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Application of SuperPower 2G HTS Wire to High Field Devices

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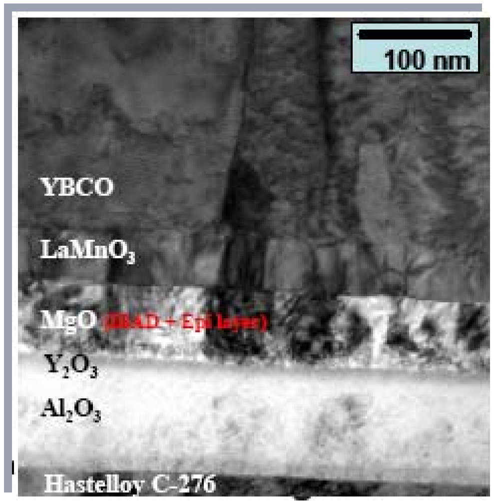
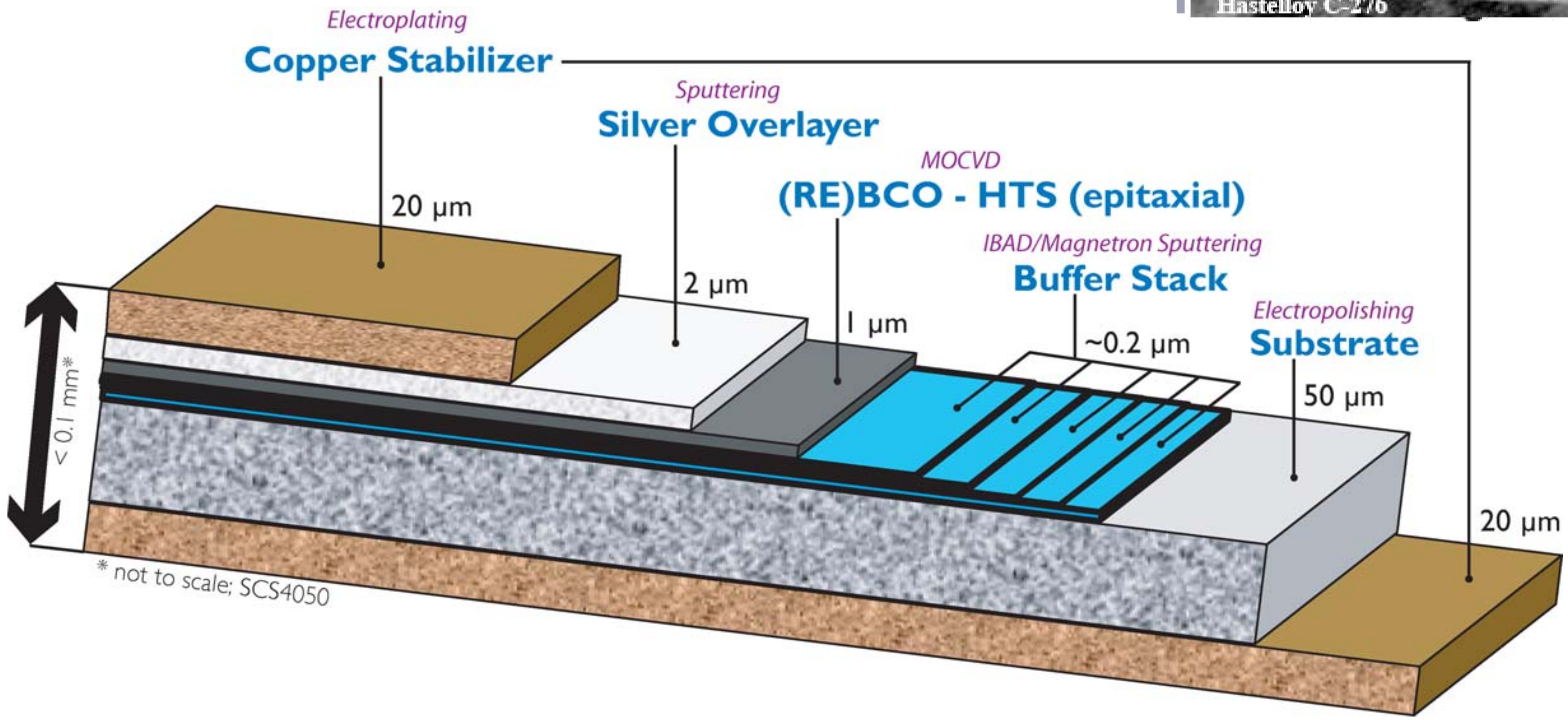
1911 ~ 2011
Celebrating 100 Years
of Superconductivity

Demands on conductor for high field applications

- High current density
- High strength
- Long lengths
- High operating currents (particularly for HEP applications)
- Low ac losses (to enable fast charge/discharge)
- Persistent current switches / joints (NMR applications)

SuperPower 2G HTS architecture

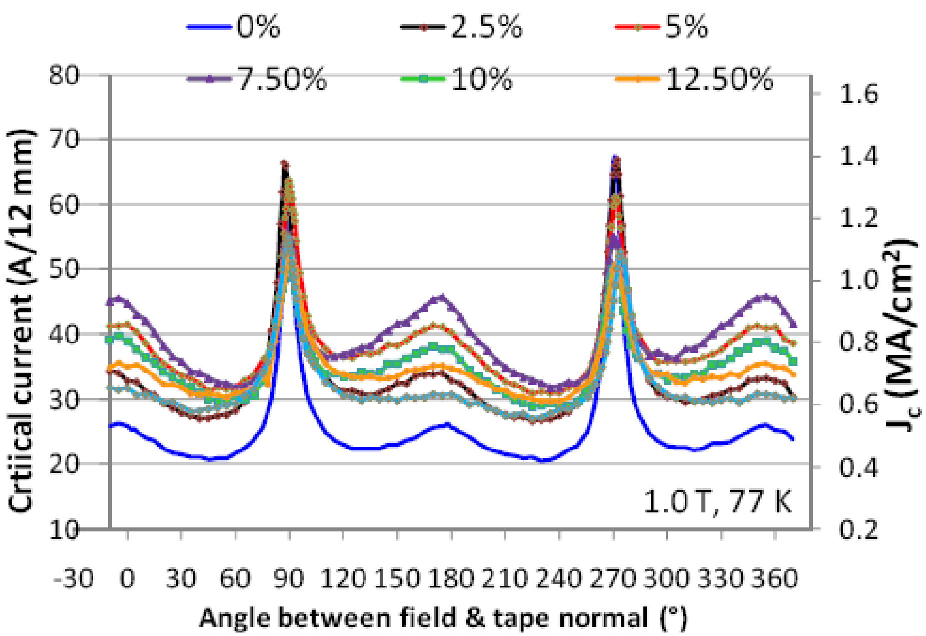


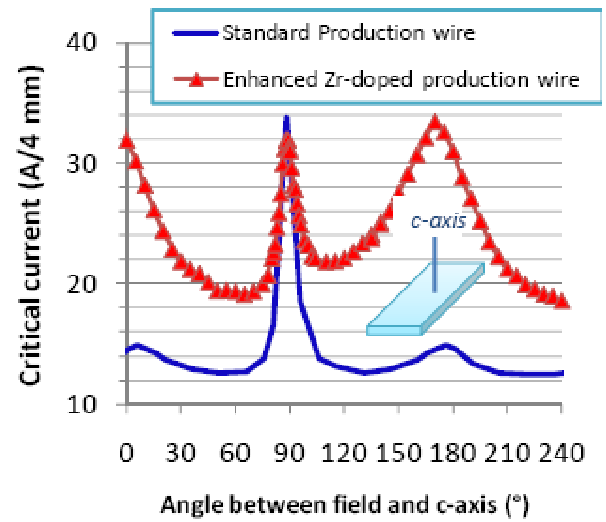


SuperPower 2G HTS current density enables high field magnet work

- Thin cross-section translates into high engineering current density needed for compact high field magnets
- Improvements in (RE)BCO thickness and advanced pinning drive current density enhancements
- Hastelloy C276 substrate provides high strength required for high field inserts
- No additional reinforcement needed in many designs, enhancing current density

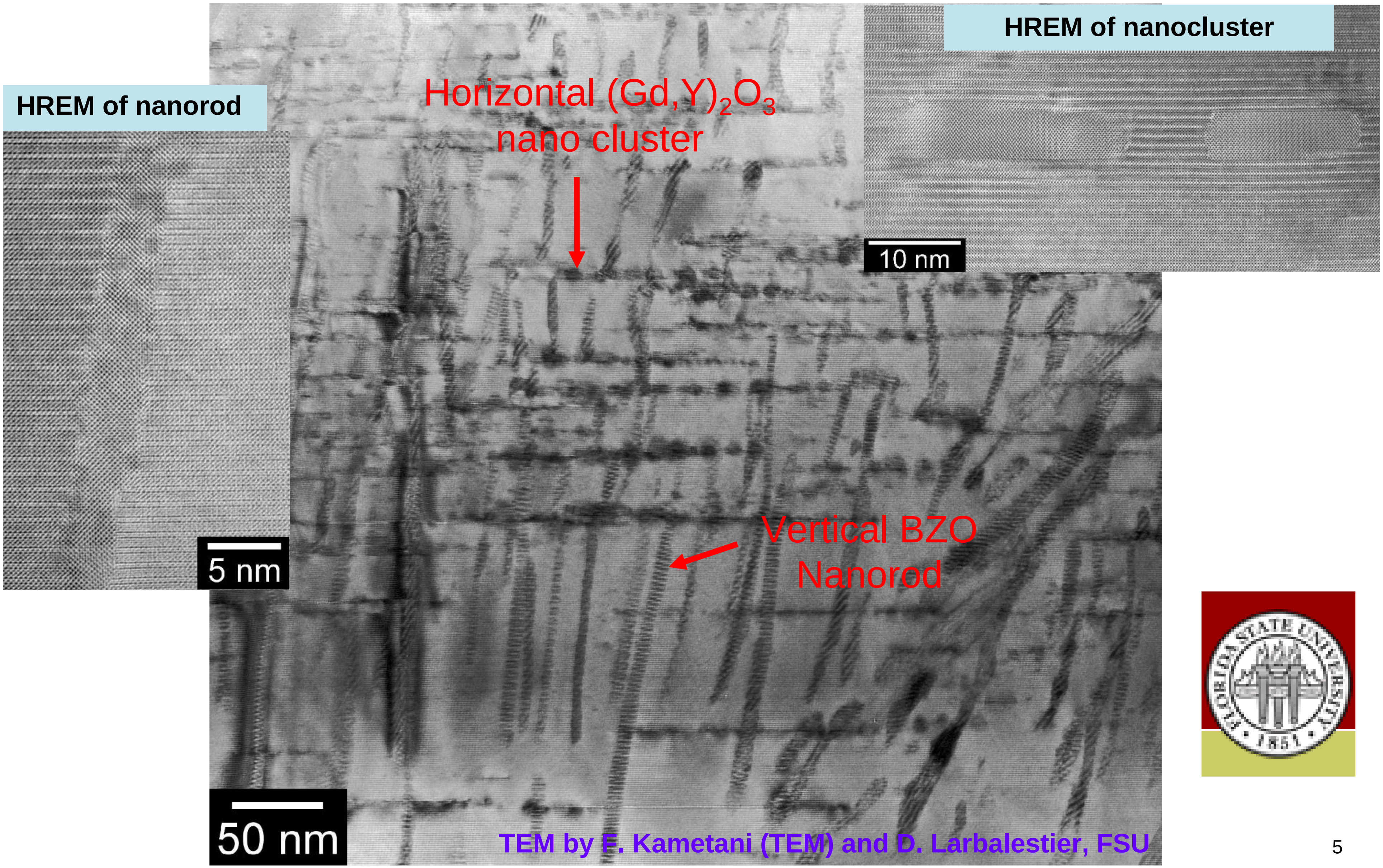
Improved pinning by Zr doping of MOCVD (RE)BCO layer





- Systematic study of improved pinning by Zr addition in MOCVD films at UH
- Process "know how" transitioned to SuperPower manufacturing

Development of nano-defect pinning sources



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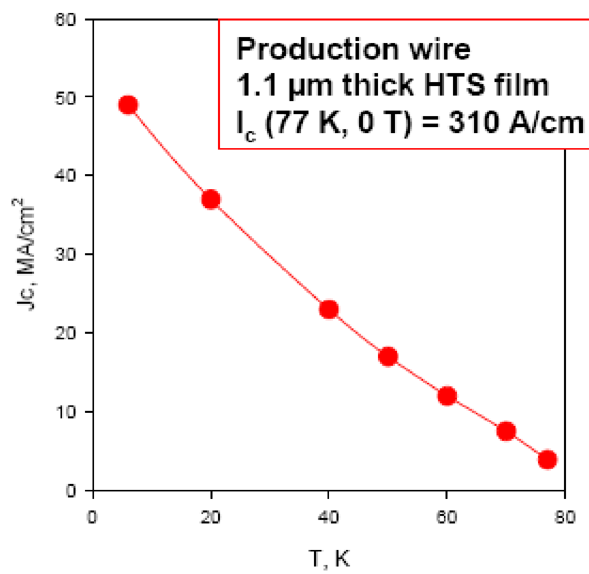
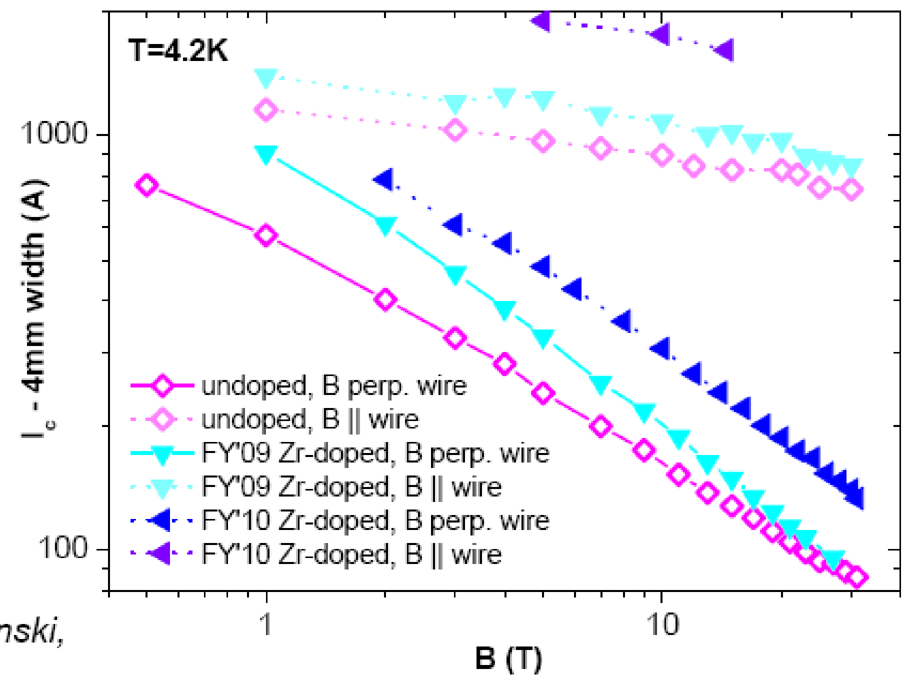
Ic improvement by pinning extends to higher fields





Measurements by V. Braccini, J. Jaroszynski, A. Xu,& D. Larbalestier, NHMFL, FSU

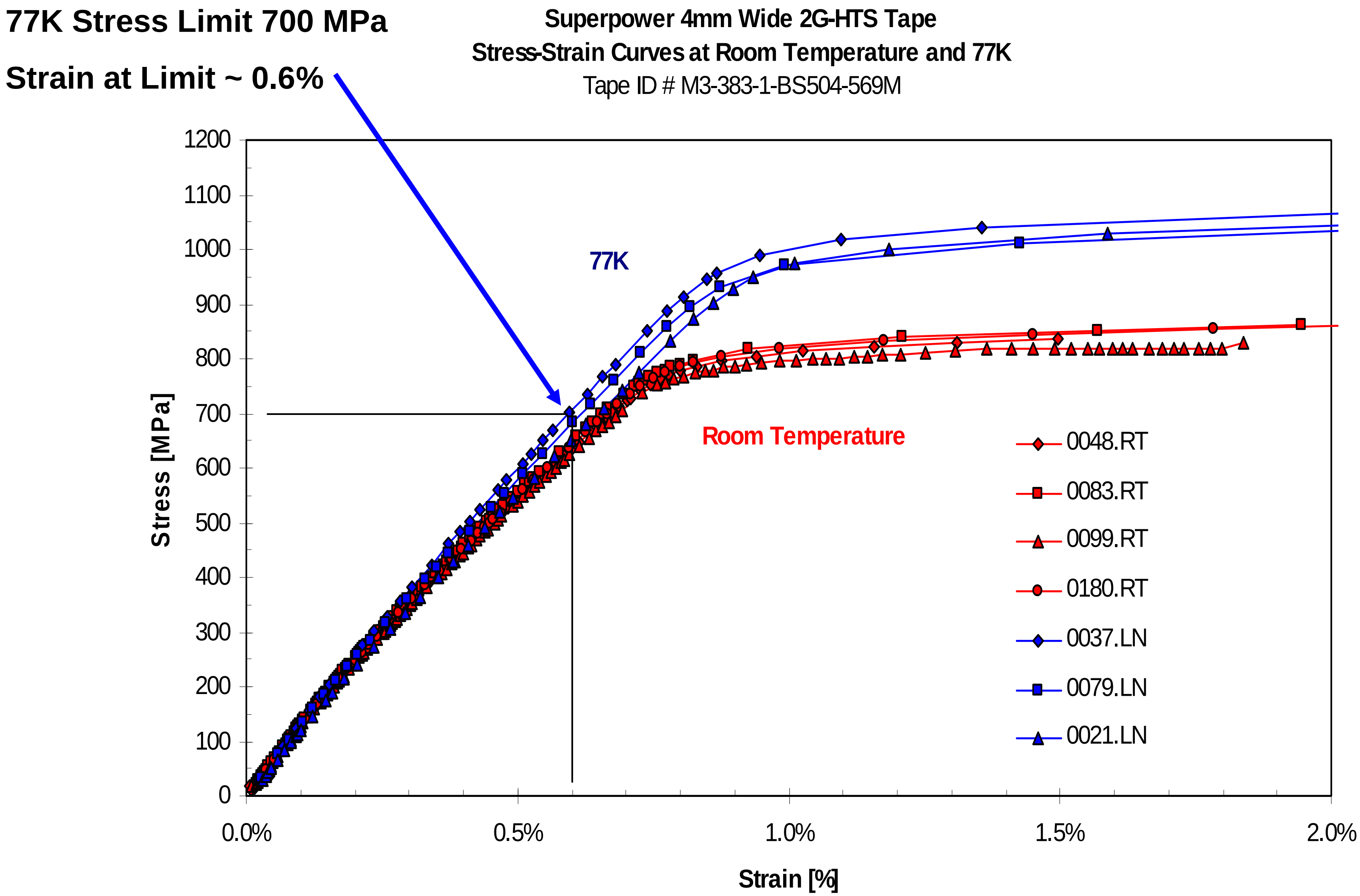
Advances with Zr-doping locked into production

Summary of mechanical properties

Yield Stress (77K)	970 MPa (140.7 ksi) @ 0.92 % strain
Stress Limit (77K) 98% Ic reversibility 90% Ic(zero strain) at limit (slide 3)	700 MPa (101.5 ksi) @ 0.6 % strain
Modulus Initial (77K, before Cu limit) Final (77K, after Cu limit)	 122.5 GPa 116.7 GPa
Fatigue Limit (77K)	> 100,000 cycles, <680 MPa tensile

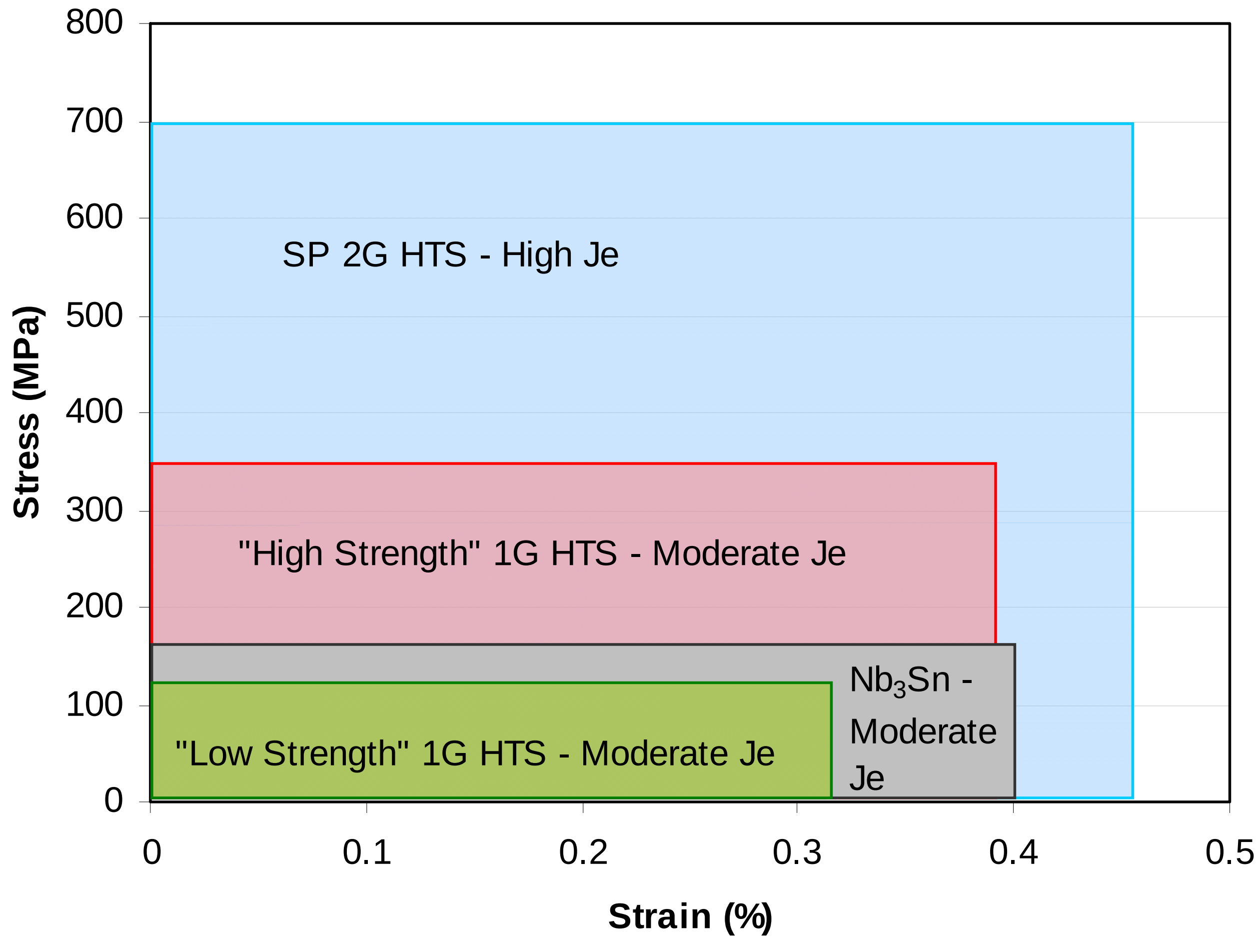
SCS4050 with 40 microns copper

SuperPower 2G HTS has excellent mechanical strength

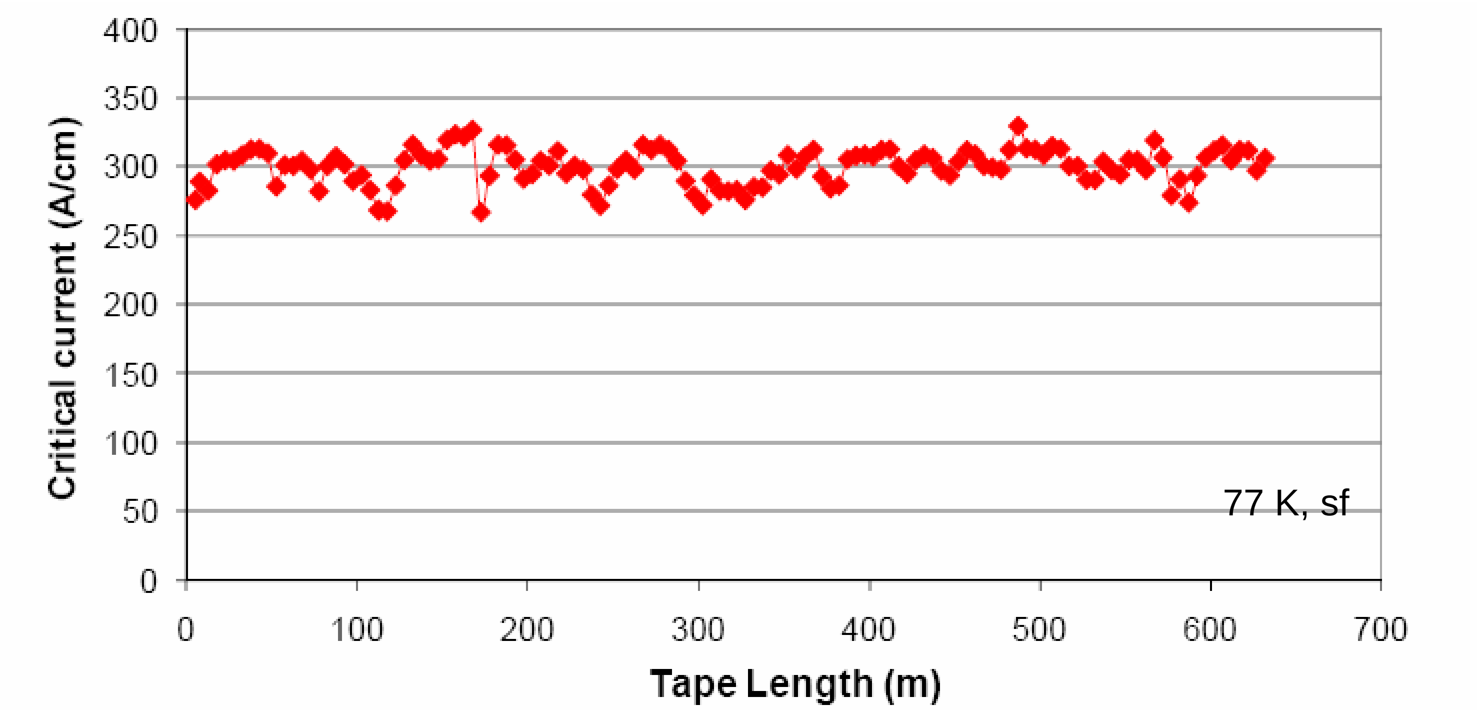


Data from R. Holtz, NRL

"React/Wind" SuperPower 2G HTS conductor has large operating stress-strain window compared to other conductors

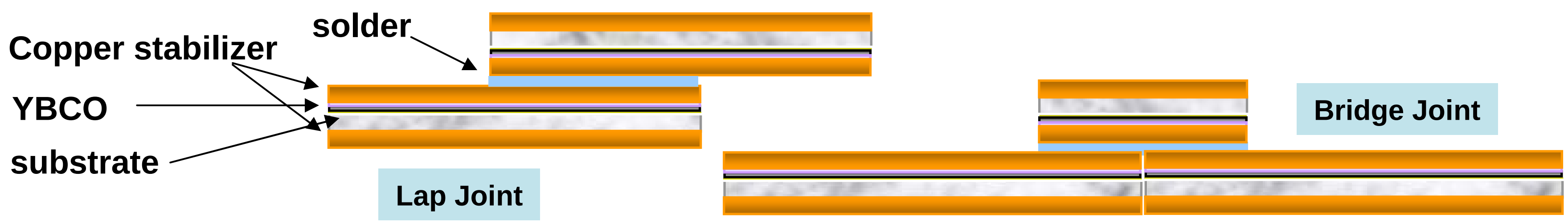


Routine manufacturing of Zr-doped tapes in long length initiated



Long tapes with Zr-doping exhibit critical currents of >250 A/cm in tapes run through the manufacturing facility

Low resistance joints/splices readily made



- No degradation in Ic (1 μV/cm) over the joint or splice
- Splice resistance typically ~ 10 nΩ (4 mm x 100 mm)
- No degradation in Ic and resistance when splice is bent over 25 mm diameter and thermal cycled three times.
- Variety of solders can be used (InAg, SnSb, PbSn)

Coil applications: world record performance achieved in HF insert coils with SP 2G HTS wire

2009:	27.4 Tesla at 4.2K in 19.9 Tesla background field (SP)
2008:	33.8 Tesla at 4.2K in 31 Tesla background field (NHMFL)
2007:	26.8 Tesla at 4.2K in 19 Tesla background field (SP)
2006:	2.4 Tesla at 64K in self field (SP)


2009 Insert Coil

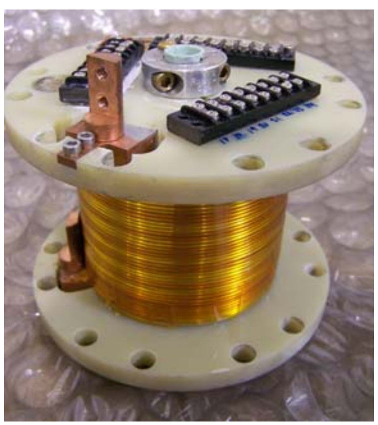
Look for new results from
- NHMFL
- MIT
- BNL

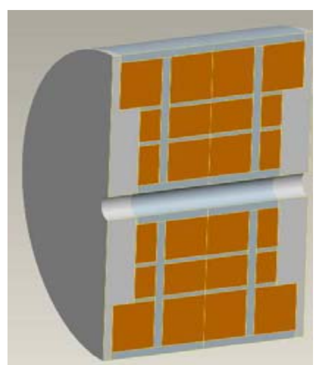
New superconducting magnetic energy storage (SMES) project initiated

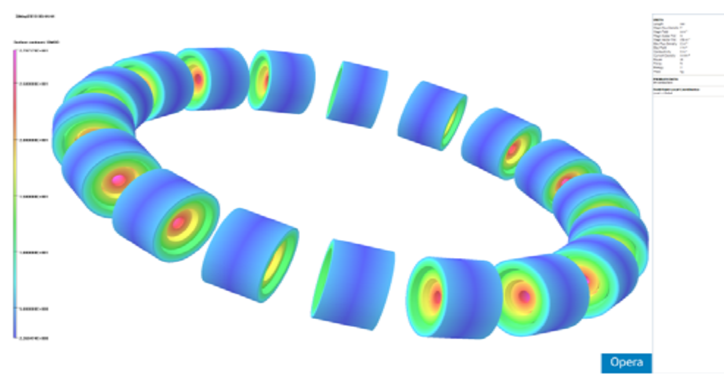
- ARPA-E funded proof of concept project recently awarded ($5.2M/3yr)
- Project Participants
  - ABB (lead – power electronics / system integration)
  - Brookhaven National Laboratory (high field coil design / fabrication)
  - SuperPower (2G HTS / coil design support)
  - Univ. Houston (enhanced 2G HTS fabrication)
- Storage capability in proof of concept coil (~2.5 MJ / 20 kwh)
  - 25 Tesla coil
  - Enhanced power electronics
  - >80% round trip efficiency

Why high field HTS SMES?

- Energy stored scales as $B^2 * r^{3,}$ while losses scale as r^2
- 2G HTS enables high field operation for a compact, high energy density system
- Toroidal geometry lessens the external magnetic forces, reducing the size of mechanical support needed.
- Fields in a toroidal SMES are mainly axial (//a,b), maximizing the use of 2G HTS
- Due to the low external magnetic field, toroidal SMES can be located near a utility or customer load.







Challenges

- High fields equate to high stresses
  - mainly hoop stress << SP 2G HTS can handle up to 700 MPA hoop stress
- High performance conductor required for economics to be competitive with advanced batteries (need to be in the $50/kAm range)
- Persistent current joints / switches highly desirable to reach loss targets
- Long lengths will be required to minimize / eliminate splices / joints (each splice is a loss source)

Questions?

Thank you for your interest!

For further information about SuperPower,

please visit us at: www.superpower-inc.com

or e-mail: info@superpower-inc.com