

Wire Development Group (WDG)

Research Towards Advanced HTS Wire Technologies

2003 DOE Annual Peer Review
July 23, 2003
Washington, DC

Argonne National Laboratory



University of Wisconsin-Madison

Los Alamos
Superconductivity Technology Center

Outline

- | | |
|---|-------------------|
| 1. WDG approach and overall performance | Malozemoff (AMSC) |
| 2. Novel processing | Hellstrom (UW) |
| 3. Characterization | Holesinger (LANL) |
| 4. Current limiting mechanisms and FY04 plans | Larbalestier (UW) |

Conclusions

- Wire Development Group is best-in-class worldwide in advanced HTS wire development
- 1G wire an ongoing critical element of DOE program
 - *We seek continued strong DOE support*
- 2G wire making rapid progress but needs critical issues addressed
 - *We propose extending WDG activity to 2G*

The Context: Status and Economic Viability of HTS Wire

AMSC producing first generation (1G) multifilamentary composite BSCCO wire

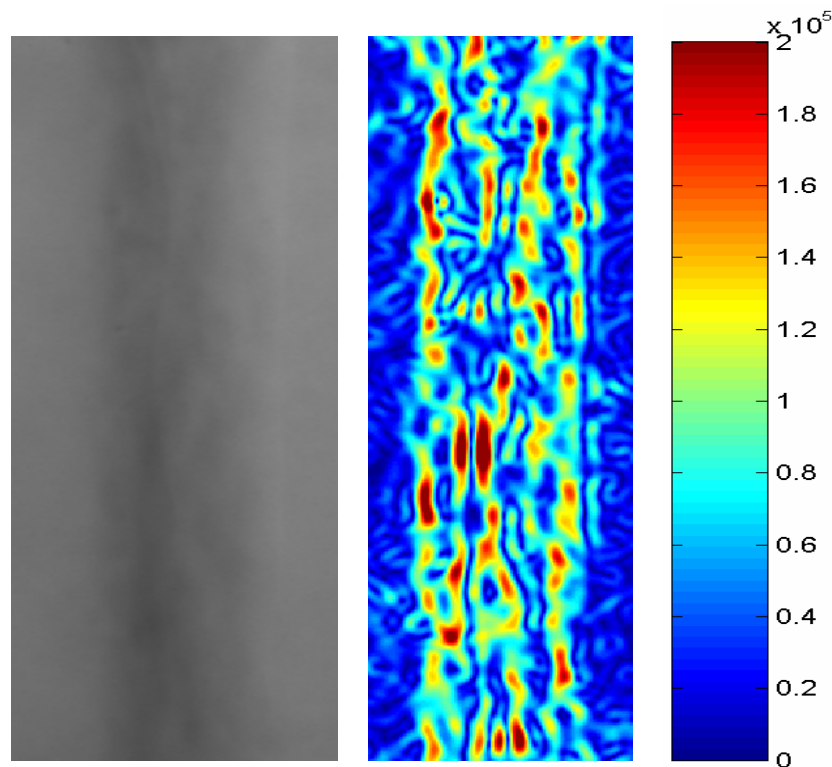
- 2003: Devens HTS wire manufacturing plant in operation, capacity at 900 km/year; designed for just-in-time expansion
- Commercial sales underway
- Targeting \$50/kA-m (77K,sf) price-performance

To broadly replace copper, \$25/kA-m required

- Need advanced technology with higher I_c , lower cost
- Second generation (2G) YBCO coated conductor advancing rapidly through R+D stage
- 1G wire also continues to improve

WDG focused on establishing and accelerating advanced HTS wire technologies

MO Image of Overpressure Processed (OP) 1G Wire (UW)



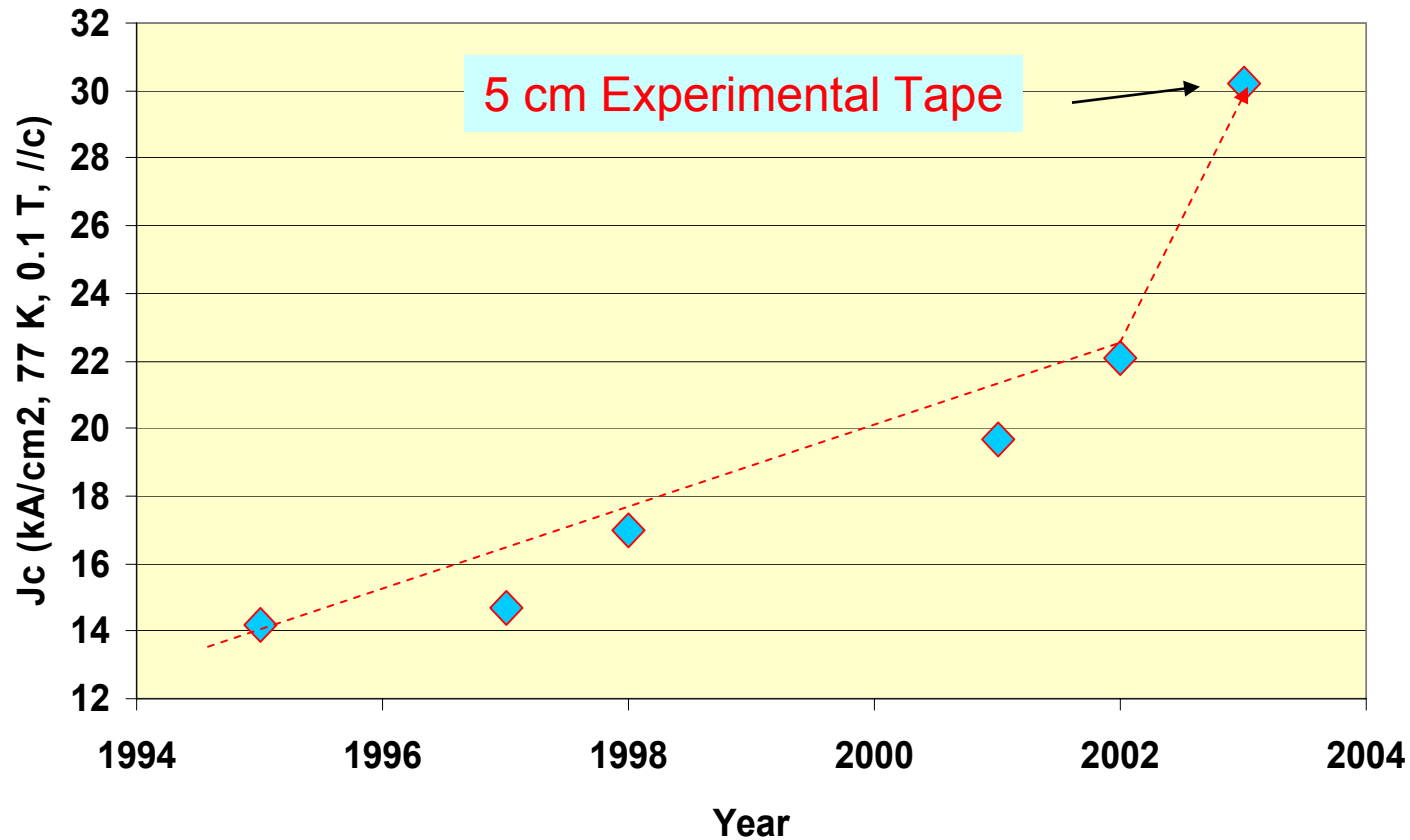
***>200 kA/cm² regions observed:
Significant headroom for further 1G progress!***

WDG Meeting All GFY2003 Objectives

- I. Evaluate new process approaches for 1G wire, controlling density, texture, secondary phases; demonstrate $>10\%$ I_c increase
- Done:** Over-pressure processing (OP) – *>30% performance enhancement on AMSC production wire (UW)*
 - Done:** Optimize thermal slide heat treatment (TSHT) – *process time reduced by ~65% (ANL)*
- II. Refine structure-property understanding
- Done:** Understand effect of 2212 intergrowths – *mechanism confirmed, process modifications introduced into AMSC production (LANL, UW, AMSC)*
 - Done:** Measure and model current limiting properties on smaller length scales – *new laser scanning method and local current flow model introduced (UW)*

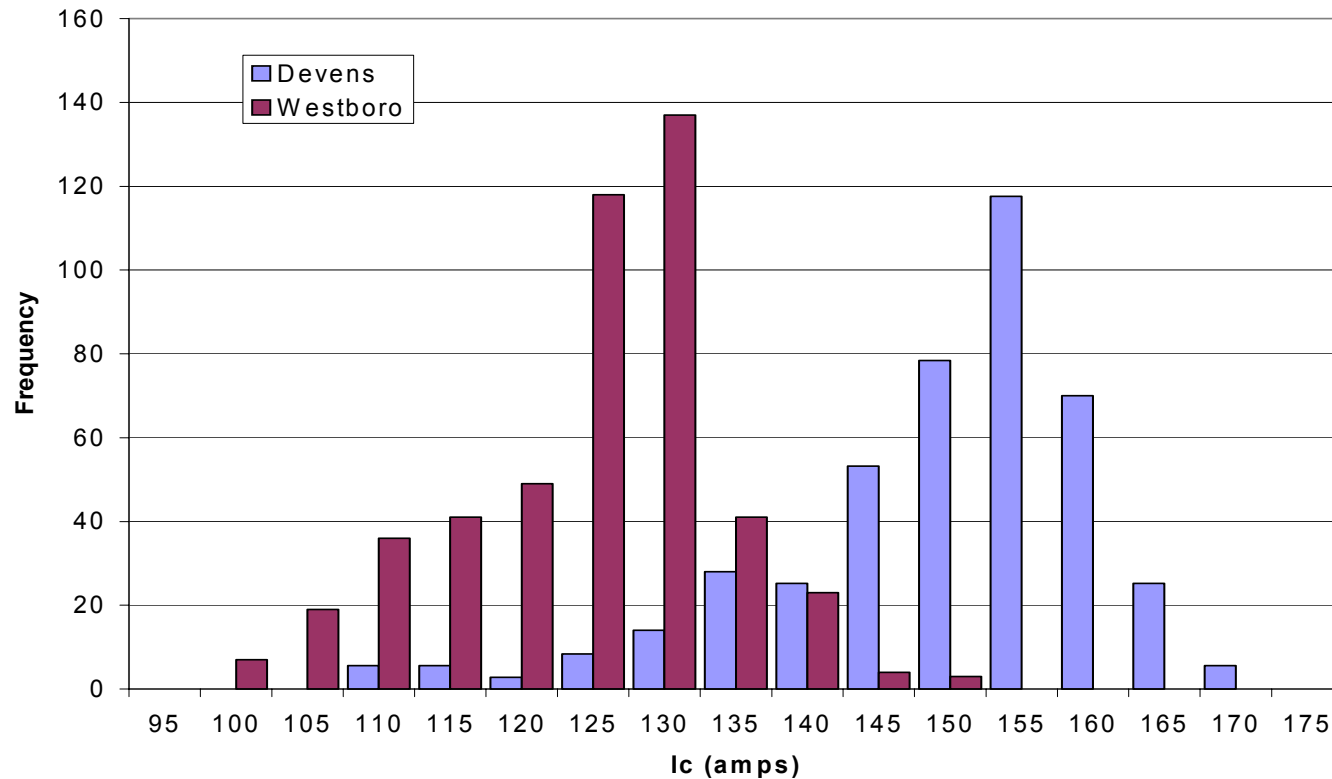
Exceeding plan in I_c enhancement

FY03 Result: New 1G R+D (OP) Wire Record Performance



At 77 K, self field, this wire carries a record 185 A

FY03 Results: AMSC 1G Production Wire I_c Enhanced by New Processing



***170 A performance (77 K) corresponds to
>400 A/cm-width: best in class for production wire***

Importance of Ongoing 1G Wire Research

- 1G is commercially available HTS wire, with demonstrated performance and reliability
- *All* HTS electric power equipment to date and for next three years uses 1G wire: the basis of the industry
- Maintaining US leadership requires ongoing improvement
- Potential for \$25/kAm
- Commercial manufacturing of any alternatives (2G) up to 3 years out

1G wire the “silicon” of the HTS industry - ongoing DOE support of WDG critical

WDG Scope

Mission:

Develop the materials science base for advanced HTS wire technology, maintaining and extending US world leadership

Program Approach:

- Leverage unique resources and competencies of world's leading HTS company, two leading DOE labs, and a major university program
- Focus on developing advanced HTS technology wire in a multi-year collaborative partnership

***12 year experience base for effective co-operation
and progress: best in class worldwide***

WDG Financial and Legal Framework

'No-funds exchanged' CRADA agreements between team members:

AMSC (CRADA support)	\$ 575K
LANL	\$ 225K
UW	\$ 750K
ANL	\$ 350K
Total DOE supported	\$ 1325K

AMSC invested \$3.5M total in its FY2003 in 1G R+D: strong commitment to 1G technology leadership

WDG Leverages Complementary Competencies

AMSC	Process innovation Product development and manufacturing Customer input to wire specifications
LANL	TEM, deformation expertise
ANL	Chemistry and reaction expertise Unique characterization: Raman, Adv. Photon Source
UW	Electrical and magnetic characterization; spatial imaging Theoretical understanding of current limiting mechanisms Special processing capabilities – overpressure

Altogether the world's most powerful effort advancing HTS wire technology

Present WDG Participants

Principals:

Huang, Rupich, Otto, Malozemoff	AMSC
Holesinger	LANL
Maroni	ANL
Larbalestier, Hellstrom, Cai	UW

Other Key Contributors:

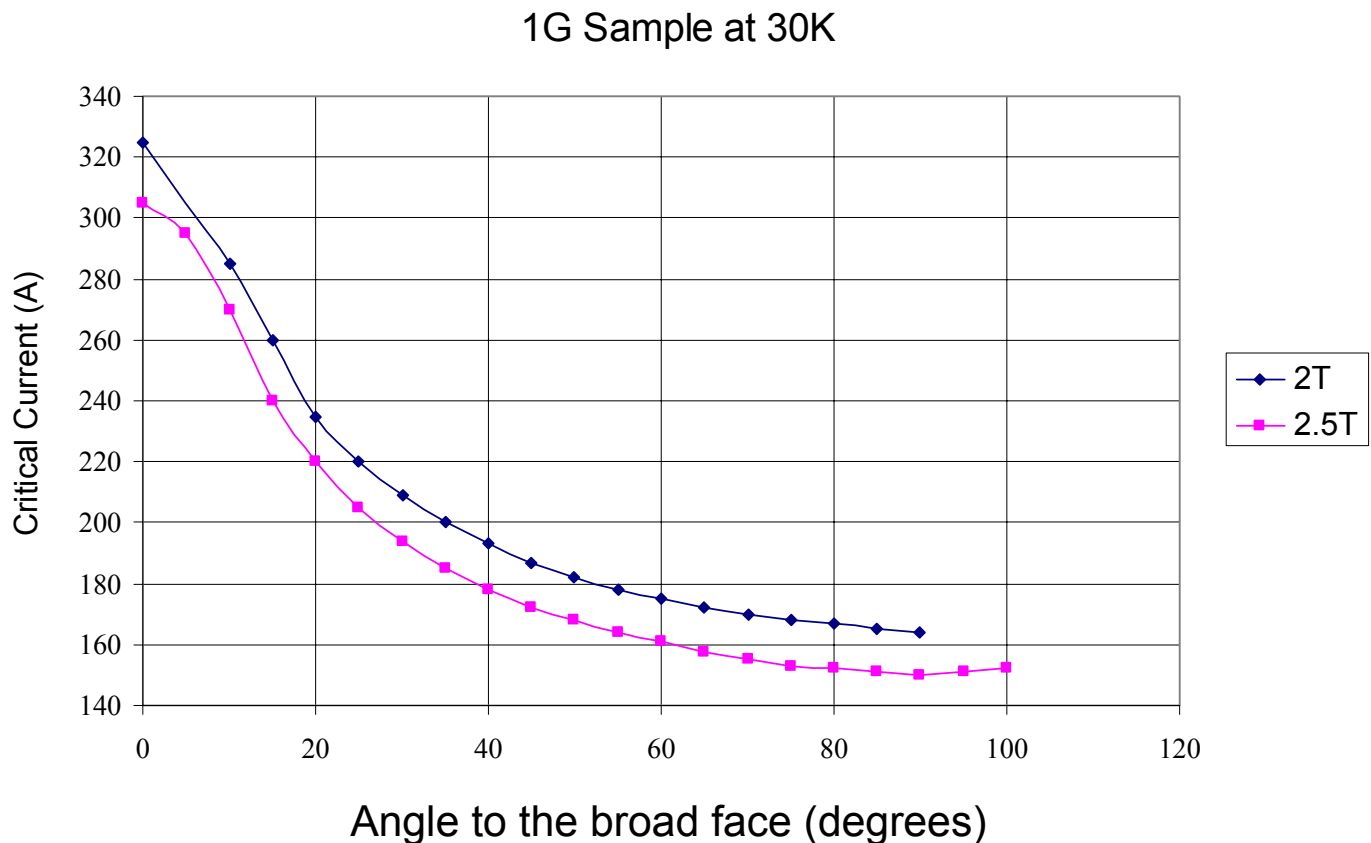
Fleshler	AMSC
Baurceanu, Fischer, Mika	ANL
Willis	LANL
Abraimov, Chandler, Jiang, Liso, Patnaik, Polyanski, Schwartzkopf, Yuan	UW

Future Directions of WDG

- 1G wire process continues to offer significant opportunities for improvement
 - To be described in following presentations
- 2G coated conductor issues form ideal topic for WDG expertise base
 - Characterization and understanding of unusual $J_c(B, T, \theta)$
 - Improved pinning to enhance J_c

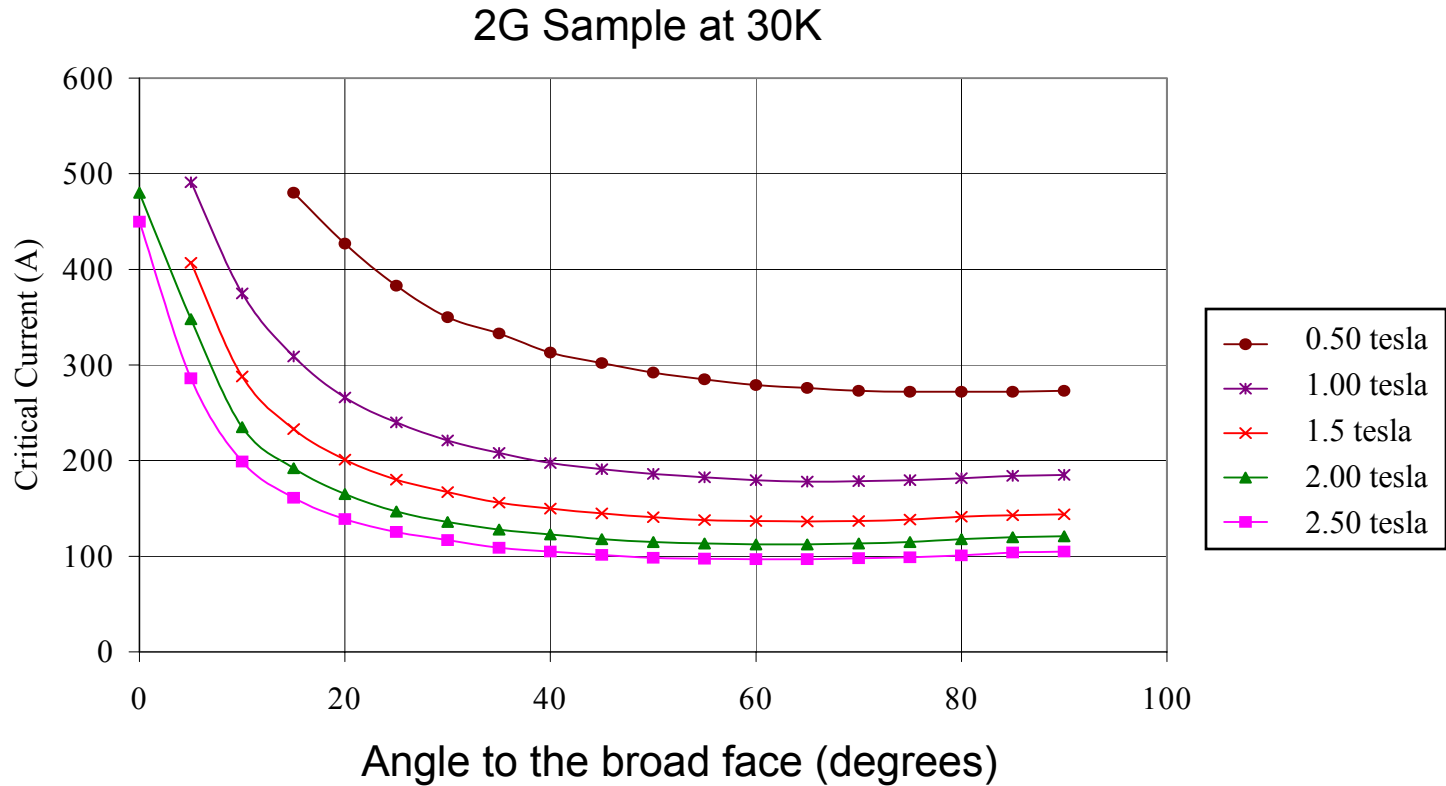
For FY04, we propose to broaden the scope of WDG activity to include 2G as well as 1G

Critical Current of 1G Wire at 30K vs Magnetic Field Angle Out of Plane



BSCCO-2223 shows “conventional” angle dependence

Critical Current of 2G Wire at 30K vs Magnetic Field Angle Out of Plane



*I_c in 45° range limits performance in coils:
an important Issue for 2G wire*

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