4MP2-09

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Persistent Current Operation of MgB_2 Coils with Superconducting Joints of Reacted Wires

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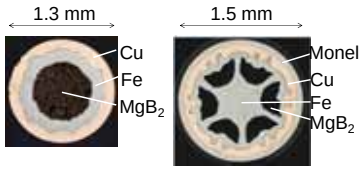
Introduction

- MgB_2 can generate a highly stable magnetic field required for NMR or MRI by persistent current (PC) mode operation without liquid helium. The superconducting joint technique is essential for realizing PC mode operation.
- We have developed *in situ* wires because of its superior current performance to that of *ex situ* wires.
- A technique for joining *ex situ* wires and unreacted *in situ* wires has been successfully developed. However, a technique for joining reacted *in situ* wires, especially for multi-filamentary wires, has been sparsely reported. It is necessary for joining reacted coils after heat treatment or coils produced by the react-and-wind (R&W) process.
- The purpose of this study is to demonstrate that an MgB_2 coil with a joint of reacted *in situ* wires can be operated in PC mode with sufficiently low resistance (< 10^{-13} Ω).

Experimental Details

Preparation of closed-loop coils



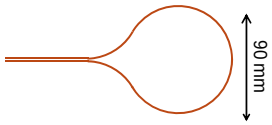
Cross-sectional views of the MgB_2 wires.

Specifications of the MgB_2 wire

	Mono-filamentary	Six-filamentary
Diameter	1.3 mm	1.5 mm
MgB_2 fraction	33 %	23 %
Doping	Non-doped	C-doped
I_c (20K, s. f.)	2400 A	4000 A

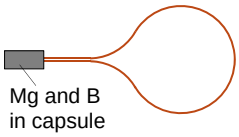
The I_c of the wire in self-field was estimated from measuring magnetization of an MgB_2 wire core made by ourselves.

1st heat treatment



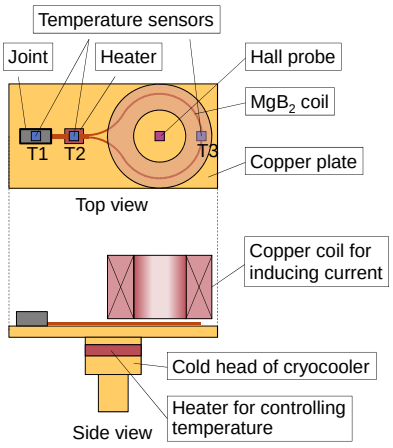
Sinter the wire core at 600 °C

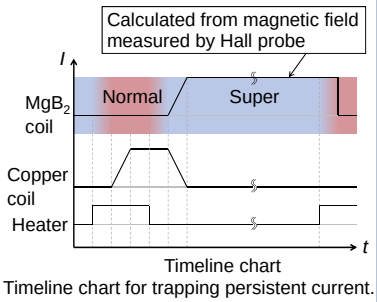
2nd heat treatment



Sinter the bulk for joining both ends of the wire at 800 °C

Setup for measurement of current decay





Timeline chart for trapping persistent current.

Specifications of the MgB_2coils

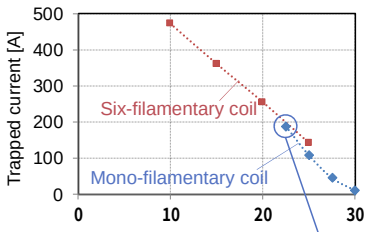
	Mono-filamentary	Six-filamentary
Diameter	90 mm	90 mm
Inductance	4.1x10^{-7} H	3.6x10^{-7} H

Specifications of the copper coils

	For mono-filamentary	For six-filamentary
Diameter of wire	0.4 mm	0.35 mm
I. D.	60 mm	70 mm
O. D.	115 mm	210 mm
Height	90 mm	60 mm
Number of turns	9000	25,000

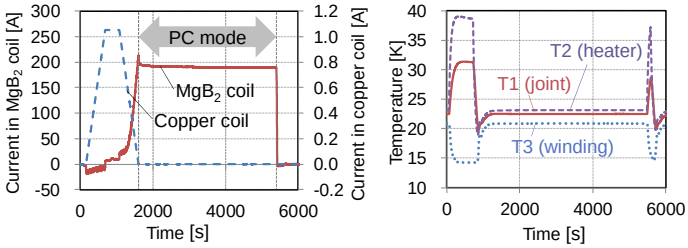
Results and Discussion

Temperature dependence of trapped current



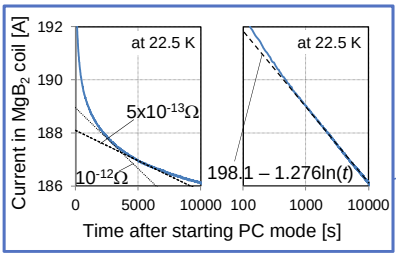
Trapped current one hour after starting PC mode.

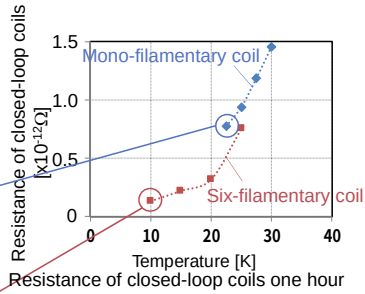
- The trapped current of the mono- and six-filamentary coils were almost the same.
- The ratios of trapped current to the I_c of the un-joined mono- and six-filamentary wires were about 11 % and 6 %.



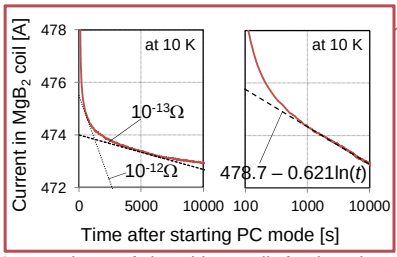
An example of the series of measurements of current decay.

Current decay properties of closed-loop coils





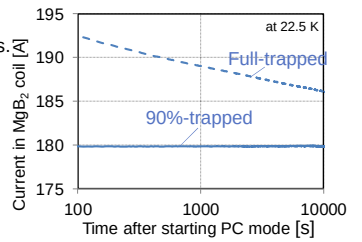
Resistance of closed-loop coils one hour after starting PC mode.



Current decay of closed-loop coils for three hours.

- There was no constant resistance larger than flux creep.
- The temperature dependence of the resistance was caused by that of flux creep.

- No decay was observed from the start of PC mode operation in the case of 90% current capacity was trapped.
- In the case of actual operation, the resistance is expected to be sufficiently low for practical use.



Current decay of full- and 90%-trapped mono-filamentary coil

Conclusion

- Current decay properties of MgB_2 closed-loop coils with a joint of reacted *in situ* mono- and six-filamentary wires were investigated.
- Measuring the current decay revealed that there was no constant resistance larger than that due to flux creep and the wires were successfully joined. The joint resistance was about 10^{-13} to 10^{-12} Ω one hour after the start of PC mode operation in the case of full-trapped current.
- In the case of actual operation at lower current capacity ratio, the resistance was less than 10^{-13} Ω and sufficiently low for practical applications.