Pressure-Induced Property Improvement of Magnesium Diboride Superconductors

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Outline of Presentation

- Introduction
- The process of cold-pressing
- Microstructure of cold-pressed wire
- Transport properties of cold-pressed wire
- Conclusion

Introduction

- limitation on the J_c performance of Powder In Tube MgB_2 wire
  - Porosity

- Solutions

  I. Hot Isotatic Pressing (HIP)

  II. Cold High Pressure Densification (CHPD)

Process of CHPD

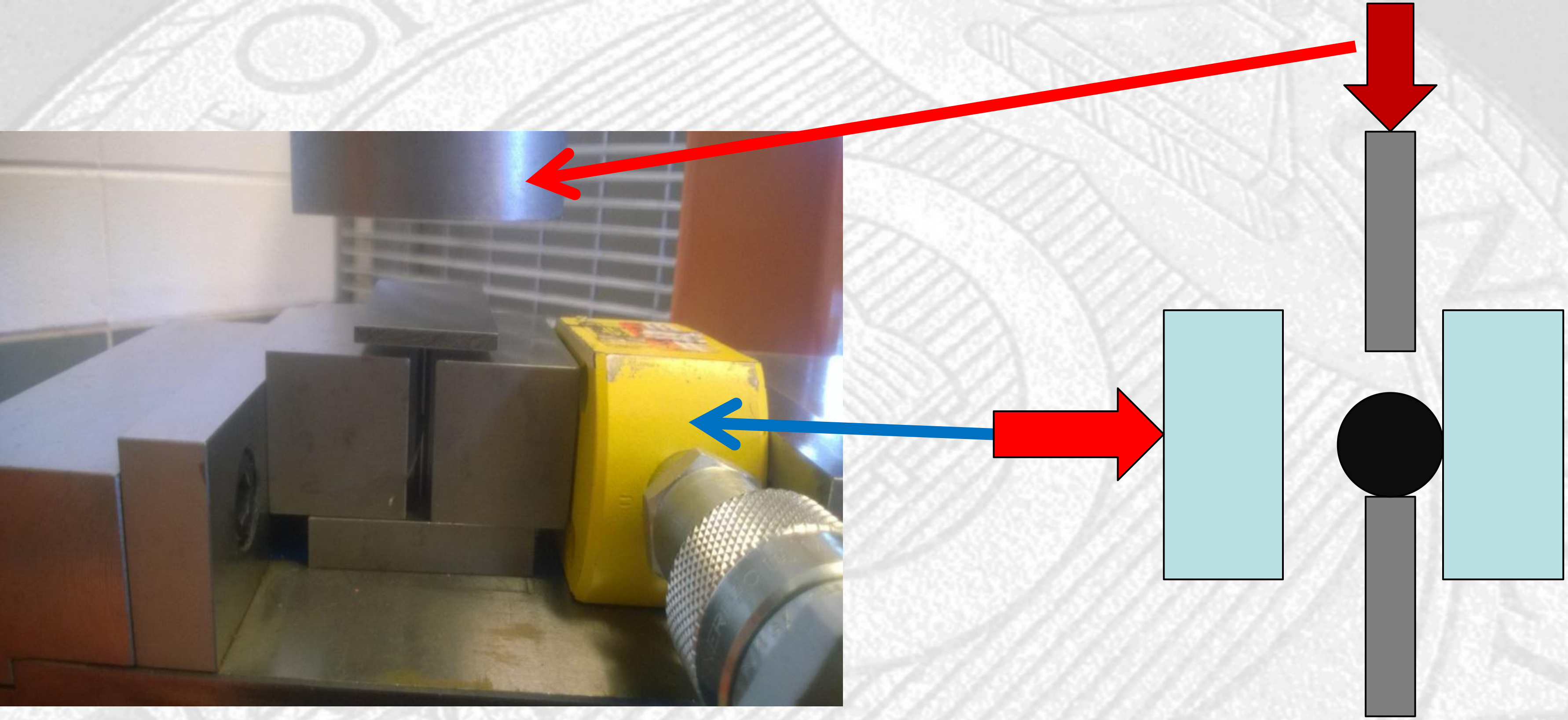


Fig 1: Cold Densification Instrument

Process of CHPD

TABLE 1. Strand Design for CHPD processed Strands

Sample No.	Vertical Pressure (GPa)	Horizontal Pressure (GPa)
W00	0.0	0.0
W10	1.0	2.0
W15	1.5	2.0
W20	2.0	2.0

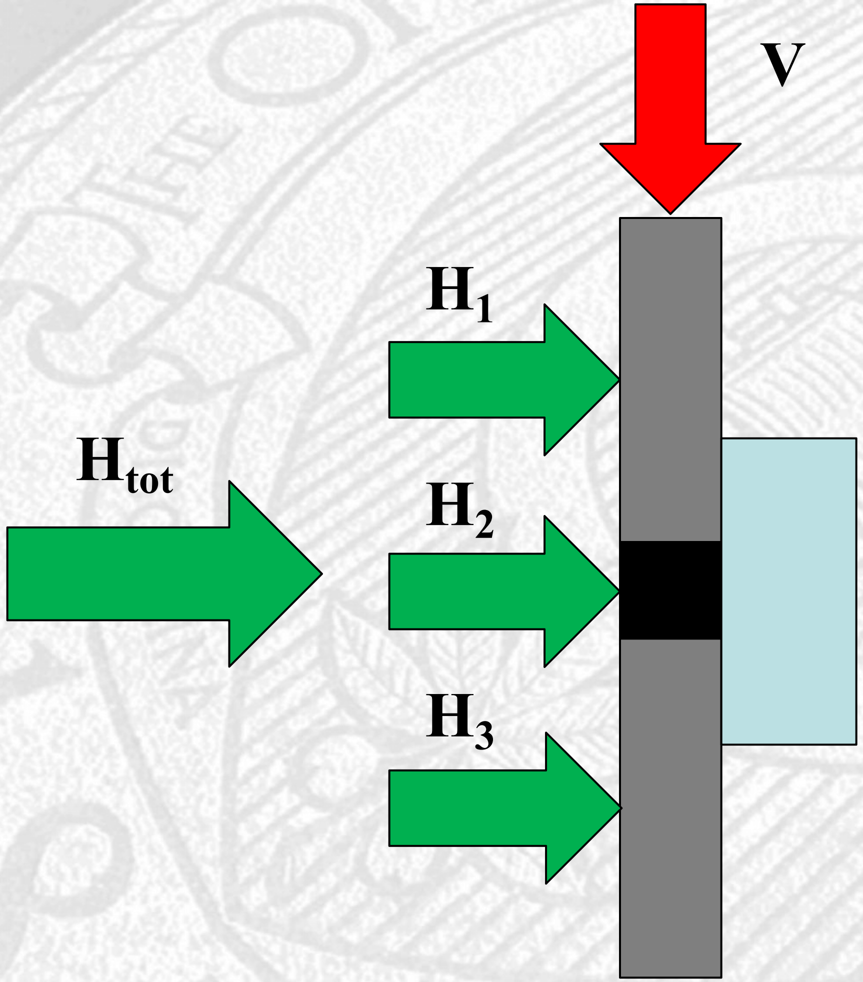
A 20–ton hydraulic press was used to vertically apply pressure on wire through a pair of blades made of tool steel.

A 10–ton hydraulic press was used to horizontally apply pressure on wire through a pair of side wall.

Horizontal pressure was maintained at 2.0 GPa.

Vertical pressure ranged from 1.0 GPa through 1.5 GPa to 2.0 GPa (Table 1)

Process of CHPD



Horizontal pressure is the sum of the pressure applied on blades and the pressure applied on wire.

$$H_{tot} = H_1 + H_2 + H_3$$

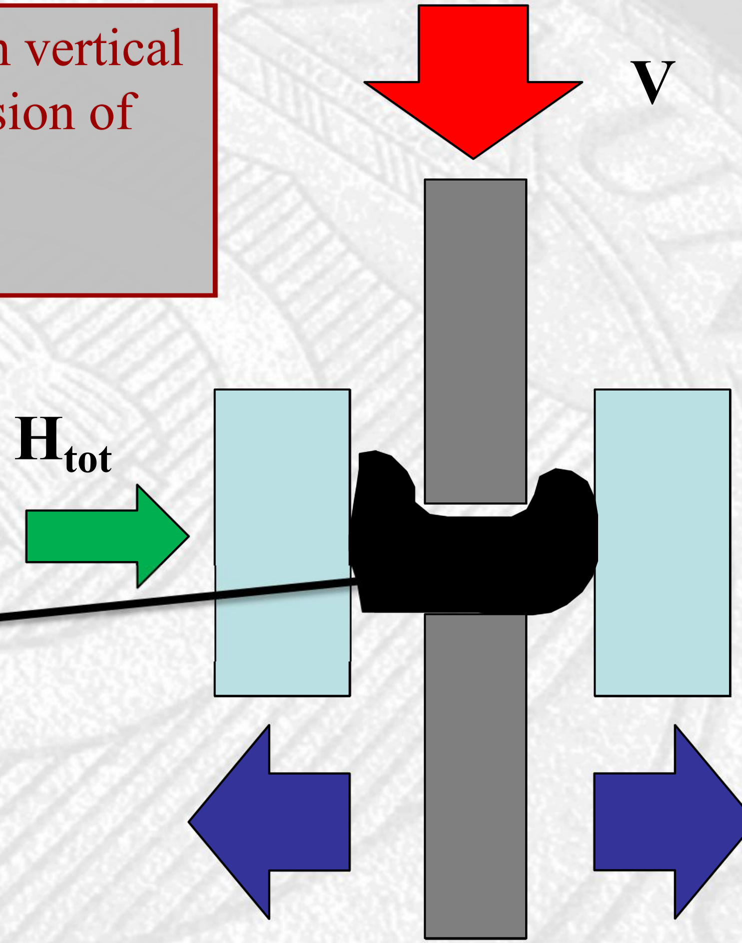
Horizontal pressure actually applied on wire should be equal to the vertical pressure applied on wire.

$$V = H_2$$

Process of CHPD

Horizontal pressure must be larger than vertical pressure in order to avoid the extrusion of the cold-pressed wire.

$H_{tot} < V$



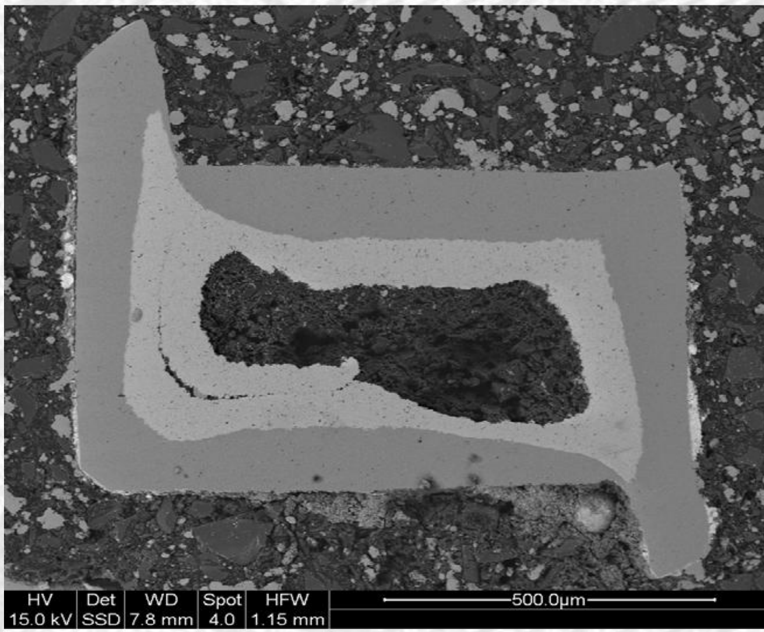
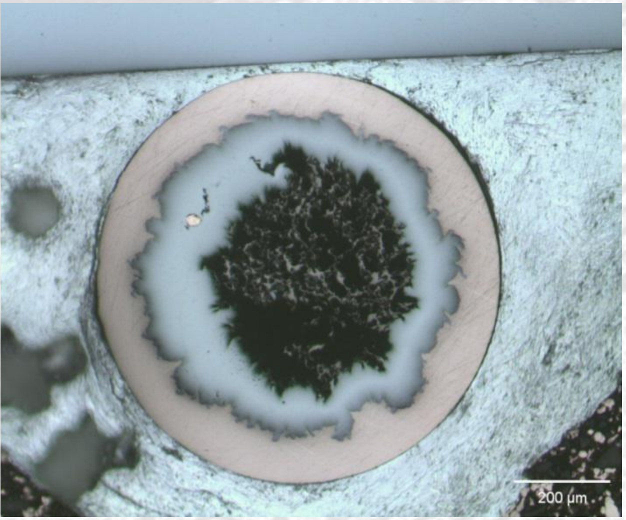


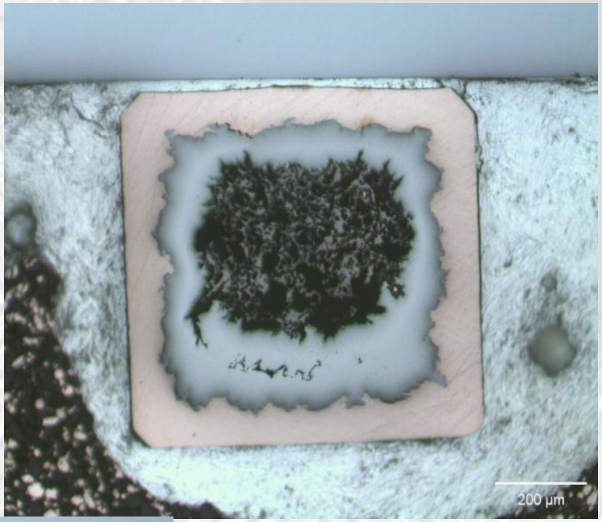
Fig 2: The extrusion of the PIT MgB_2 wire cold-pressed by 2.0 GPa

Microstructure

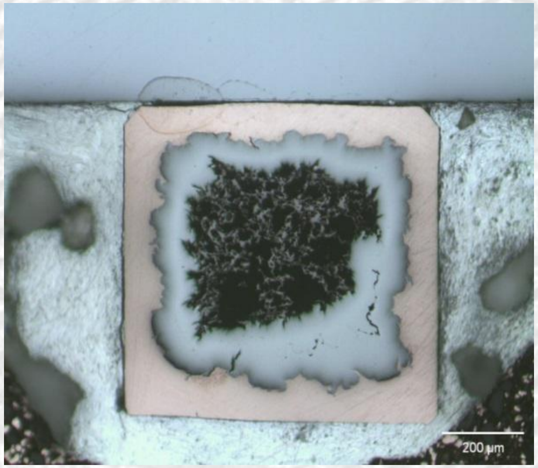


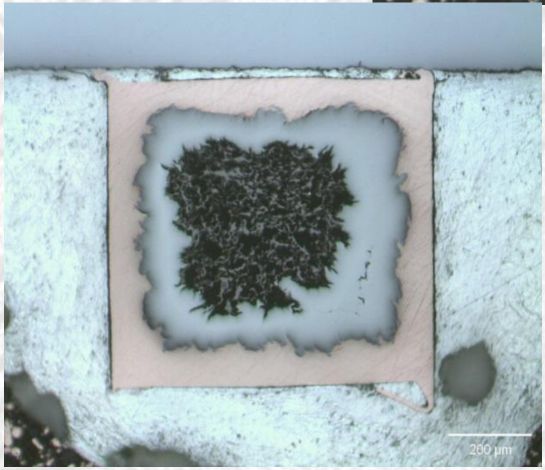
W00
0.0 GPa

W10
1.0 GPa



W15
1.5 GPa

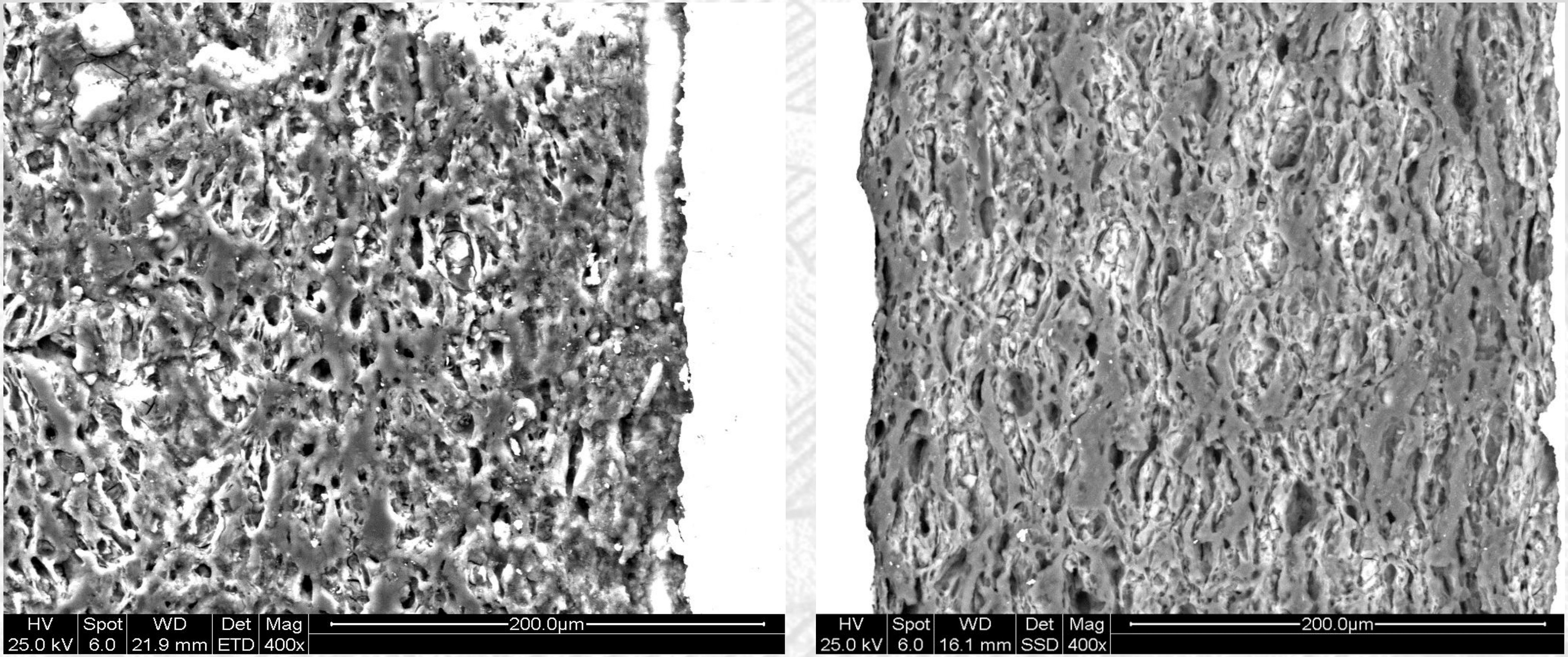




W20
2.0 GPa

Fig 3: Cross section areas of cold-pressed wires

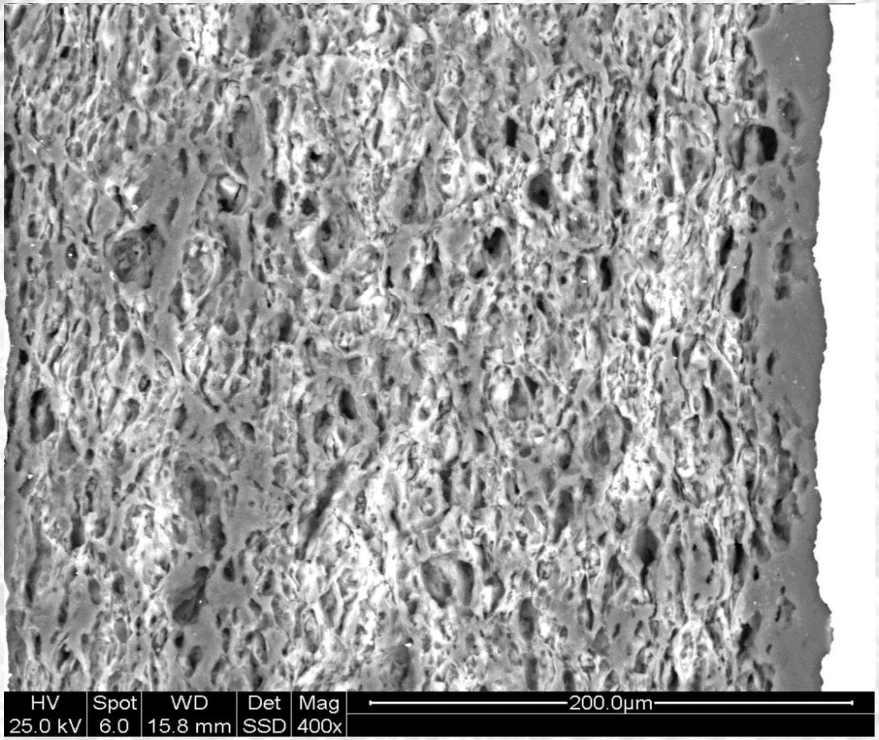
Longitudinal Cross Sections



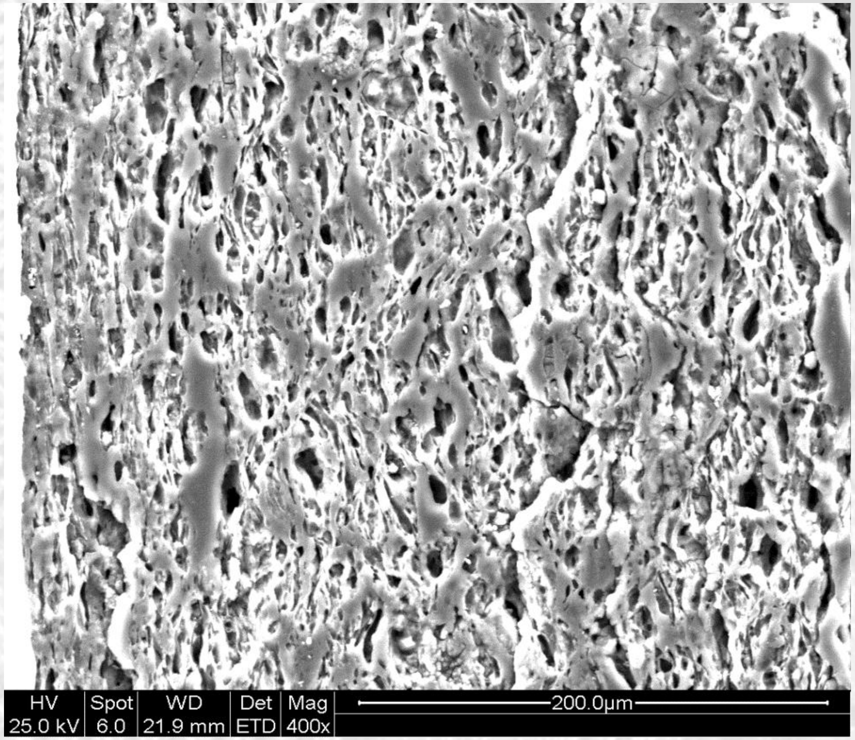
(a) W00 (b) W10

Fig 4: SEM of PIT MgB_2 wire (a) W00 (Control) and (b) W10 (1.0 GPa Pressed).

Microstructure



(c) W15



(b) W20

Fig 5: SEM of PIT MgB_2 wire (c) W15 (1.5 GPa Pressed) and (d) W20 (2.0 GPa Pressed).

4.2 K Transport Critical Current Density

- At 10 T, the transport J_cs of the W10 and W15 have been improved by **15.8% and 20.5%**, respectively, by comparing with that of W00
- Compared with W15, the W20 has lower transport J_cs at all applied magnetic fields

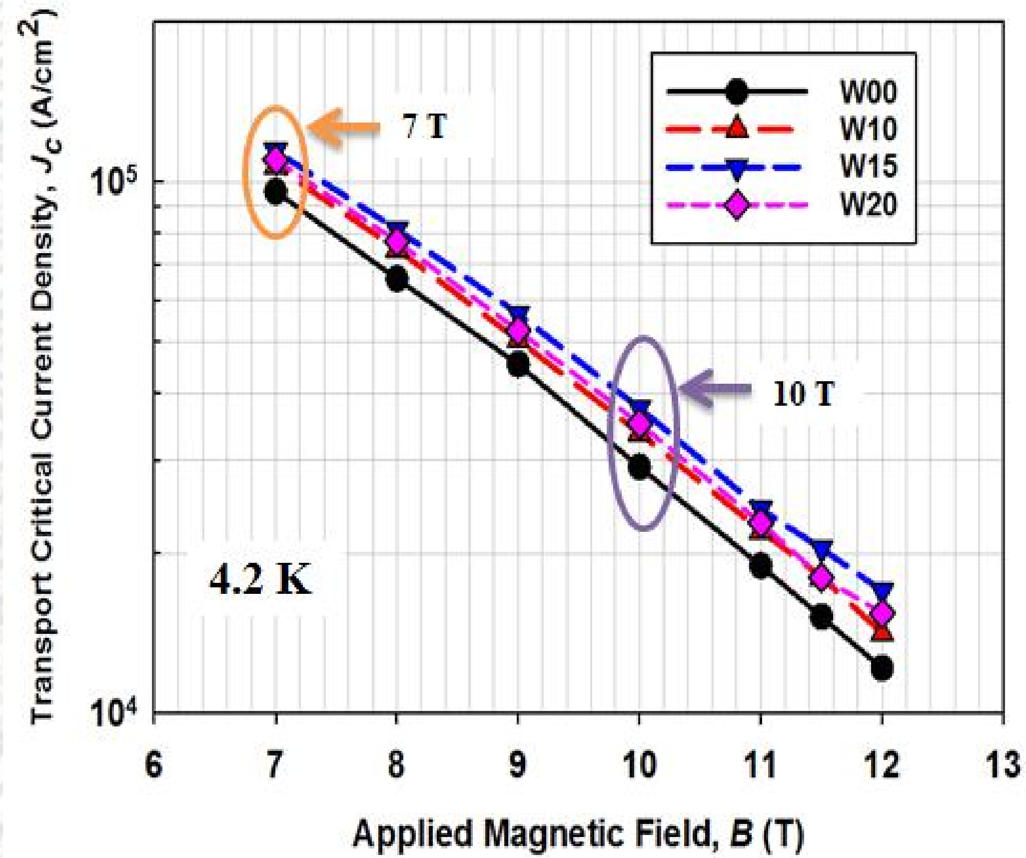


Fig. 6: Field dependence of transport critical current densities of the cold-pressed MgB_2 wires at 4.2 K.

Pressure Induced Damage

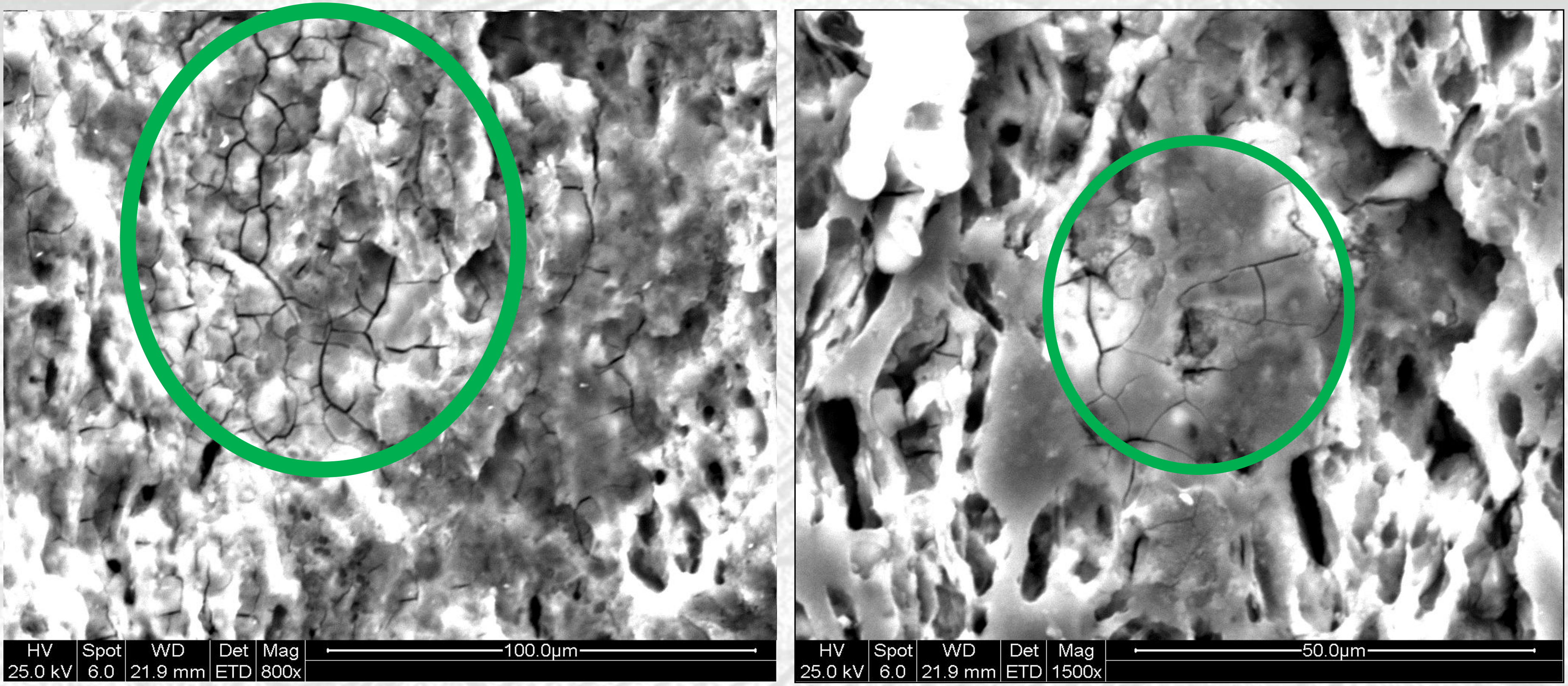


Fig. 8: SEM of the W20; the cracks have formed in the reacted wire.

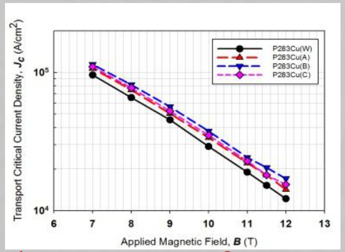
Conclusion

- ## Microstructure

I. Cold densification induced the alignment of the MgB_2 phases along the longitudinal direction of the wire.

II. Longitudinal grain connectivity has been improved by the cold densification.

iii. High pressure results in the cracks in the wire.



- ## Transport Properties

I. 1.5 GPa cold pressing resulted in the best J_c performance, for example a 22.5 % increase at 10 T, 4.2 K.

II. Enhanced transport J_cs proved the improved longitudinal grain connectivities of the cold-pressed wires.

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Questions?

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