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Reduction of internal porosity in $Bi_2Sr_2CaCu_2O_x$ round wires with overpressure processing

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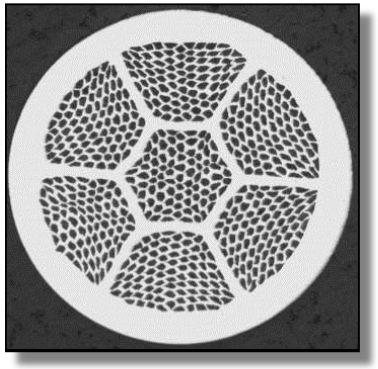
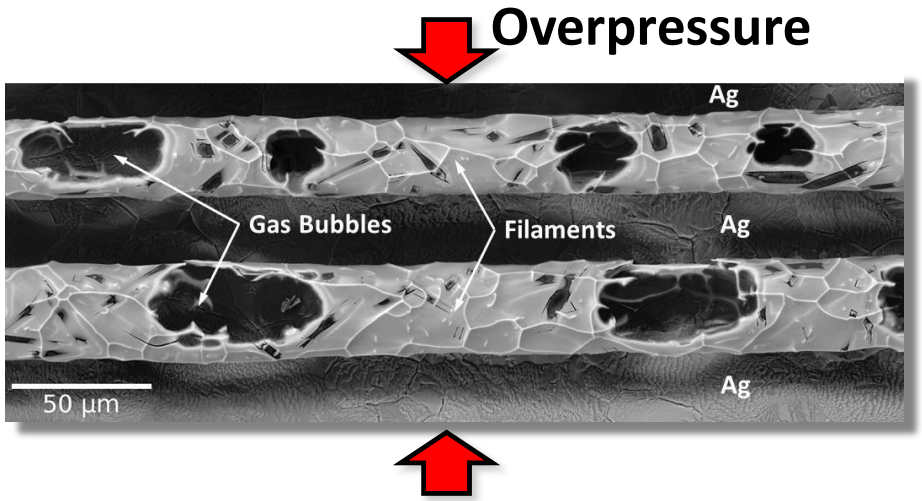
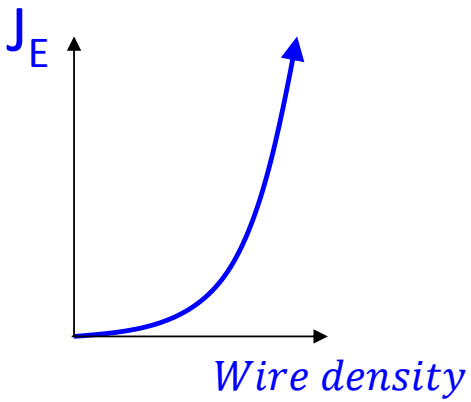
NSF/DMR-1157490

Motivations







How can we reduce internal porosity?

What is the densification process?

Driving questions

Why do we need Overpressure processing?

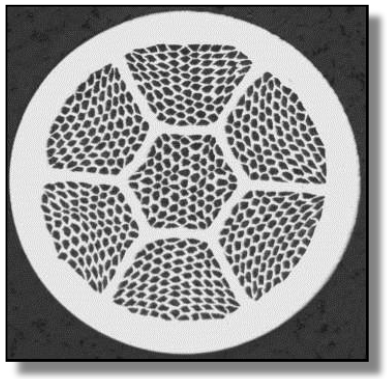
- Low powder packing density and filament size bubbles
- Diameter expansion and leakage
- Densification with Overpressure is the key for high J_E

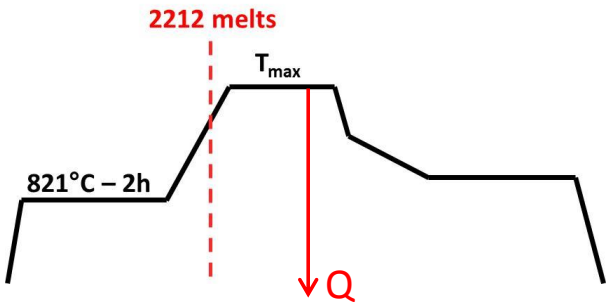
What is the wire densification process?

- Densification vs. time
- Densification vs. temperature
- What happen if seals fail?

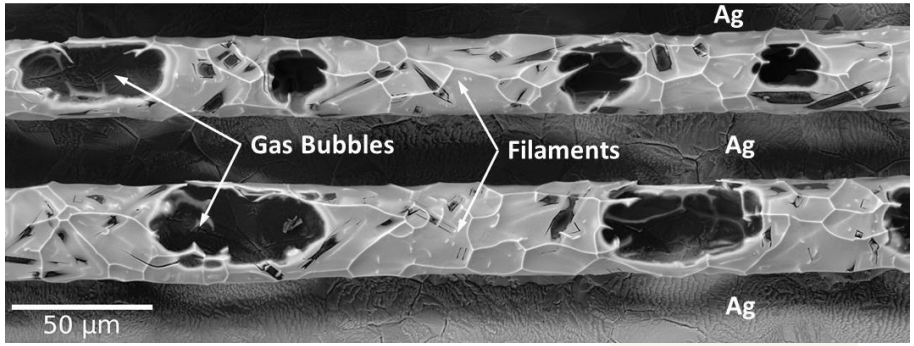
As-drawn wires are only 65-70% dense

Cross section As-drawn 85x7





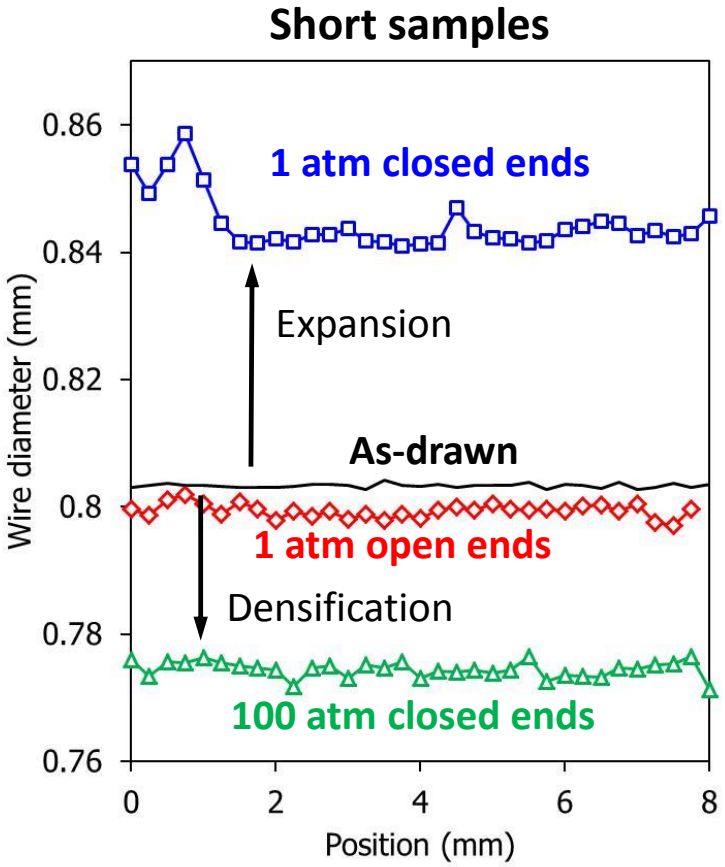
- **As-drawn filaments are 65±5 % dense (PIT process)**
- **35±5 % gas bubbles after 2212 melts**
- **Bubbles block current transport**



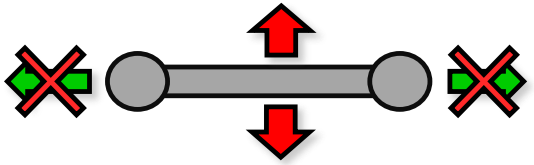
Filaments from wire quenched in the melt

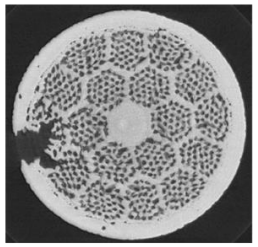
Kametani *et al.*, *Supercond. Sci. Technol.* 24, 075009 (2011)

Internal trapped gas generates wire expansion and leakage



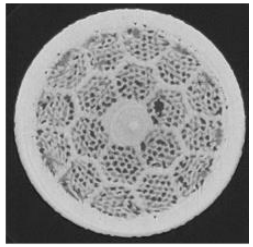
- **Closed ends 1 atm: <65% dense**



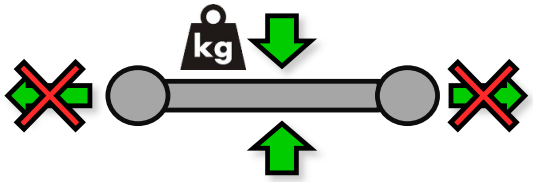


- **As-drawn wire: 65% dense**

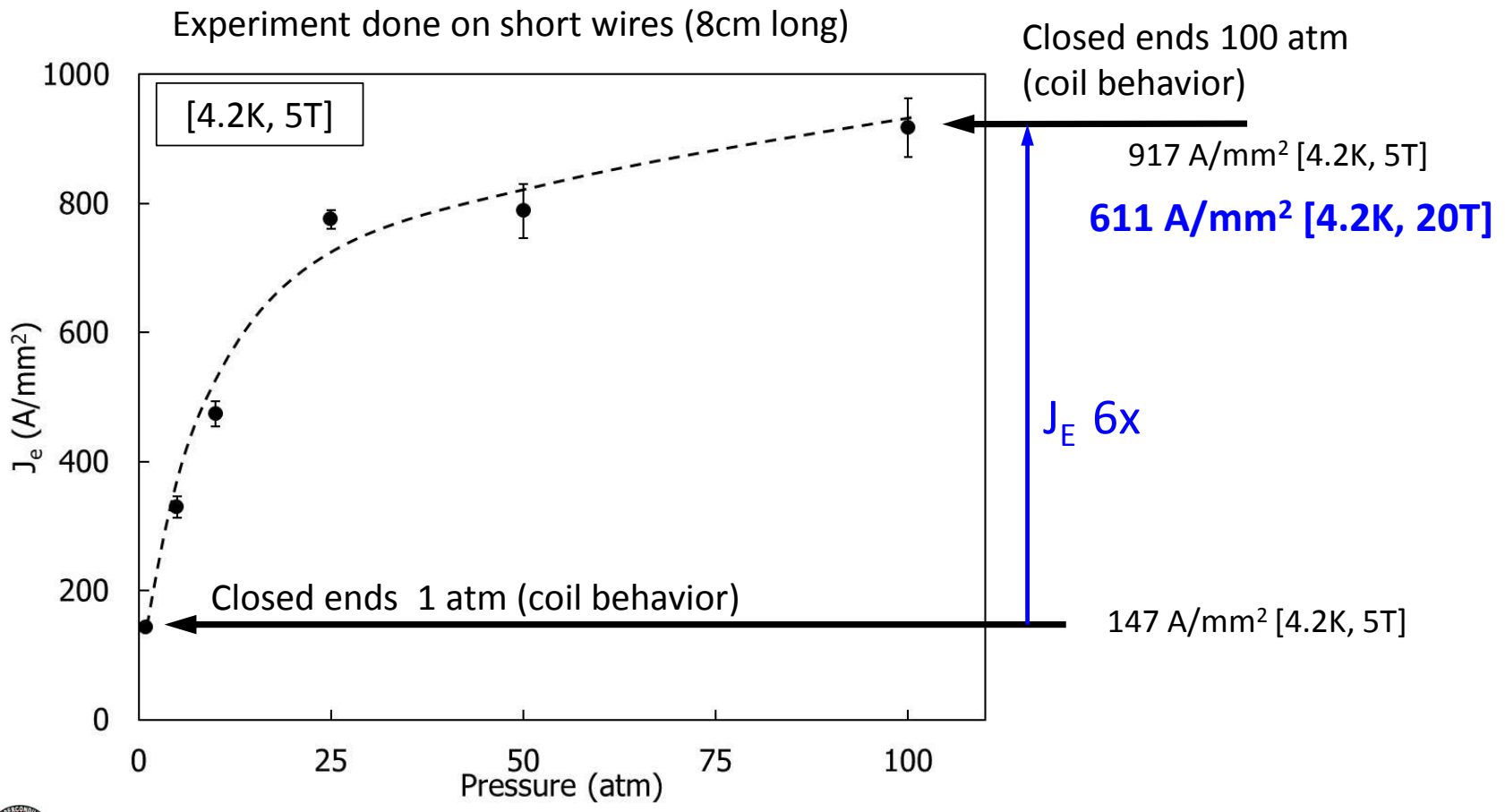
- **Open ends 1 atm: 65% dense**



- **Closed ends 100 atm: ~98% dense**

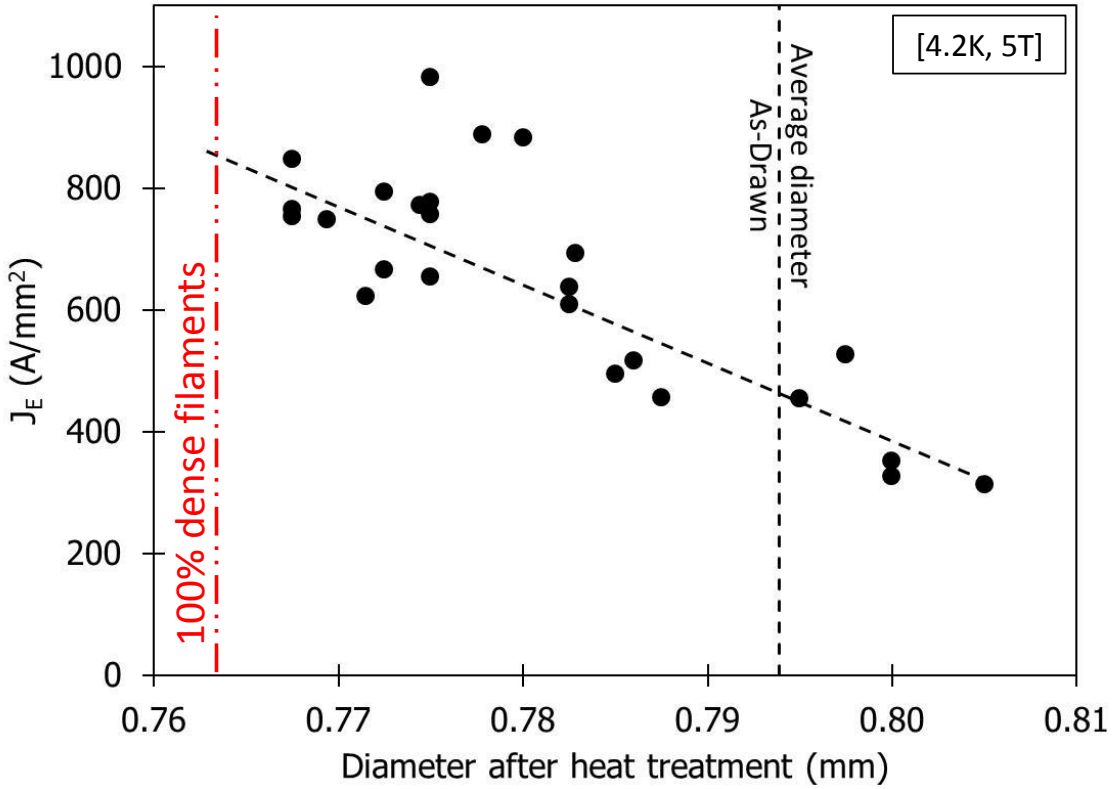


Overpressure is the key for high J_E

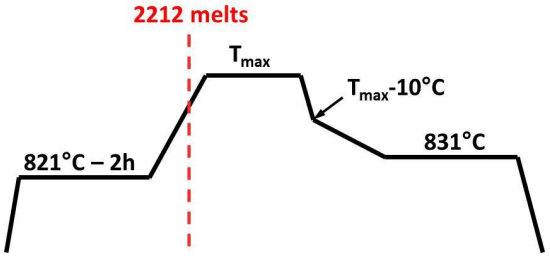


Dense filaments is the key for high J_E

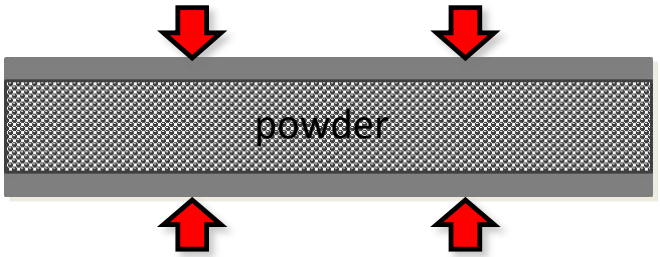
0.8 mm diameter wire, double stack architecture



When does densification occur?

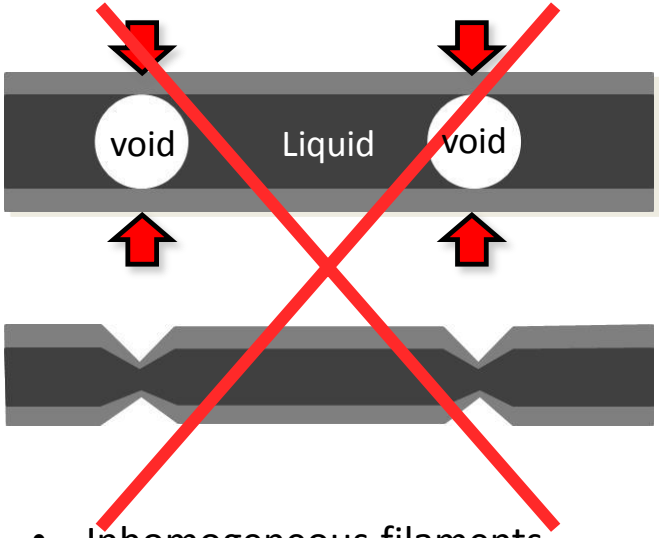


Densification before melt



- Homogeneous filaments,
- Densification only increases J_E

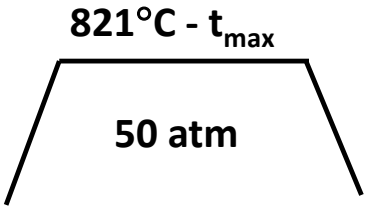
Densification after melt



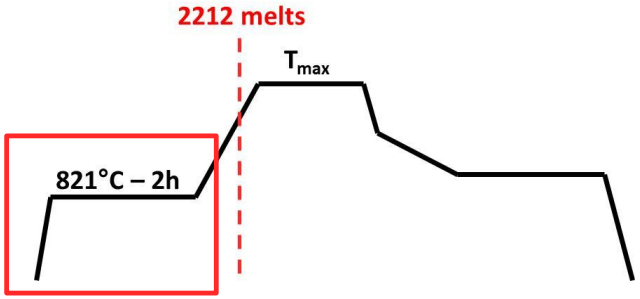
- Inhomogeneous filaments,
- Densification limits J_E

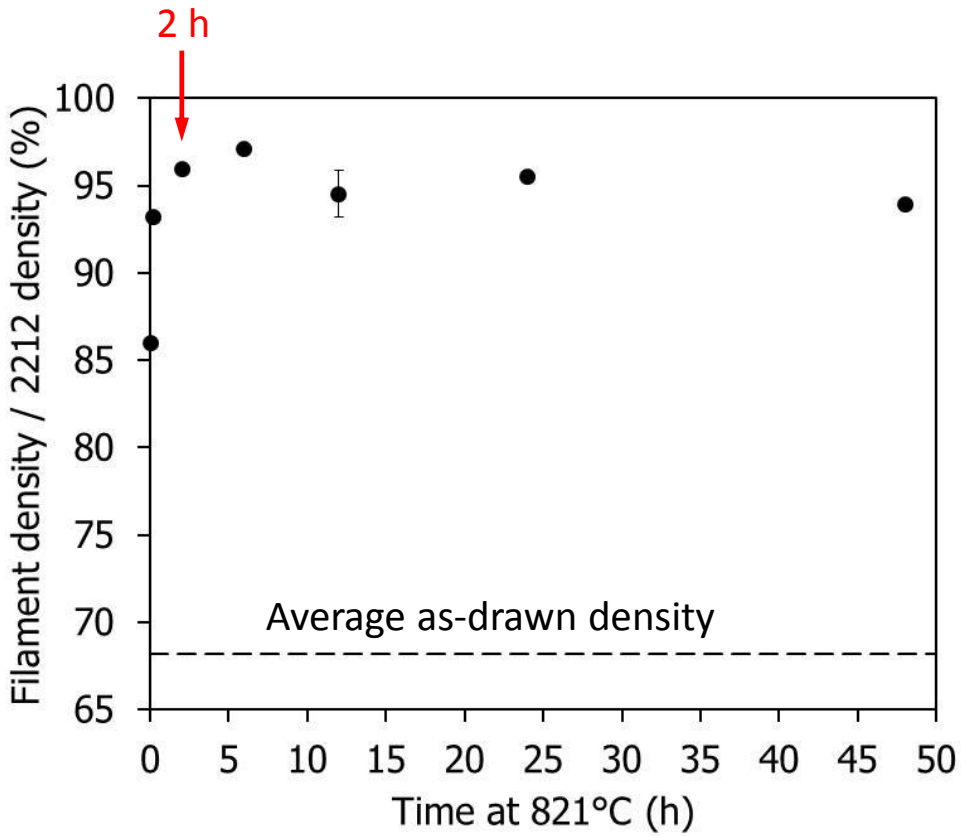
2212 wires densify at 821°C in 2h

Heat treatment:



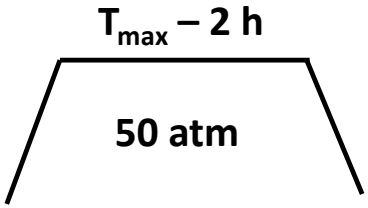
Densification occurs within 2 h



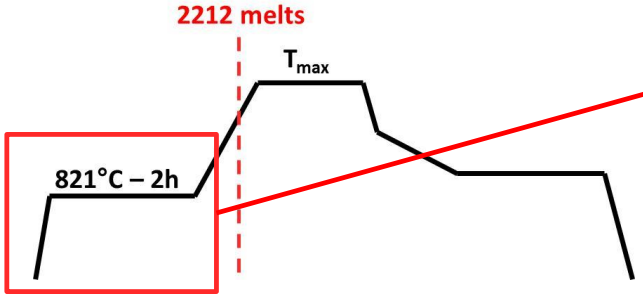


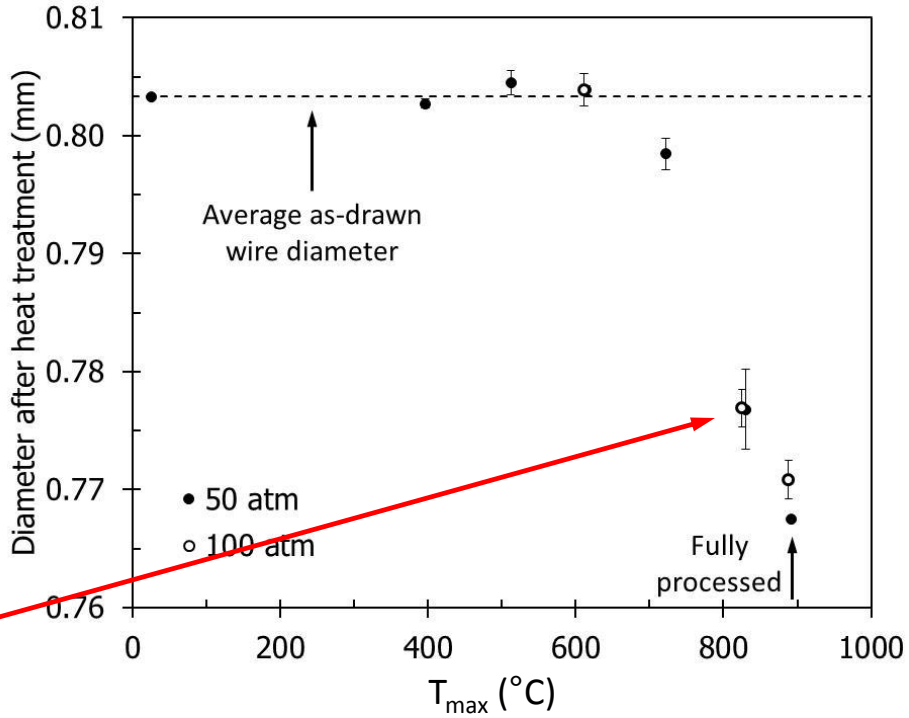
2212 wires fully densify at about 821°C in 2h

Powder densification:

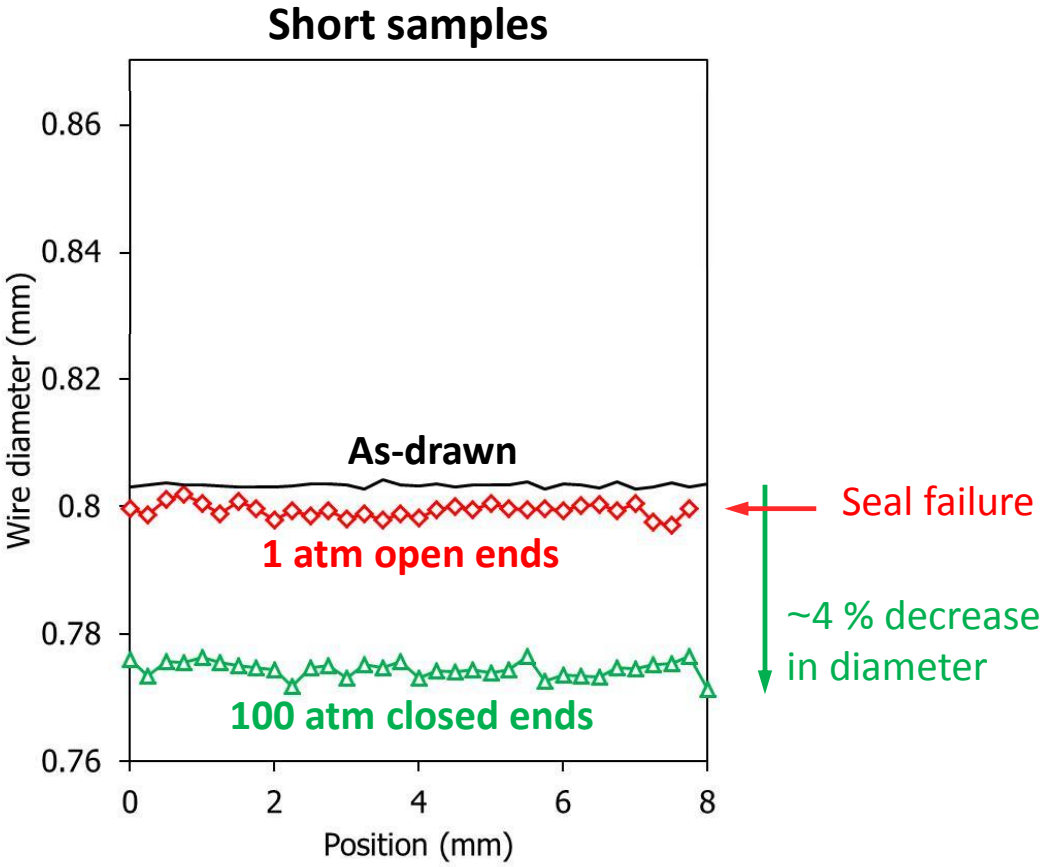


- **Densification is reached at about 821°C for 2h.**
- **50 atm and 100 atm show similar results.**





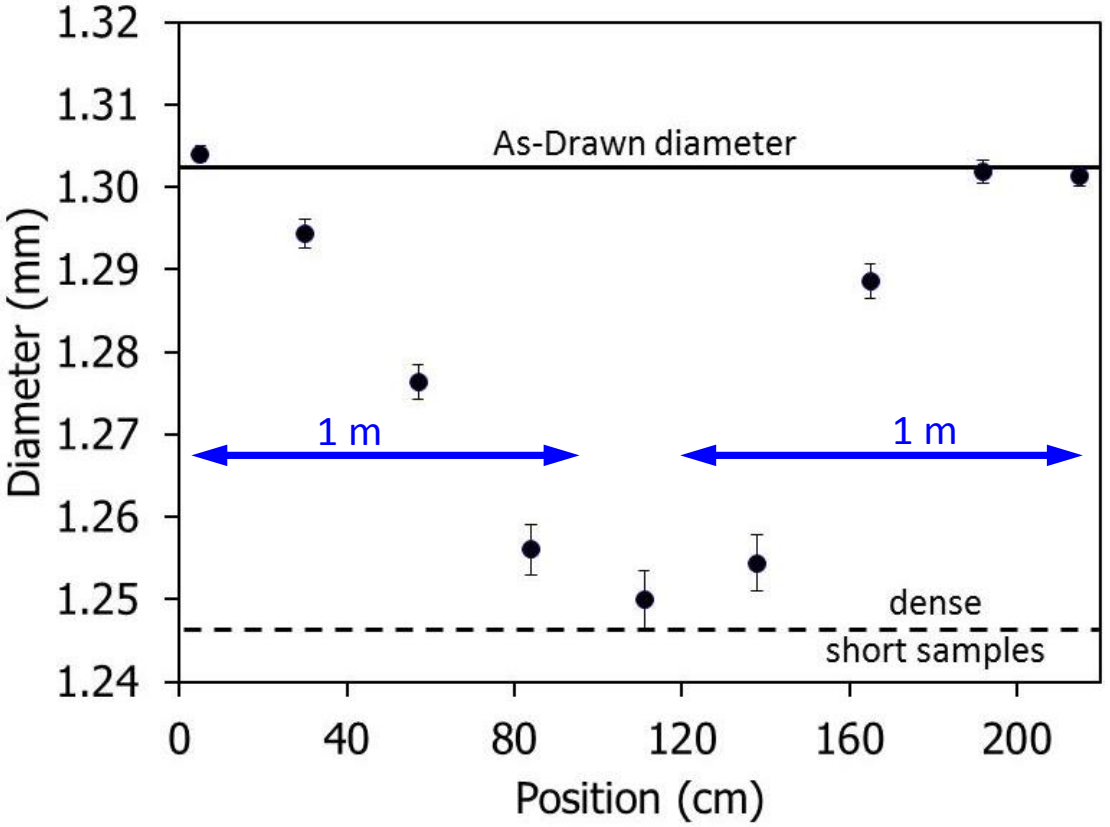
4 % decrease in wire diameter at 100 atm



Wire fully densifies about 1 m in from the open end

- 2.2 m long sample
- Fully heat treated
- 100 atm
- Both ends open

- 1 extra meter needs to be added to coil terminals when OP processed



Conclusion

- Wire densification with overpressure is the key for high J_E.
- High densification is reached before 2212 melts.
- Densification is complete around 821°C within 2 h.
- Wire diameter decreases by 4 % at 100 atm.
- If seal fails, wire is fully dense up to 1 m in from the open end.

Acknowledgement

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THANK YOU
FOR YOUR ATTENTION