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Measurement of irreversible external-compressive strain and minimization of reversible bending radius on MgB_2 multifilament wire

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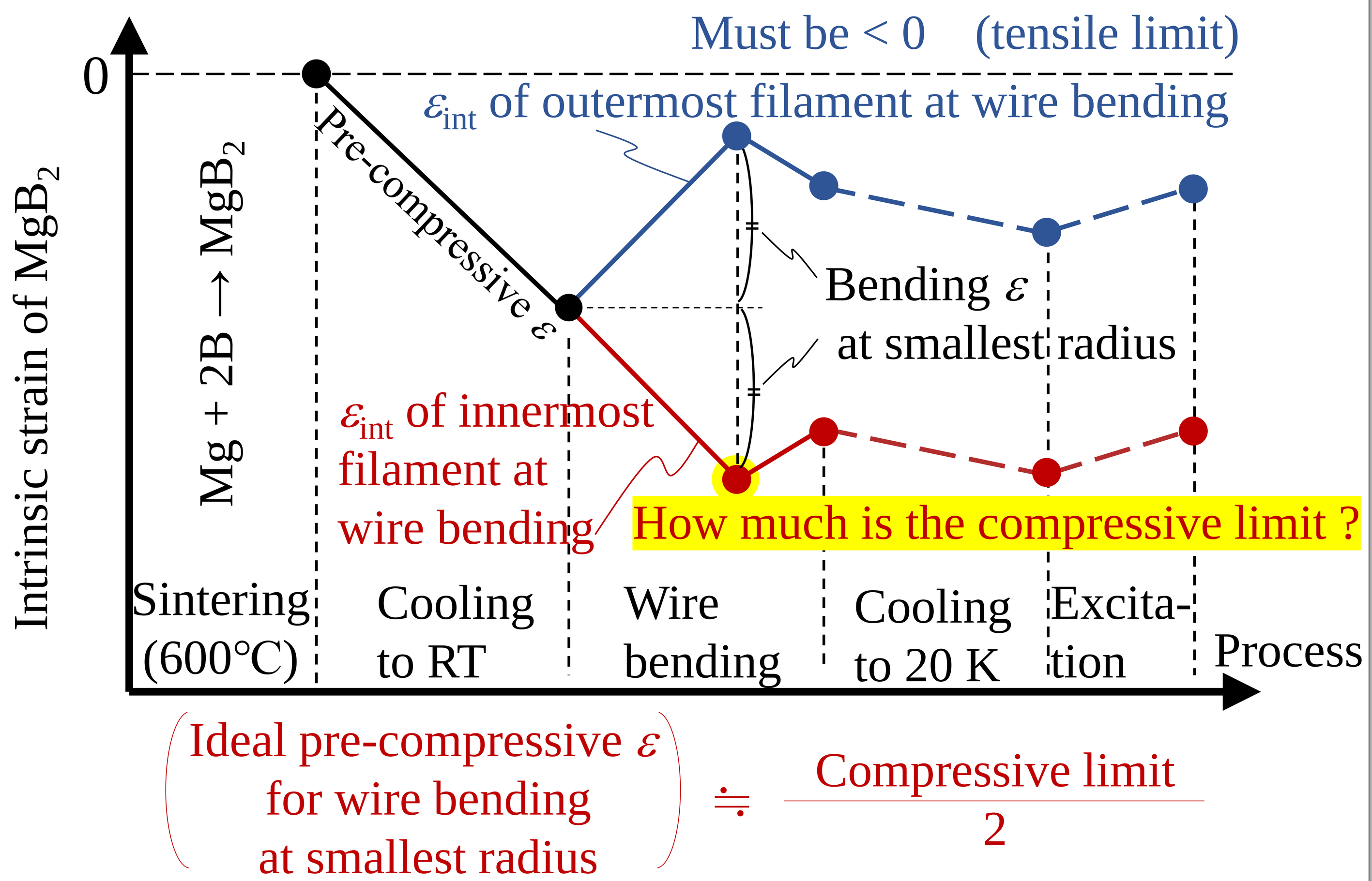
1. Introduction

- The strain tolerance of MgB_2 wire at room temperature (RT) is important to make MgB_2 coils by the React & Wind method.
- MgB_2 filaments are assumed to be irreversibly damaged by tensile strain at the intrinsic strain ε_{int}=0, so the tensile strain tolerance at RT must be improved by increasing pre-compressive strain from sintering temperature to RT.
- On the other hands, the compressive limit of strain should be considered to avoid the I_c degradation due to too much compressive strain.

Strain change along with wire/coil fabrication

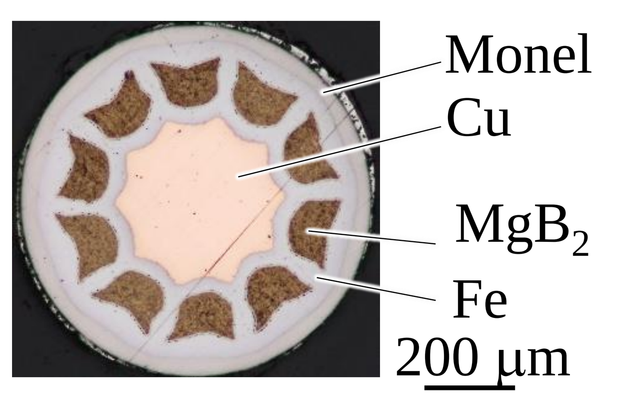


- In this paper, the irreversible external-compressive strain of Fe sheathed MgB_2 wire was measured, and the ideal pre-compressive strain to minimize the reversible bending radius was estimated.
- Then, SUS reinforced 18-filament round MgB_2 wire was made and the ex-ternal strain tolerance of it was evaluated.

2. Experimental Details

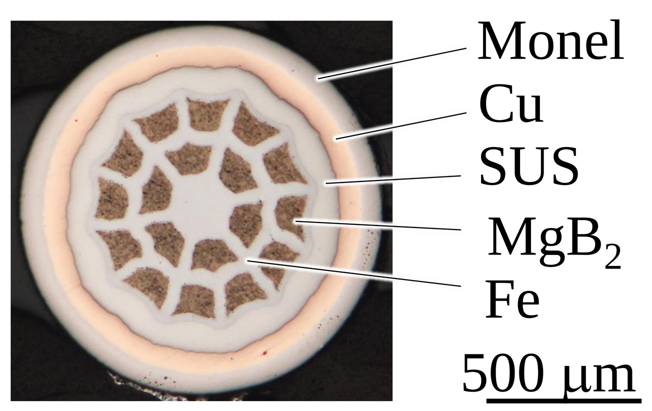
2.1. Sample wires

Wire 10-Mo



Outer diameter (O.D.) = 0.67 mm

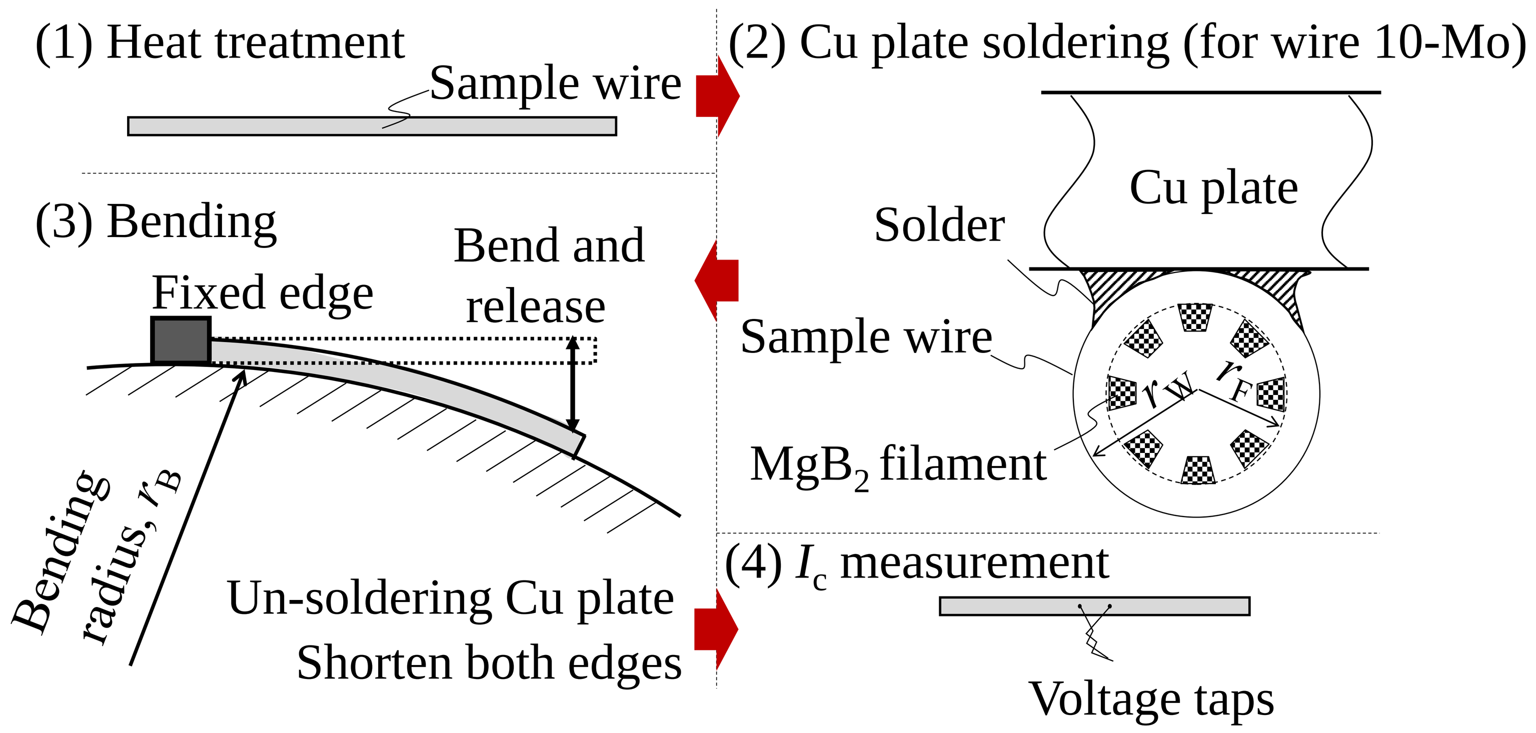
Wire 18-Mo&SUS



O.D. = 1.5 mm (tension)
O.D. = 1.16 mm (bend)

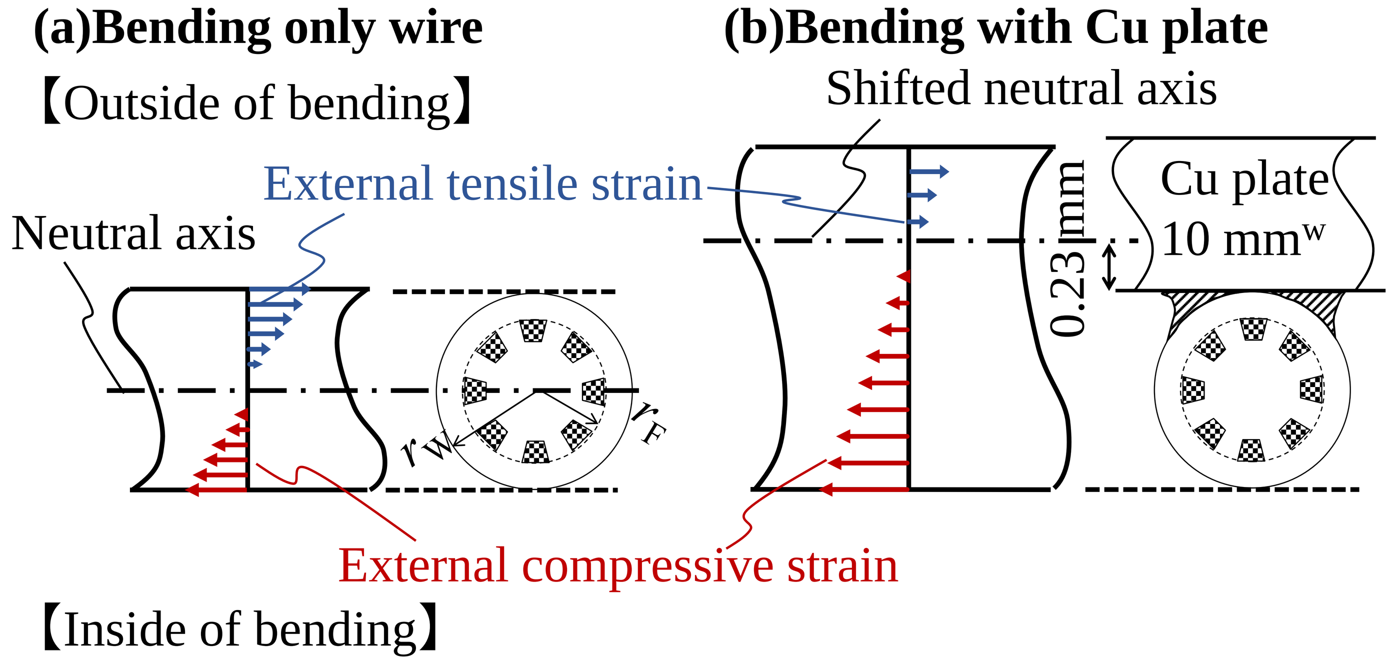
2.2. Bending sample wire with Cu plate to apply external compressive strain

How to apply external-compressive strain



Sample wires

Strain distribution

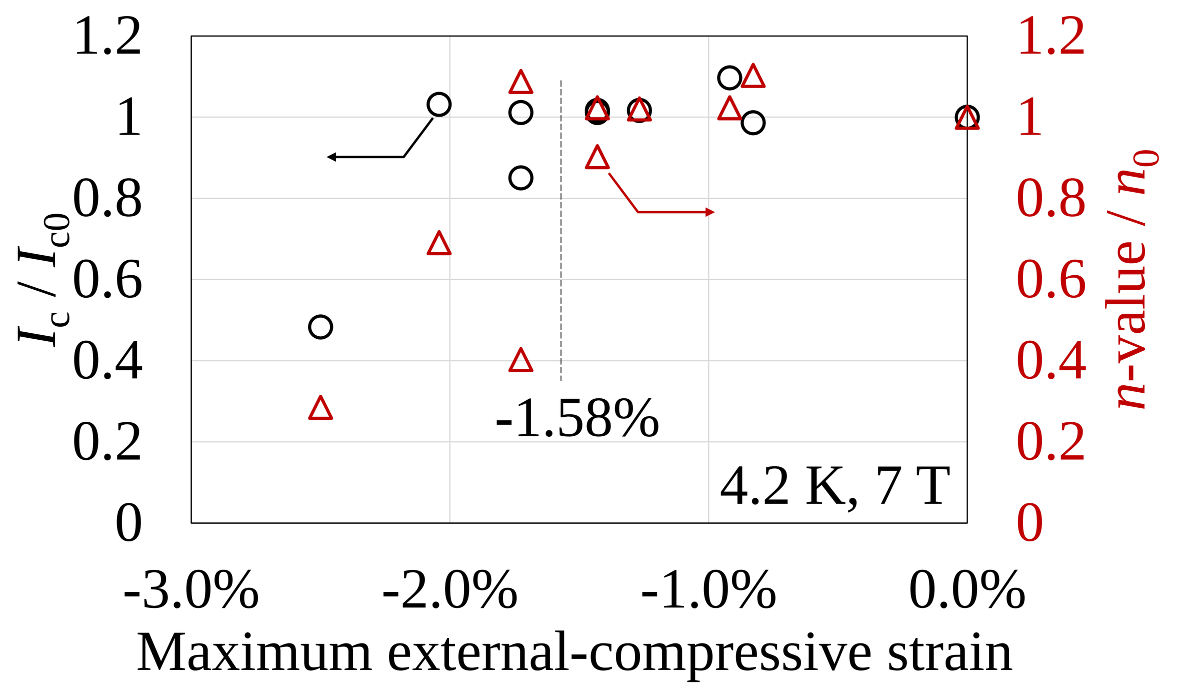


Maximum external-compressive ε at innermost filament at (b) $= -\dfrac{r_F + r_W + 0.23\ \text{mm}}{r_B + 2r_W + 0.23\ \text{mm}}$

The distance 0.23 mm was calculated by formulas [1].

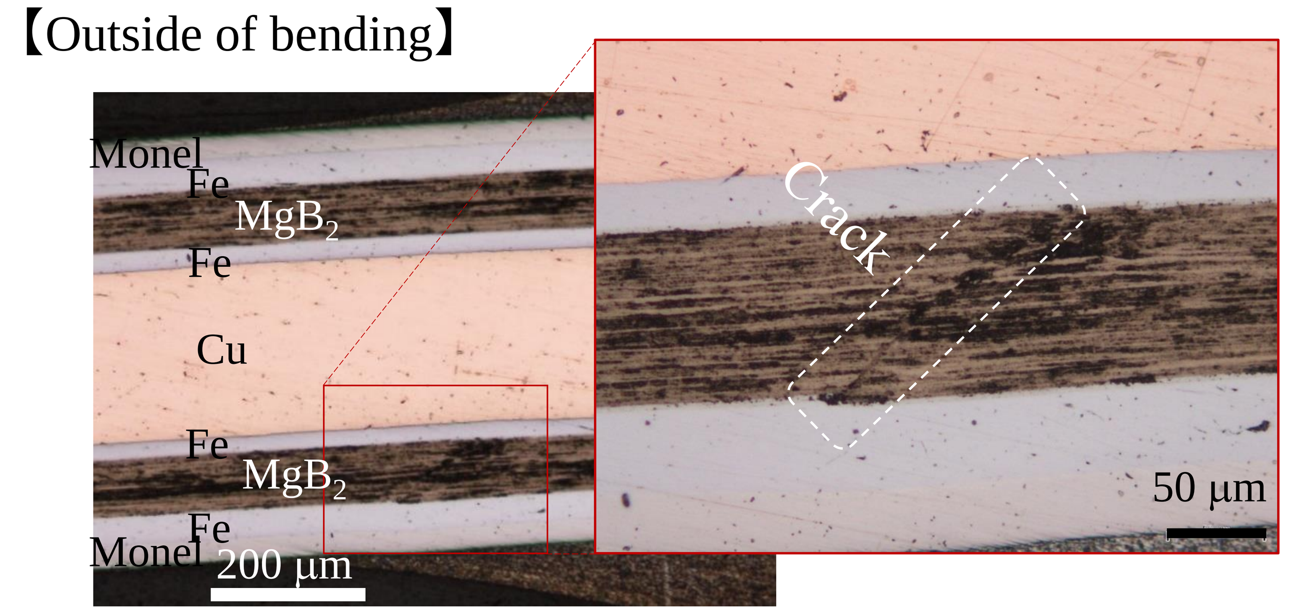
3. Evaluation of compressive strain limit (Wire 10-Mo) and estimation the ideal pre-compressive strain for the R&W method

I_c measurement results



Cross-sections of damaged sample (ε_{ext} = -2.5%)

【Outside of bending】

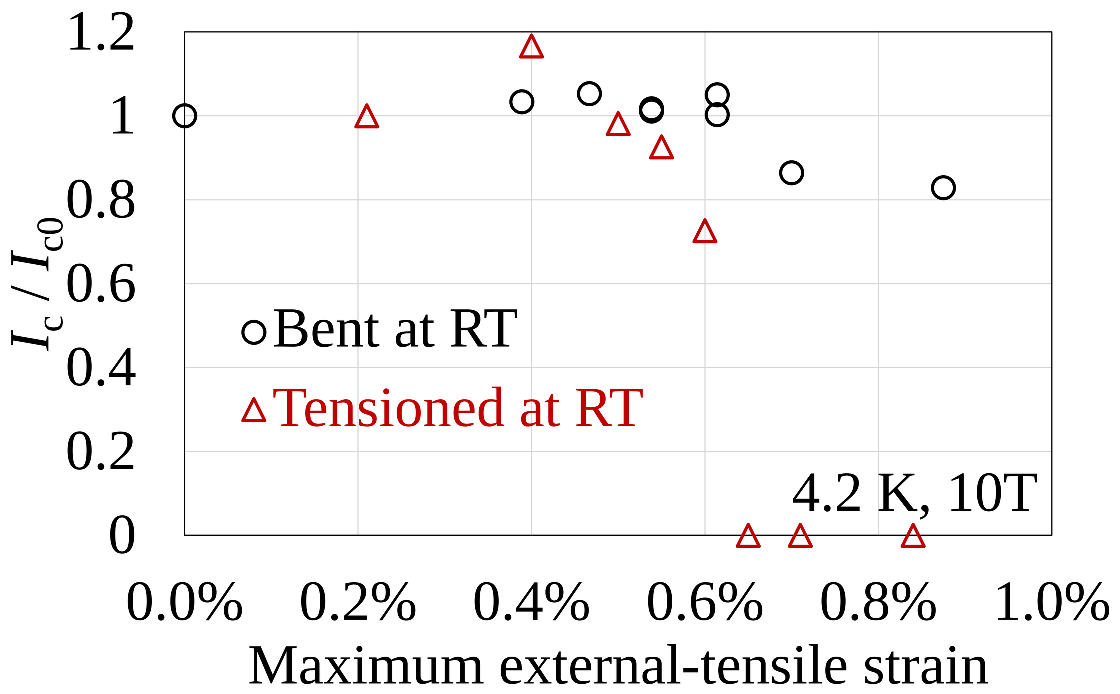


【Inside of bending】

- The irreversible external-compressive strain of this wire was measured as -1.58%.
- Pre compressive strain of this wire is -0.19% [2].
- The compressive limit of intrinsic strain is -1.58% -0.19% = -1.77%.
- So, the ideal pre-compressive strain to minimize bending radius at RT is estimated from a half of this value as -0.88%.

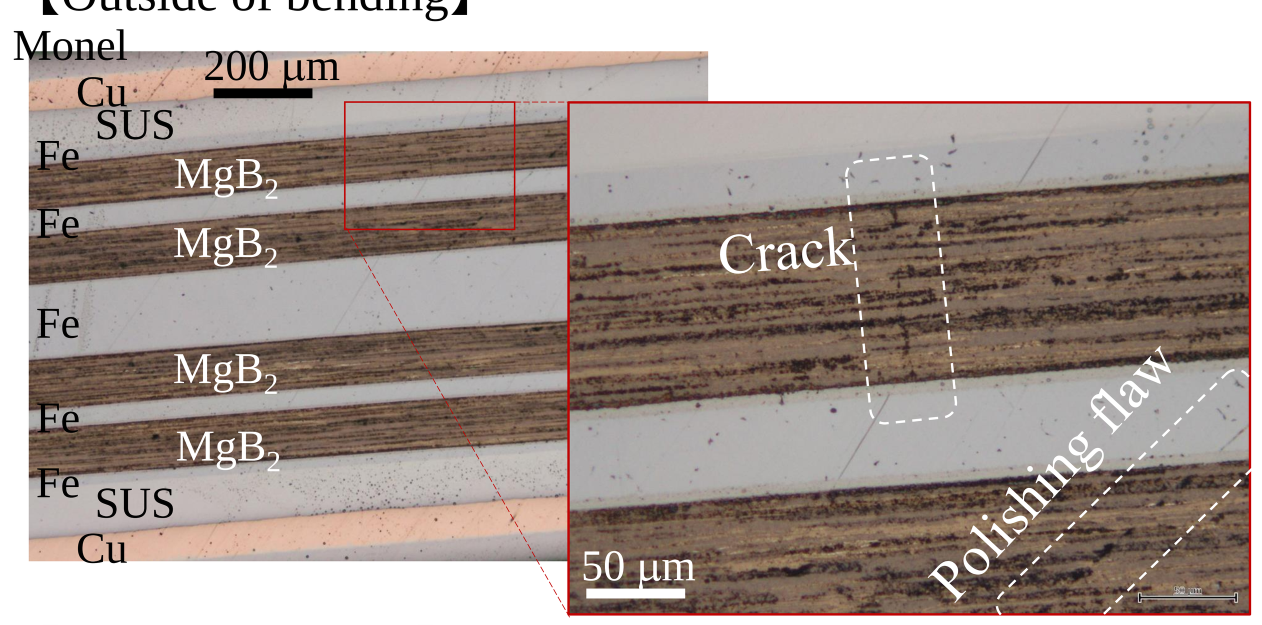
4. High strain tolerance and high J_e (Wire 18-Mo&SUS)

I_c measurement results



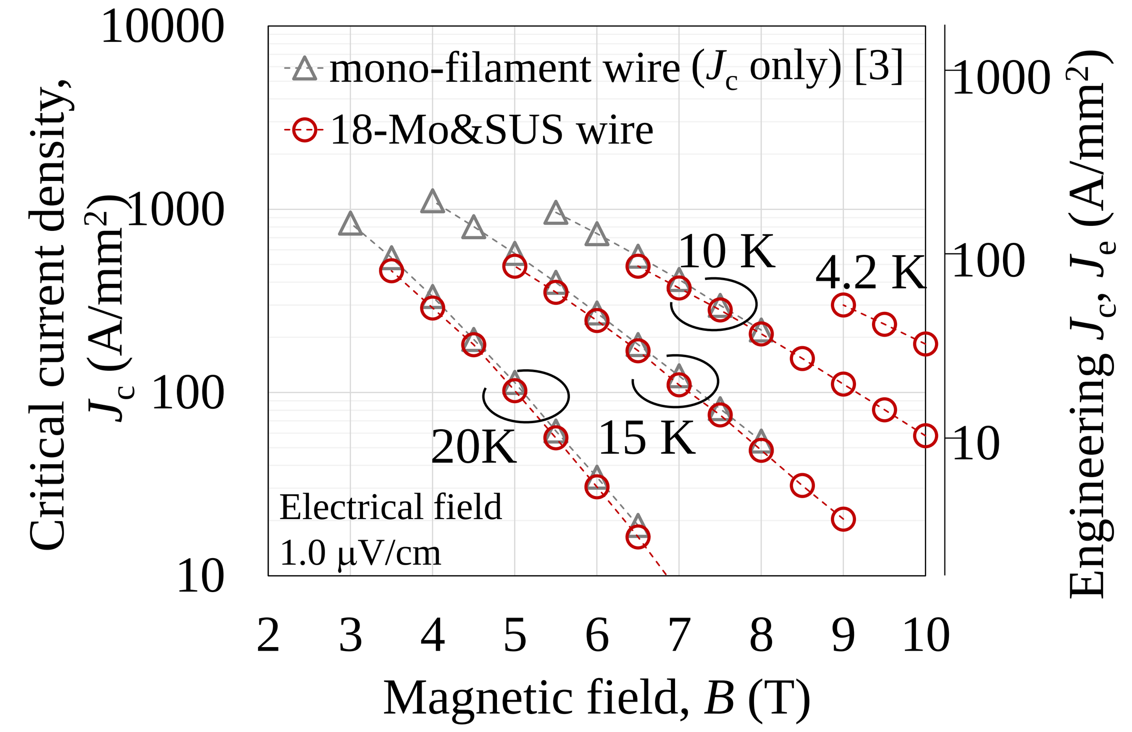
Cross-sections of damaged sample (ε_{ext}= 0.7%)

【Outside of bending】



【Inside of bending】

J_c (J_e) - B- T (C doped)



- Wire 18-Mo&SUS was irreversibly damaged at strain 0.6% at RT, so pre-compressive strain of this wire is -0.6% (a little smaller than the ideal value, -0.88%).
- Reversible bending radius of this wire (ϕ 1.16 mm) is assumed as 116 mm, and it's enough small for the React & Wind method.

5. Conclusion

- The ideal pre-compressive strain to minimize reversible bending radius at RT was obtained as -0.88%.
- The pre-compressive strain of the SUS reinforced wire 18-Mo&SUS was measured as -0.60% and it was a little smaller than the ideal value.
- Both high strain tolerance and high engineering J_c (e.g. J_e = 200 A/mm² at 20 K, 3 T) was shown by the wire 18-Mo&SUS.

[1] P. Kováč et al., *IEEE Trans. Appl. Supercond.* 25, 2015,6200607, [2] H. Tanaka et al., *IEEE Trans. Appl. Supercond.* 29, 2019, 8401104, [3] M. Kodama et al., *Supercond. Sci. Technol.* 30, 2017, 044006.