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Research on the Health Monitoring of HTS Tape Using Fiber Bragg Grating Sensors

fiber

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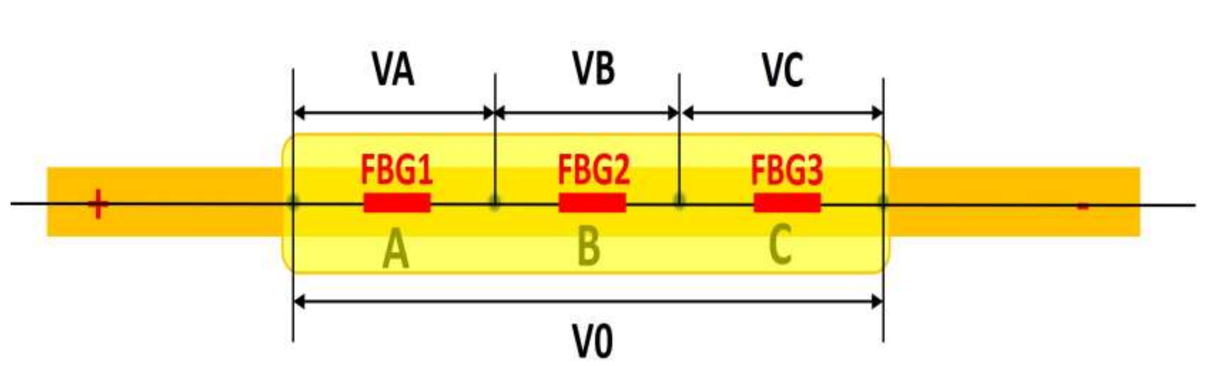
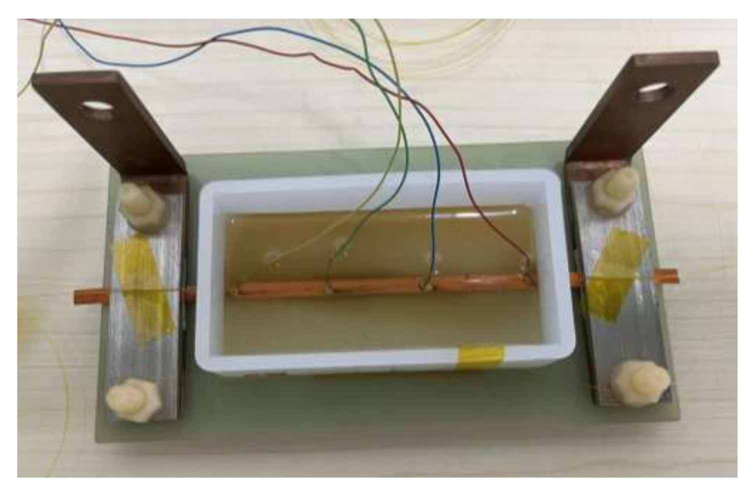
Introduction

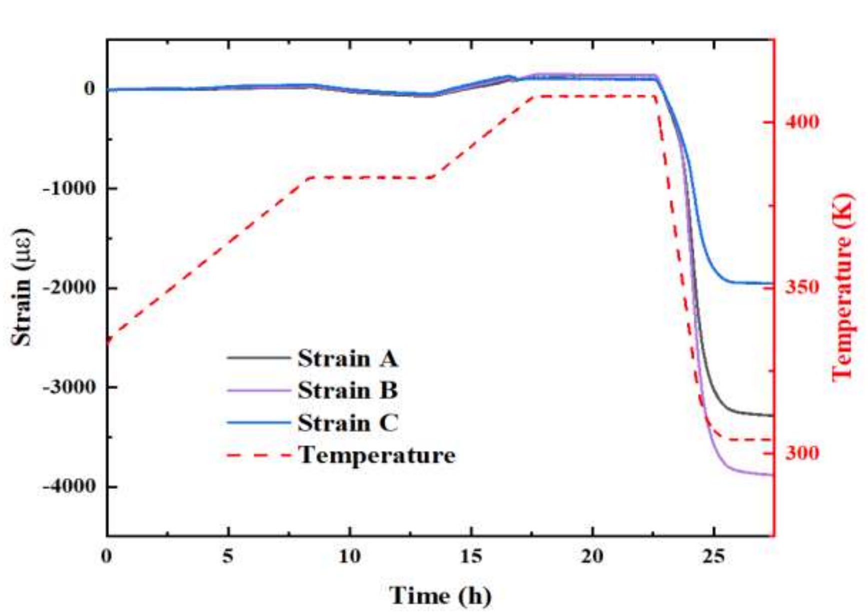
- ✓ The second-generation high temperature superconducting (HTS) tapes have significant mechanical strength anisotropy due to their multi-layer structure. The cooling shrinkage of epoxy resin is much larger than that of the HTS tape, resulting in strong stress on the conductor.
- ✓ It may cause the crack, spalling, or even fracture of the superconducting layer, and then result in the decline of the critical current.
- ✓ In the present work, the fiber Bragg grating (FBG) sensors were used to monitor the strain of the YBCO tape during curing and cooling process, and the critical current before and after the epoxy resin curing was measured. Also, we have explored the use of the embedded FBGs for quench testing.

The experimental setup of critical current



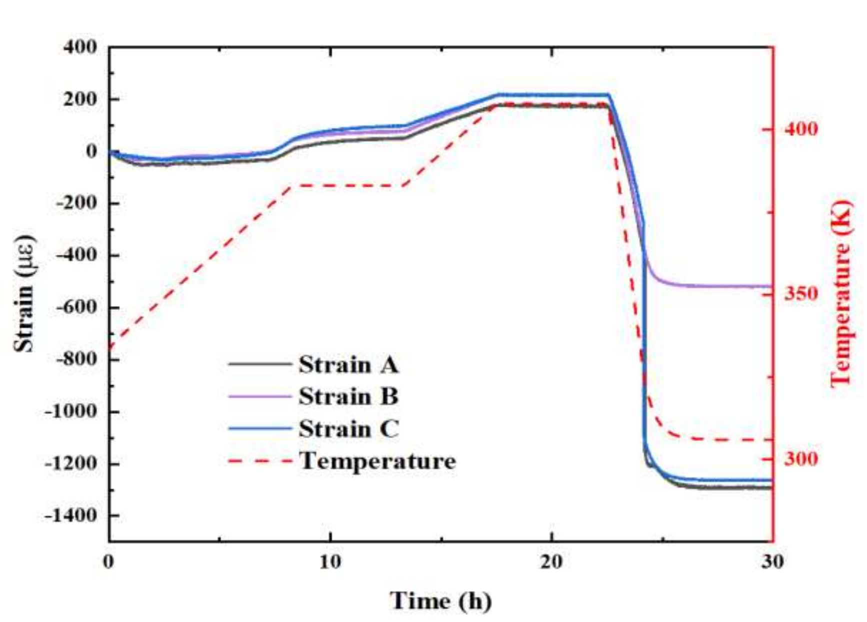


Critical current and the strain



	A	B	C
Solid residual strain(με)	-3286.22	-3885.77	-1950.86
Strain after cooling (με)	-9682.28	-9531.93	-9626.64
Total residual strain (με)	-12968.5	-13417.7	-11577.5
Ic before dipping (A)	123.64	130.25	133.92
Ic after curing (A)	119.4	121.09	131.72
Change of current (A)	4.24	9.16	2.2

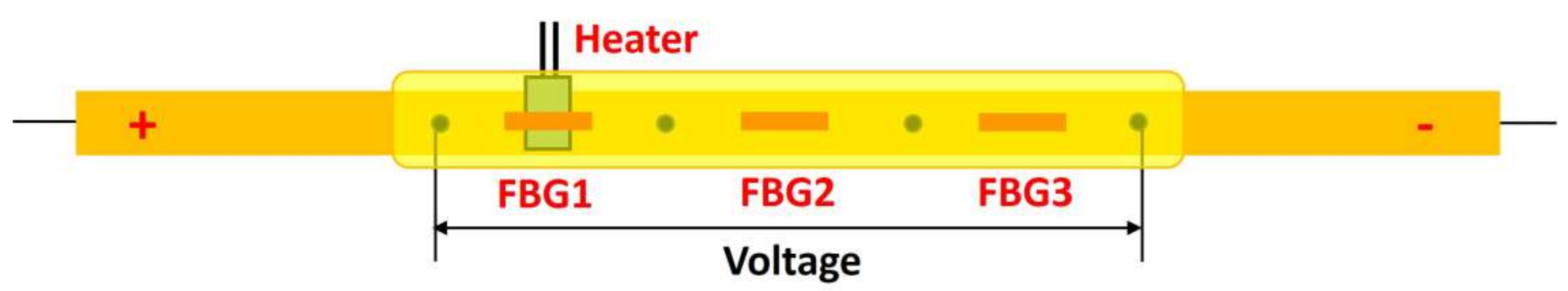
impregnated with pure epoxy resin

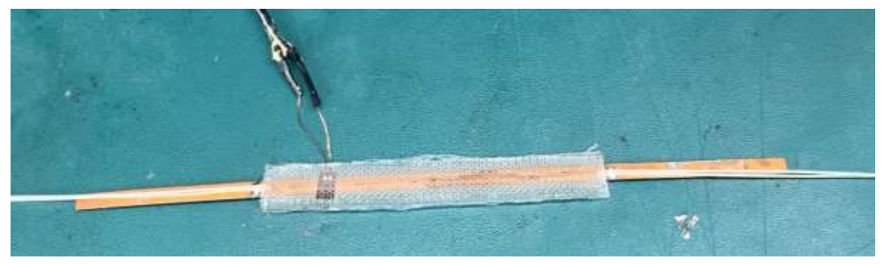


	A	B	C
Solid residual strain (με)	-1274	-537	-1264
Strain after cooling (με)	-2858	-2828	-2957
Total residual strain (με)	-4132	-3365	-4221
Ic before dipping (A)	123.22	125.31	127.95
Ic after curing (A)	123.76	124.86	126.77
Change of current (A)	-0.54	0.45	1.18

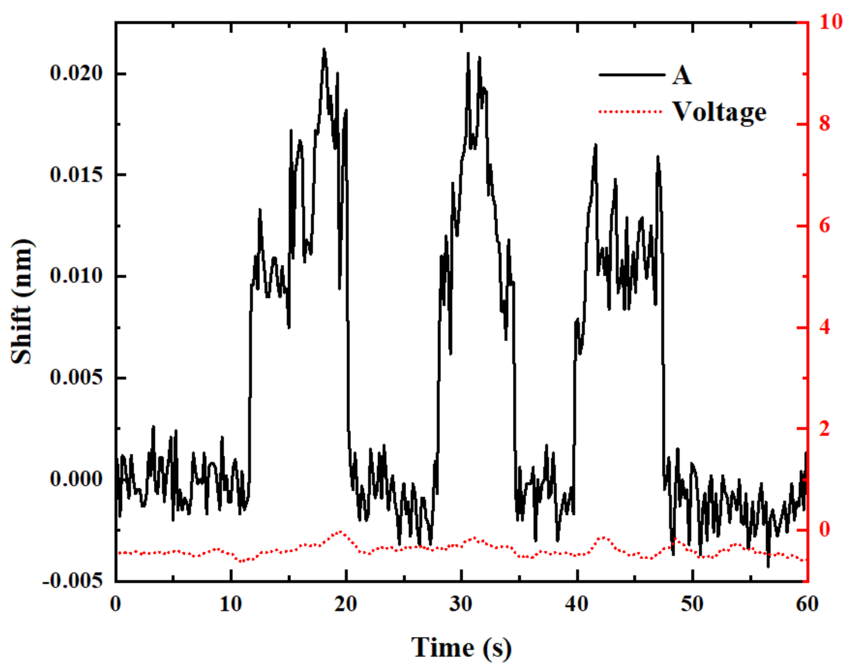
impregnated with glass fiber/epoxy resin

The HTS quench testing with FBGs

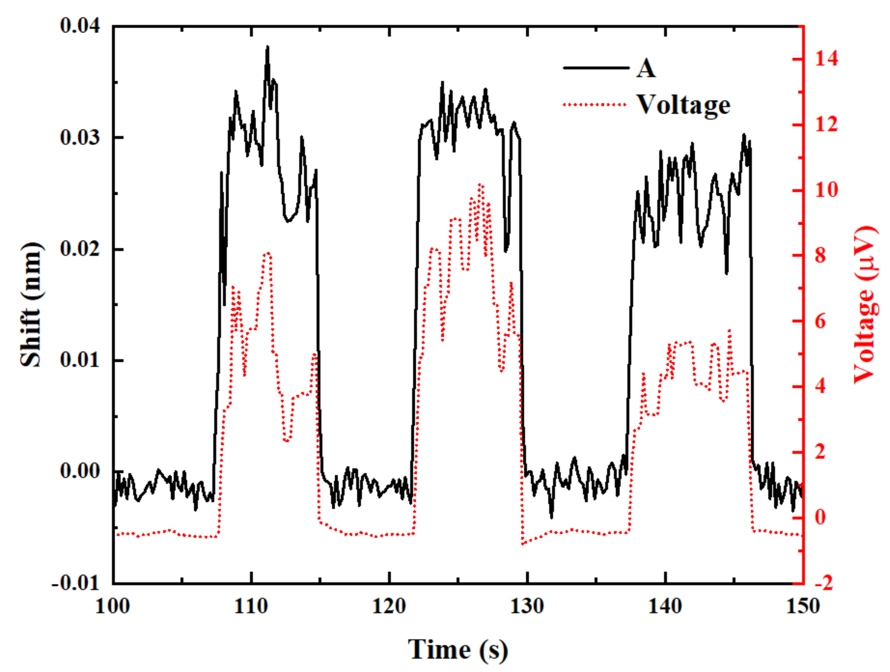




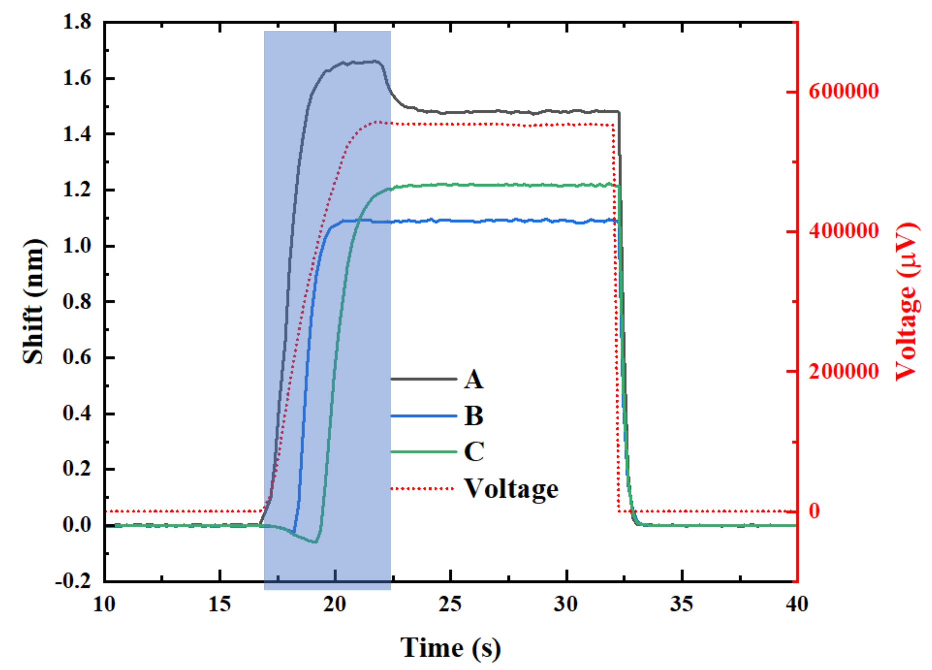
Results and discussions



Heat input: 0.288W



Heat input: 0.392W



Heat input: 0. 657W

- ✓ Only FBG 1 has a quench signal while FBG 2 and FBG 3 do not. At low heat input power, the voltage signal cannot be detected, but the signal of FBG1 can be detected.
- ✓ The wavelength of FBG1 increases and stabilizes immediately, decreases to a certain extent after stopping heating, and then remains at a higher position, and quickly returns to the initial after power-off.
- ✓ FBG2 and FBG3 then reacted sequentially, but the wavelength first decreased a little, then increased, and finally stabilized and the wavelength of FBG3 increased more.

Conclusions

- ✓ The addition of glass fiber greatly reduces the curing residual strain and cooling shrinkage, so that the critical current degradation of YBCO Tape is greatly reduced.
- ✓ The quench detection is highly dependent on the distance of the FBG from the quench point.
- ✓ At low quench power, the voltage signal cannot be detected, but the signal of FBG can be detected.