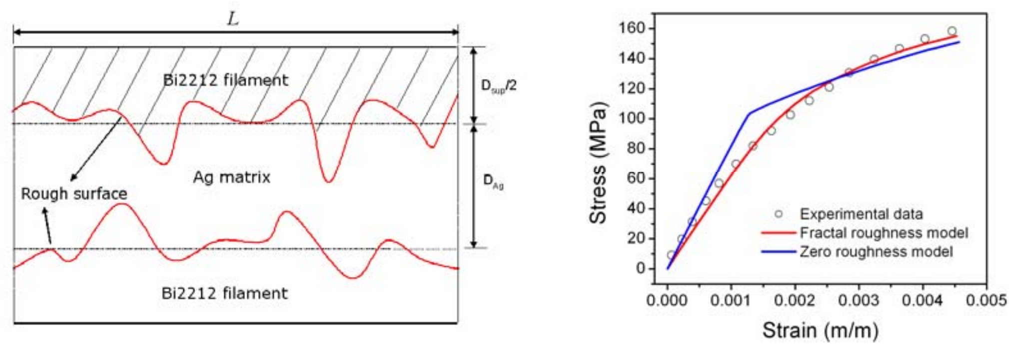


Fig. 3. Power spectrums of the profiles of rough surfaces of Bi2212 filament. The least square fitting to the scattered data was carried out and shown by red lines.

STRESS-STRAIN RELATION OF Bi2212 RWS

On the fractal characterization of the rough surface of the Bi2212 filament, considering its symmetry of the microstructure, we present the geometrical fractal model with the Weierstrass-Mandelbrot (W-M) fractal function [3] simulation of the rough surface (Fig. 4).



(a) (b)

Fig. 4. (a) The schematic of fractal geometry model of Bi2212/AgMg structure; (b) Comparison of stress-strain of Bi2212 RWs based on fractal roughness and zero roughness models with experimental one

Base on the geometrical model, the finite element method (FEM) modeling has been carried out. Comparison result shows that the modeling result on considering the rough surface of the filaments is much closer to the experimental data.

CONCLUSIONS

In this paper, we presented a theoretical frame which enables us to study the correlation of macro properties of the Bi2212 RWs with its micro structure. After the stress-strain relation modeling on the fractal geometrical model has been carried out in this paper, hopefully, this theoretical frame will be developed, and more mechanical or electromechanical behaviors of the Bi2212 RWs will be investigated in the future.

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