Vortex pinning change caused by external stress/strain in REBCO coated conductor

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Introduction

In the quest of ultra-high-field magnet, one inevitable challenge for the conductor is the increasing electromagnetic forces alongside. How the conductor behaves under stress/strain is a big issue for the magnet. $REBa_2Cu_3O_{7-x}$ (REBCO) coated conductor has become popular in recent years because of its good transport properties in high field. Actually, it was the addition of artificial pinning centers (APCs) that improved its in-field performances. Meanwhile, the internal stress/strain of REBCO lattice is also increased due to the APCs. It has been known that transport I_c of REBCO can be affected by external strains, and is reversible as long as the external strain is within certain range. [1] However, the relation between vortex pinning properties and the external strains is not well understood, especially, how permanent changes of vortex pinning properties can be made by external strains. This study aims to answer these questions and analyze the potential challenges for the application of REBCO coated conductor in ultra-high-field magnets.

Experimental

Position dependence of I_c ($I_c(x)$) of REBCO tape manufactured by SuperPower was measured by YateStar in LN_2.[2] After the measurement, 5 pieces of 16 cm long REBCO tapes were cut out and tested under 0.2%, 0.4%, 0.6%, 0.8% and 1.0% strain, respectively. The stress-strain tests were done by free-standing sample with an extensometer in the machine 100 kN MTS – *The Workhorse*. Then all the tested tapes were soldered together and run through YateStar again for $I_c(x)$ and angular I_c ($I_c(\theta)$) measurements. Lastly, small pieces with 4 × 4 mm in size were cut out from the middle of the 5 samples and measured in SQUID for their critical temperatures (T_c).

Results and Discussion

The top panel of Fig. 1a shows the magnetization map of the 5 samples after being tested under different strains and the bottom panel is the corresponding transport measurement result with B||*ab* and B||*c*, 0.6T. The irreversible strain is between 0.6% and 0.8%. The sample strained to 1.0% almost lost all its superconductivity. Fig. 1b shows the angular I_c of the samples at 77 K, 0.6T before and after the strain tests. The featuring peak of $BaZrO_3$ (B||*c*) disappears for the sample strained to 0.8%. The other 3 samples that were strained to 0.2%, 0.4% and 0.6% have no change of their transport properties after the tests. Fig. 1c shows the magnetization versus temperature (M(T)) of short pieces from the 5 samples with zero field cooling and 10 Oe field applied during warming. All the samples have very similar T_c except the one strained to 1.0%. Its T_c has been lowered by ~1 K. These results indicate that the vortex pinning change happens before the T_c change. Further investigation about the microstructures is needed for a full understanding.

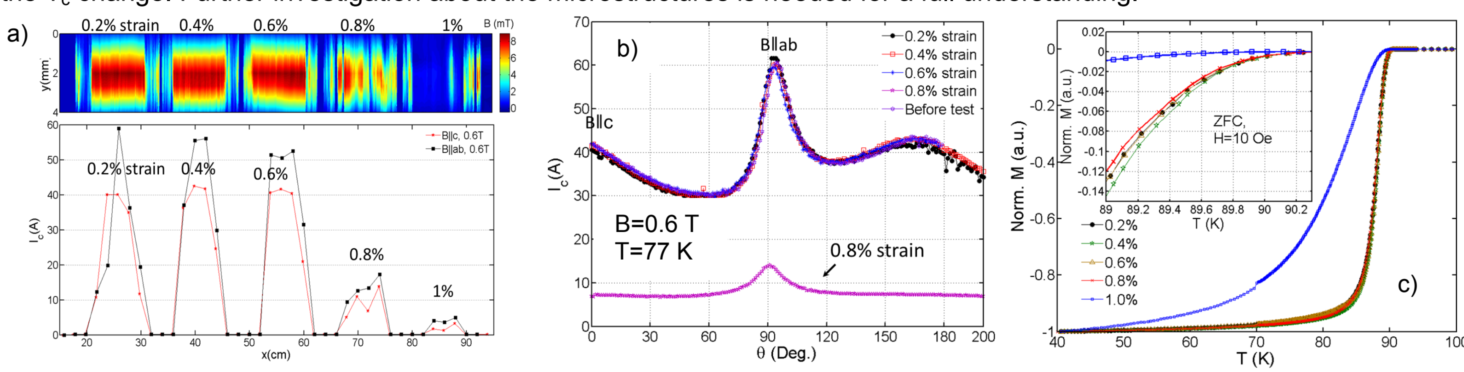

Fig.1. a). Top: 2D magnetization map of the 5 tapes after mechanical tests; bottom: $I_c(x)$ measured with B||*ab* and B||*c*, 0.6 T. b) $I_c(\theta)$.measured at 77 K, 0.6T. c) Normalized magnetization versus temperature, zero field cooling (ZFC), H=10 Oe. The insert figure is an enlarged view around the transition.

Conclusions

The mechanical and transport tests of Zr-doped REBCO coated conductor confirmed that external strains can cause vortex pinning change in the conductor.

Acknowledgements

This work was supported by the the NSF Cooperative Agreement No. 1644779 and the State of Florida.

References

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[2] Hu, X., *et al.*, IEEE Trans. Appl. Supercond. **27** 1–5 (2017).