

Coated Conductor R&D Status in Europe

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U.S. DOE Wire Development Workshop

St. Petersburg, Florida

German national laboratories developing YBCO coated conductors (Update 01/03)

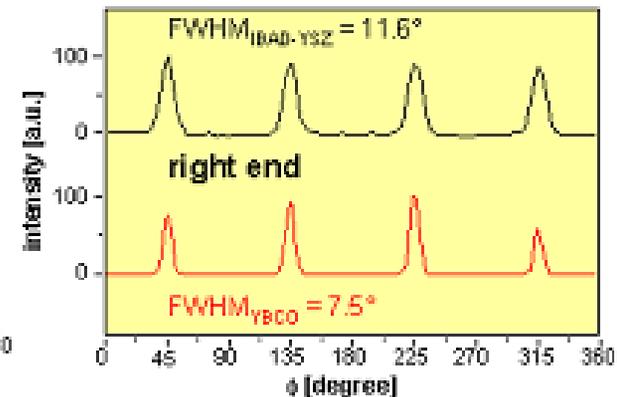
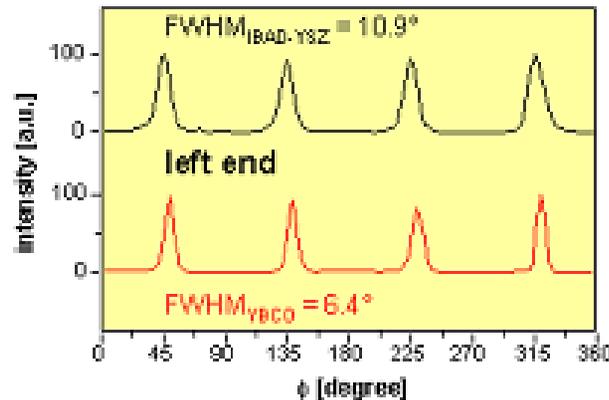
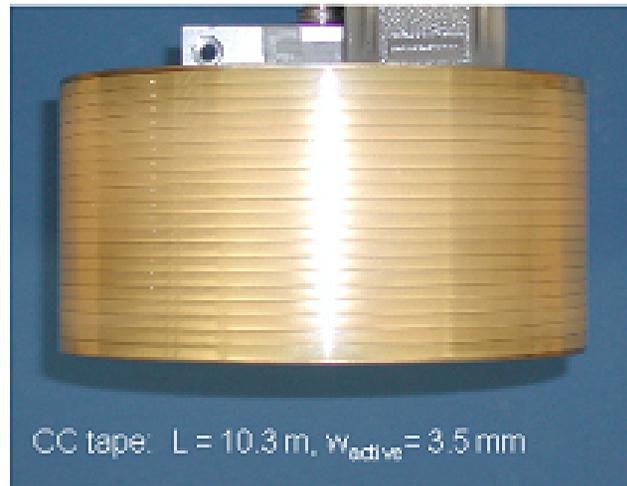


Company	Country	YBCO process	Tape length (m)		Critical current density (MA/cm ²)	Critical current (A/cm width)
<i>IBAD</i>						
Univ. Göttingen/ZFW	Germany	PLD	1		1.3	317
			10		2.2	223
			15		X	X
Siemens CT EN4	Germany	TCE	0.2		>1.6	>105
<i>ISD</i>						
TU Munich	Germany	TCE	Short sample		0.79	X
<i>RABiTS</i>						
THEVA + IFW Dresden	Germany	TCE	0.2		0.75	X
Siemens CT EN4	Germany	TCE	0.2		0.5	X
Cryoelectra	Germany	MOCVD	Short sample		>1.4	X

“X” values: No reliable and recent information published or available.

Data courtesy of H.-W. Neumueller

Oak Ridge National Laboratory
U.S. Department of Energy



- SS tape (0.1 mm) // IBAD-YSZ (1.3 μm) // CeO_2 (<0.1 μm) // YBCO (1.0 μm)
- Coated Conductor : **10 m long, 4 mm wide, with 3.5 mm wide YBCO film**
- Critical current, I_c , and current density J_c :
 $I_c = 78 \text{ A}$ & $J_c = 2.23 \text{ MA/cm}^2$, & $I_c/w = 223 \text{ A/cm}$ (77K, SF)

ZFW data, continued

- **Tape uniformity**
 - **7.8-m tape: 105 +/- 5 amperes (22-cm voltage taps)**
 - **20 long-length tapes have been made, with better than 10% uniformity**
- **Highest current: 20-cm long, 391 A/cm width (3.5-mm wide tape)**

cnc technologies GmbH formed

- **Taking orders for YBCO tapes**
- **A “real, registered company” in Germany**
- **Company address is H. Freyhardt’s home address**
- **Capital must be acquired**
- **All employees part time (they’ve kept their day jobs)**

Funding for superconductivity “tight” in Europe

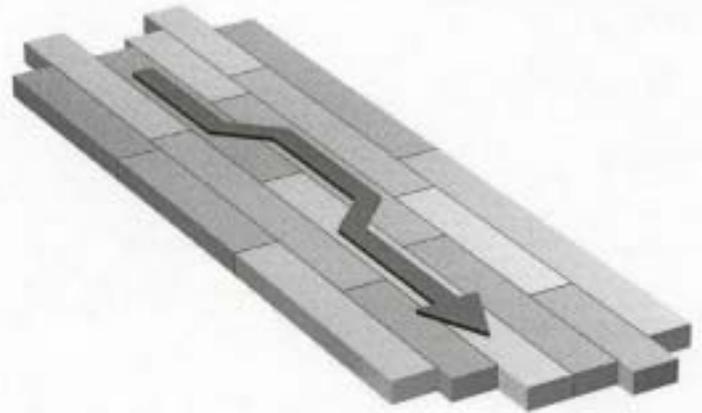
- **German government plans to reduce coated conductor funding to zero in 2005**
 - **All German national labs are “cooperating” in responding to a recent call for proposals; integrated program proposed; Ministry of S&T expected to fund**
- **December 17th call for proposals issued via European “framework” program**
- **SPI-type projects will be funded (cables, motors, current limiters); proposals due March 2003**

Short sample results from Dec 2002 Fall MRS Meeting

- **University of Augsburg**
 - **Mechanism to enhance flux pinning**
 - **Attempting to dope just the grain boundaries (avoid T_c suppression)**
 - **$Y_{0.7}Ca_{0.3}BaCuO_{7-x}$ “dead layer” deposited on YBCO**
 - **Micro-bridge on RABiTS: J_c increased from 1.5 MA to 1.7 MA**
 - **Siemens’ IBAD sample (3mm x 1-cm): J_c increased from 1.4 to 2.1 MA**
 - **Enhanced J_c occurs in fields up to 8-T**

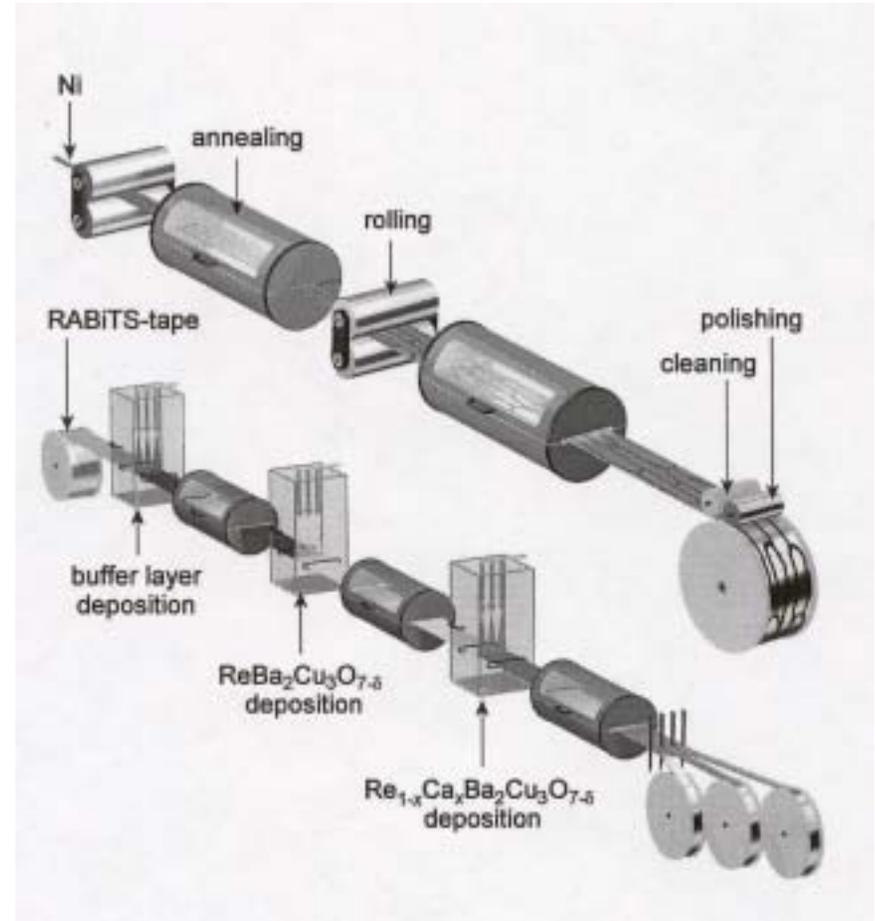
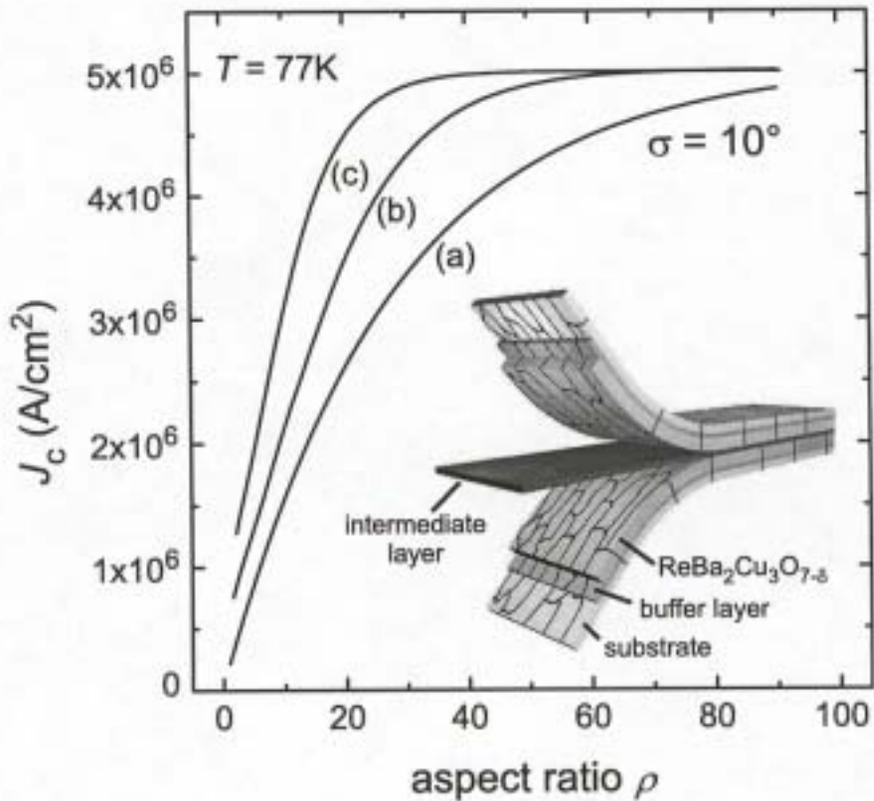
Augsburg, continued

- Researching “large aspected grains” to increase critical current
- 20 times longer than they are wide
- No data shown for actual samples
- Percolation models show a long, 1-mm wide sample (20-grains wide) would have negligible I_c decrease



Hammerl, et. al., APL 81 (17), 3209-3211, Oct 2002

Hammerl, et. al. (con't)



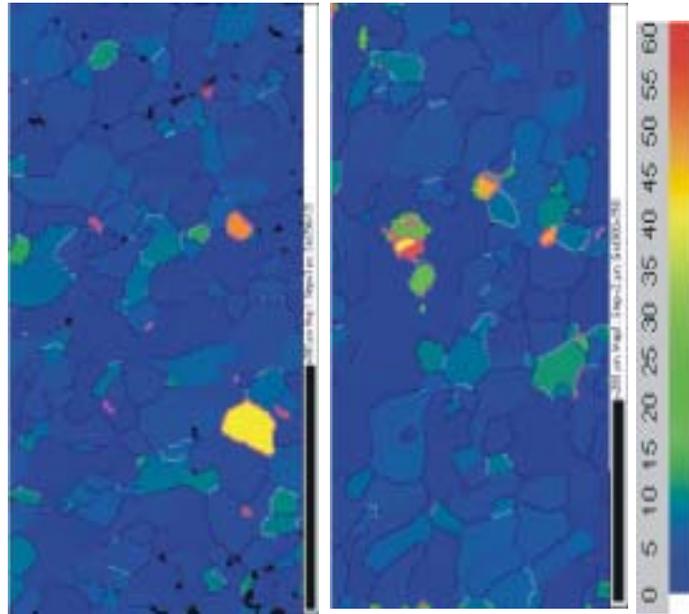
Hammerl, et. al., APL 81 (17), 3209-3211, Oct 2002

Additional German work on short samples

- **Single buffer layer (CeO_2) thermally evaporated on 100-um thick Ni-5%W and Ni-7%Cr substrates**
 - $T_c=91\text{K}$; $I_c(77\text{K})= 70$ amperes
 - No NiO formation based upon TEM examination
 - Used interesting Moire fringe technique to determine lattice mismatch of 3%
- **“Drawing and Annealing” (DABiTS) shows development of cube texture via cold drawing (IFW-Dresden)**

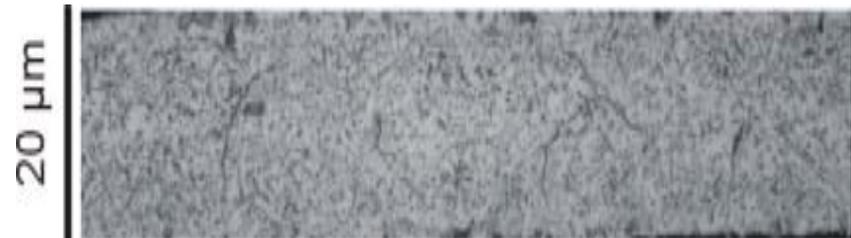
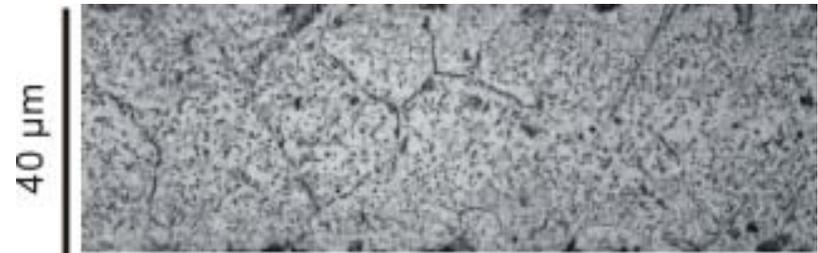
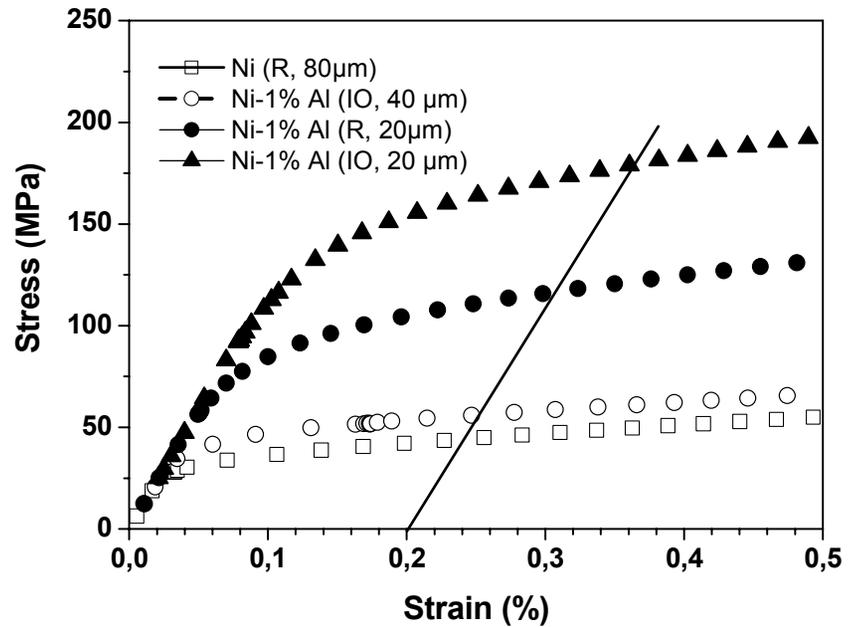
Thin Particle-Strengthened RABiTS

Ni - 1 % Al, Rex 900°C



40µm RD 20µm
↕

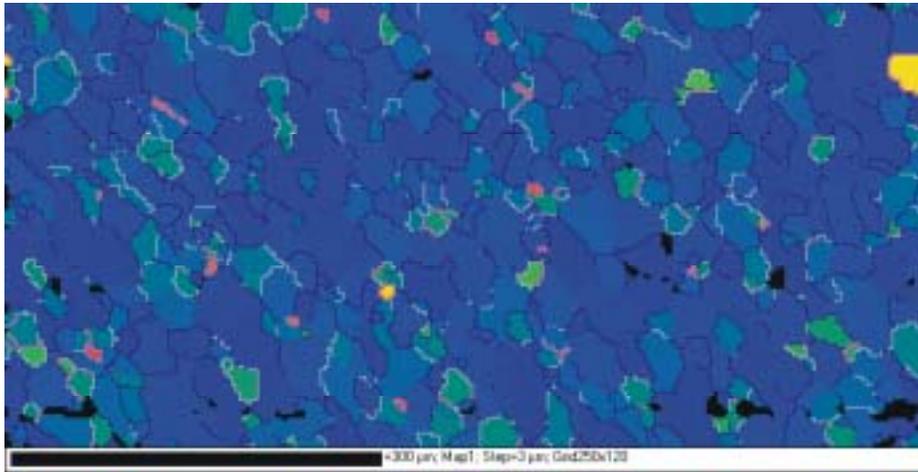
Deviation from cube texture



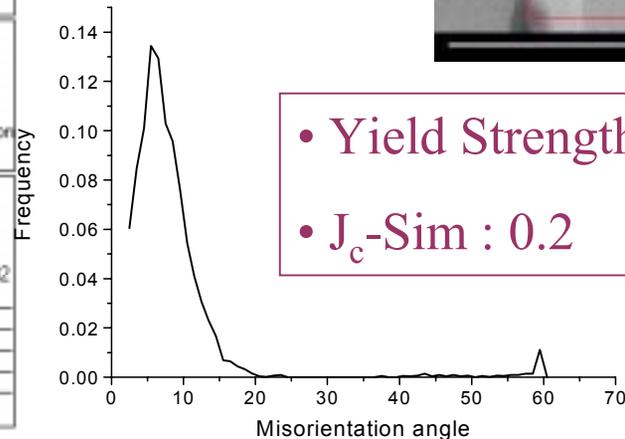
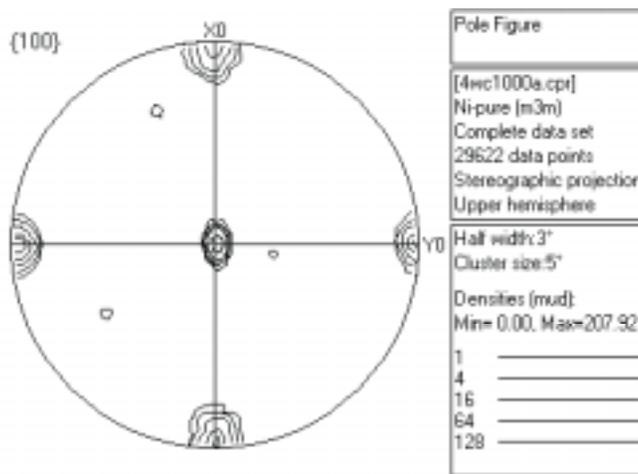
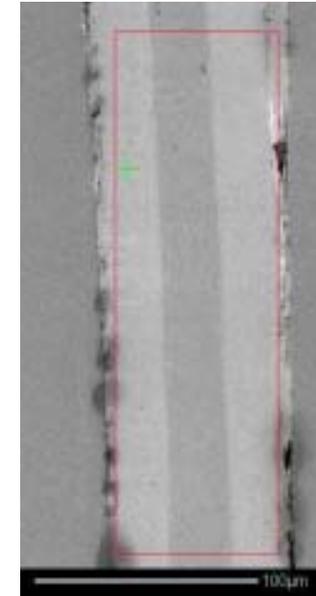
Yield Strength	
Pure Ni :	44 MPa
Ni-1%Al (40µm, recr.) :	56 MPa
Ni-1%Al (40µm, io) :	117 MPa
Ni-1%Al (20µm, io) :	179 MPa

Ni-4at%W / Ni-15at%Cr Composite

EBSD



SEM



- Yield Strength : 197 MPa
- J_c -Sim : 0.2

High Quality, Strengthened and Low Magnetic Tape

ENEA, Centro Ricerche Frascati, Italy

- **PLD-YBCO on two textured substrates**
 - **Ni-5%W/CeO₂, Ni-11%V/NiO/CeO₂**
 - **Highest J_c: 1.2 MA on Ni-5%W, 0.6 MA on Ni-11%V**

Organizations are tackling tape stability issues

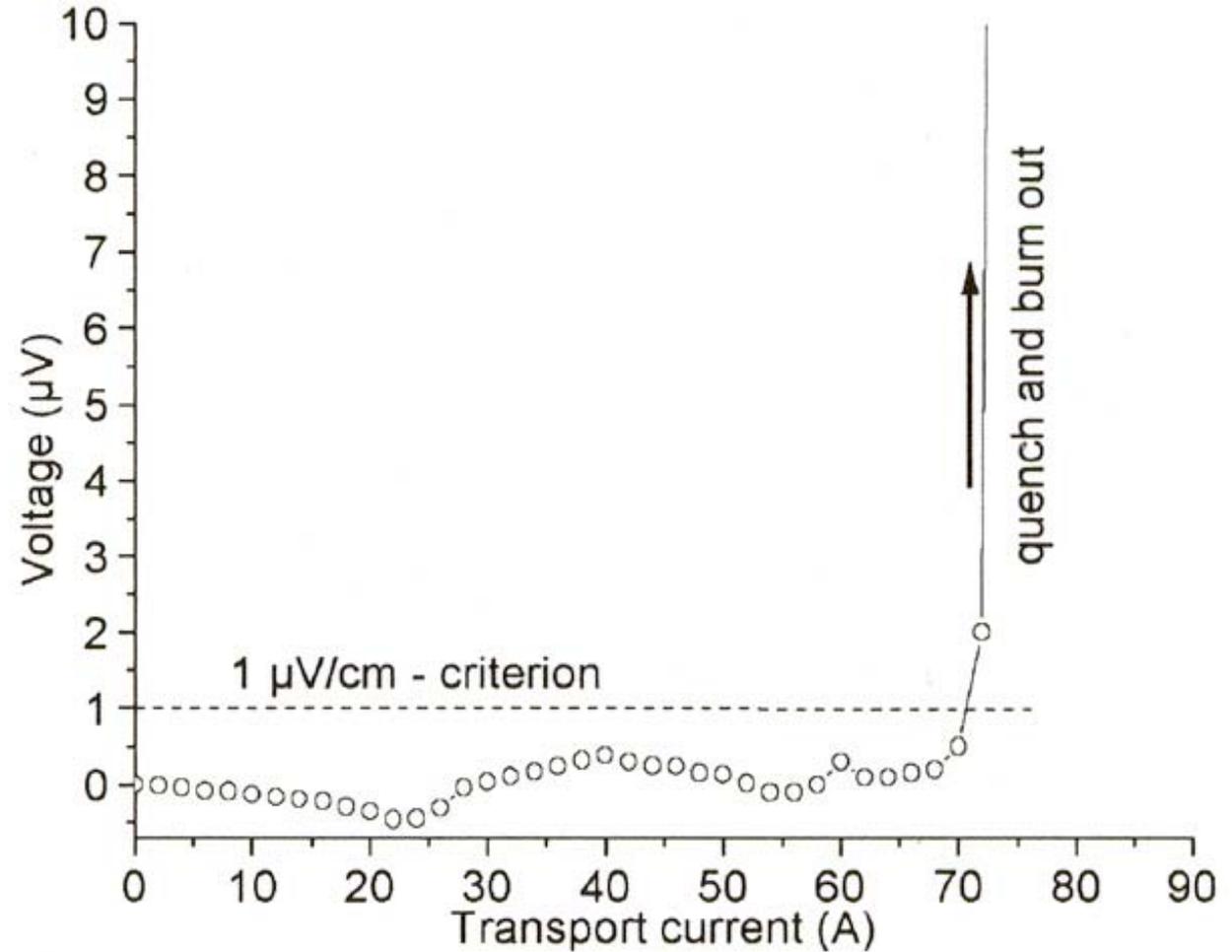
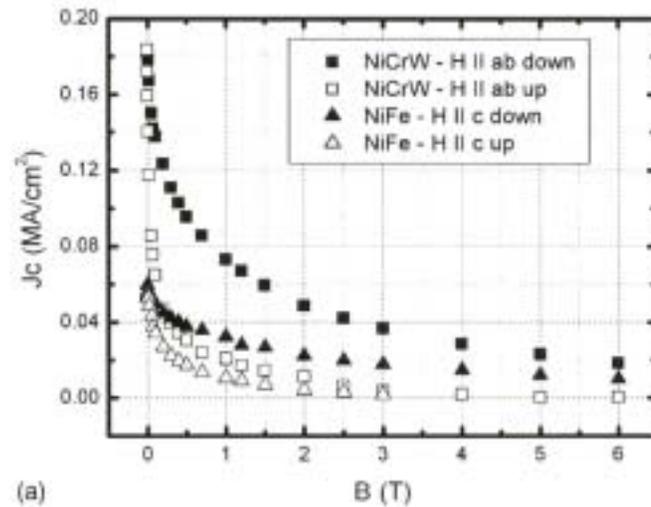
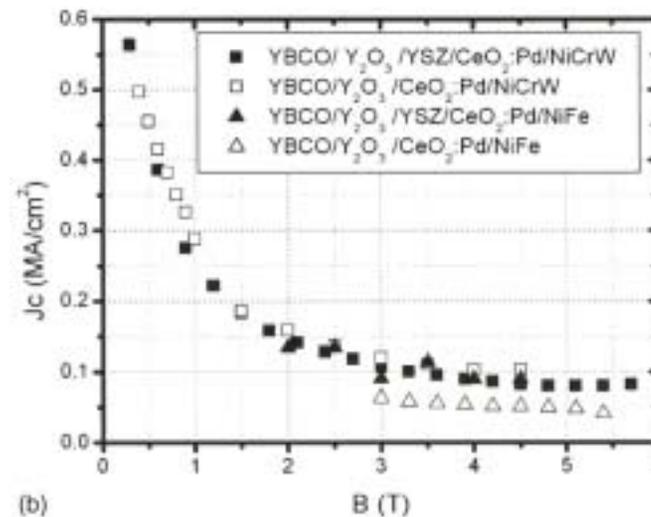


Fig. 10. Transport current measurement on a Ni substrate with $\text{CeO}_2/\text{YSZ}/\text{CeO}_2/\text{YBCO}$ layers. The YBCO thickness is 400 nm.

IRC Cambridge group reports YBCO on NiCrW non-magnetic ternary alloy tape by PLD



(a)



(b)

Fig. 16. Field dependence of (a) transport critical current measured on YBCO/Y₂O₃/YSZ/Pd:CeO₂ architecture deposited on Ni₈₈Cr₈W₄ and Ni₅₀Fe₅₀ substrates; (b) SQUID current measurements of YBCO/Y₂O₃/Pd:CeO₂ architecture deposited on Ni₈₈Cr₈W₄ and Ni₅₀Fe₅₀ substrates.

Summary

- **YBCO/IBAD tapes are being scaled up to >10-m in Germany**
- **Short-sample YBCO/IBAD (20-cm) tapes show parity with BSCCO (~400 A/cm)**
- **University groups are pursuing innovative means to enhance flux pinning and J_c**