

High- I_c YBCO Thick Films on RABiTS by PLD

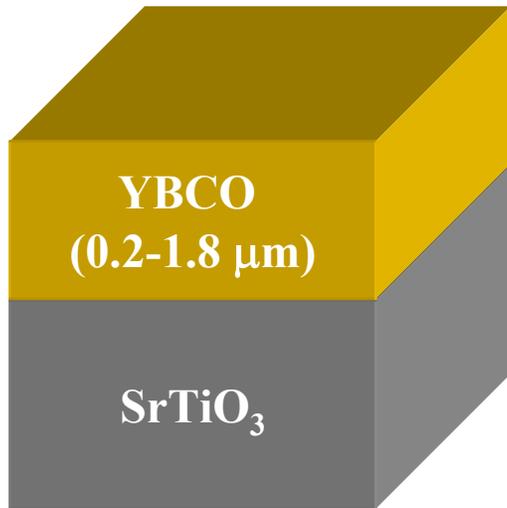
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OAK RIDGE NATIONAL LABORATORY

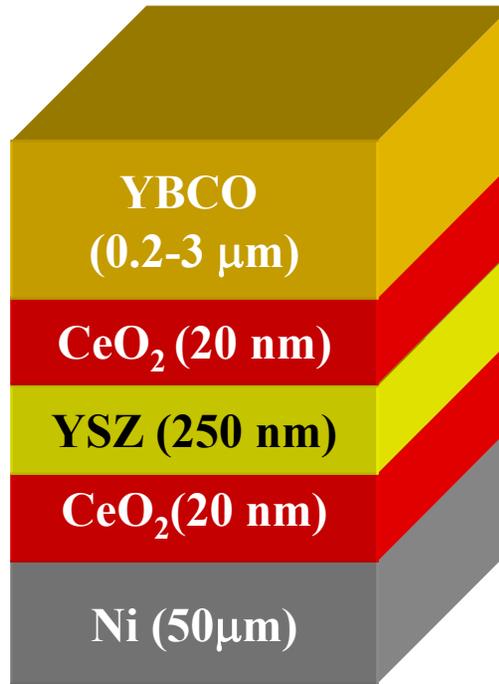
HTS Wire Development Workshop
St. Petersburg, FL, January 21, 2003

Three sets of samples studied

YBCO/STO

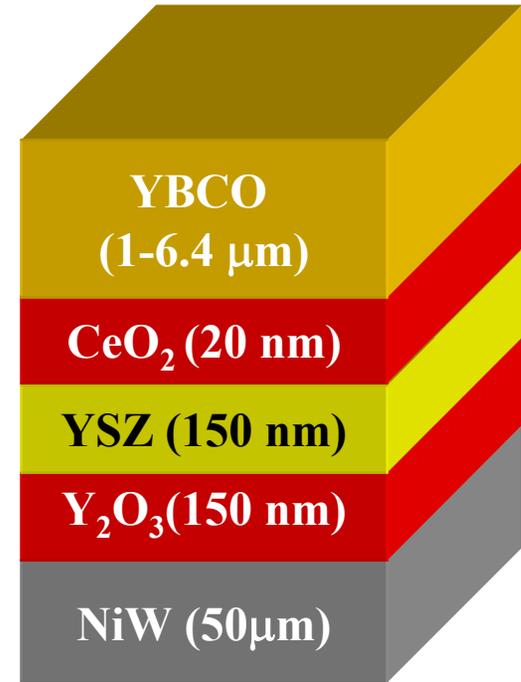


YBCO/RABiTS



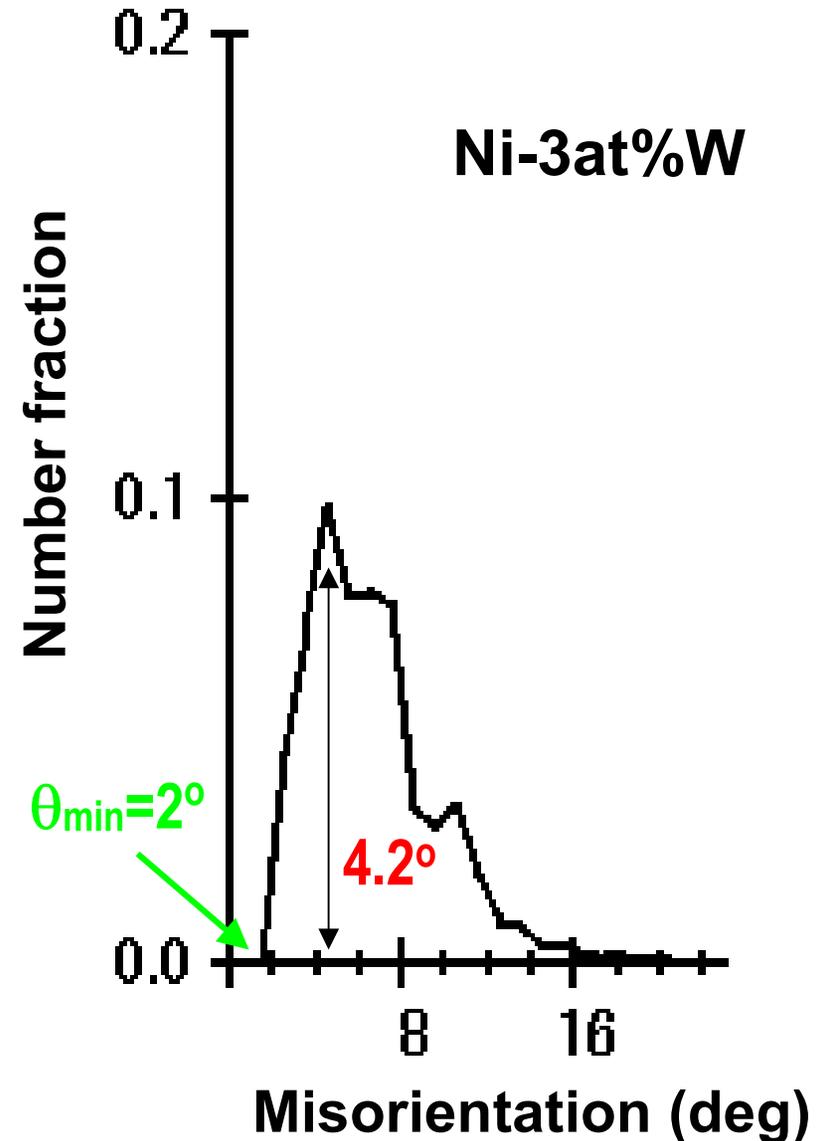
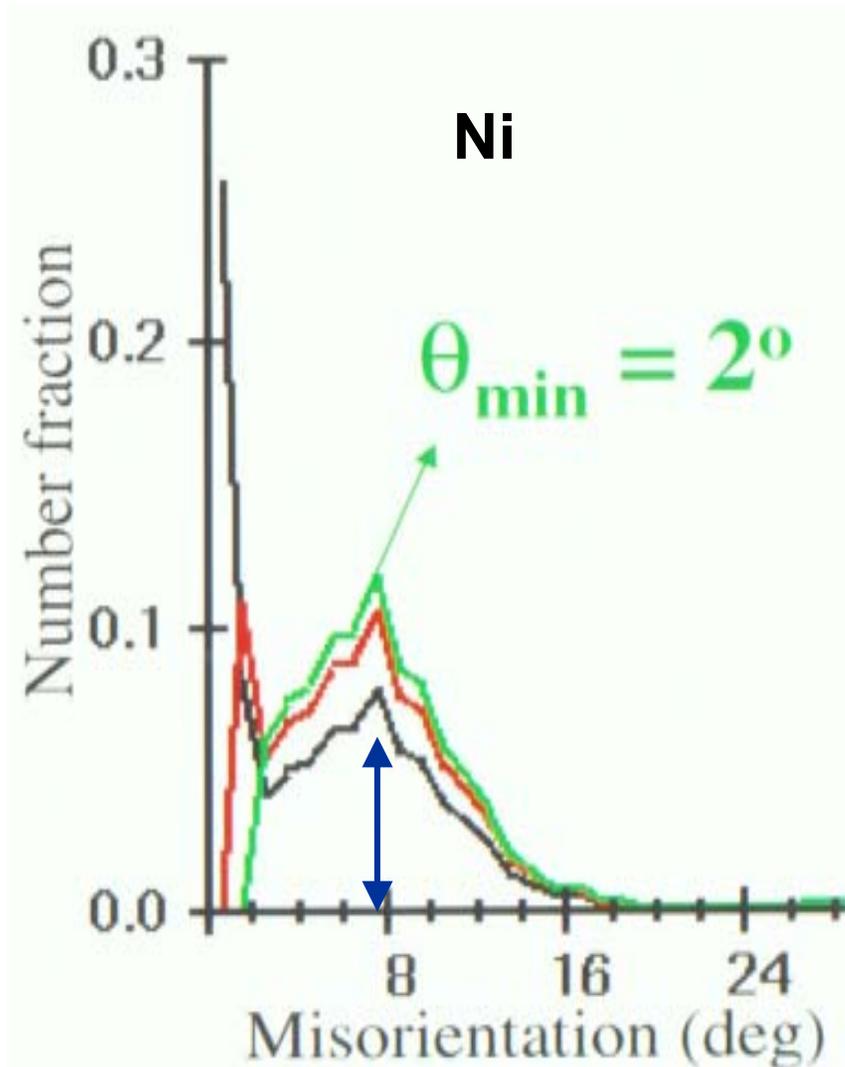
$$\Delta\omega = 7-8^\circ;$$
$$\Delta\phi = 9-10^\circ$$

YBCO/RABiTS1

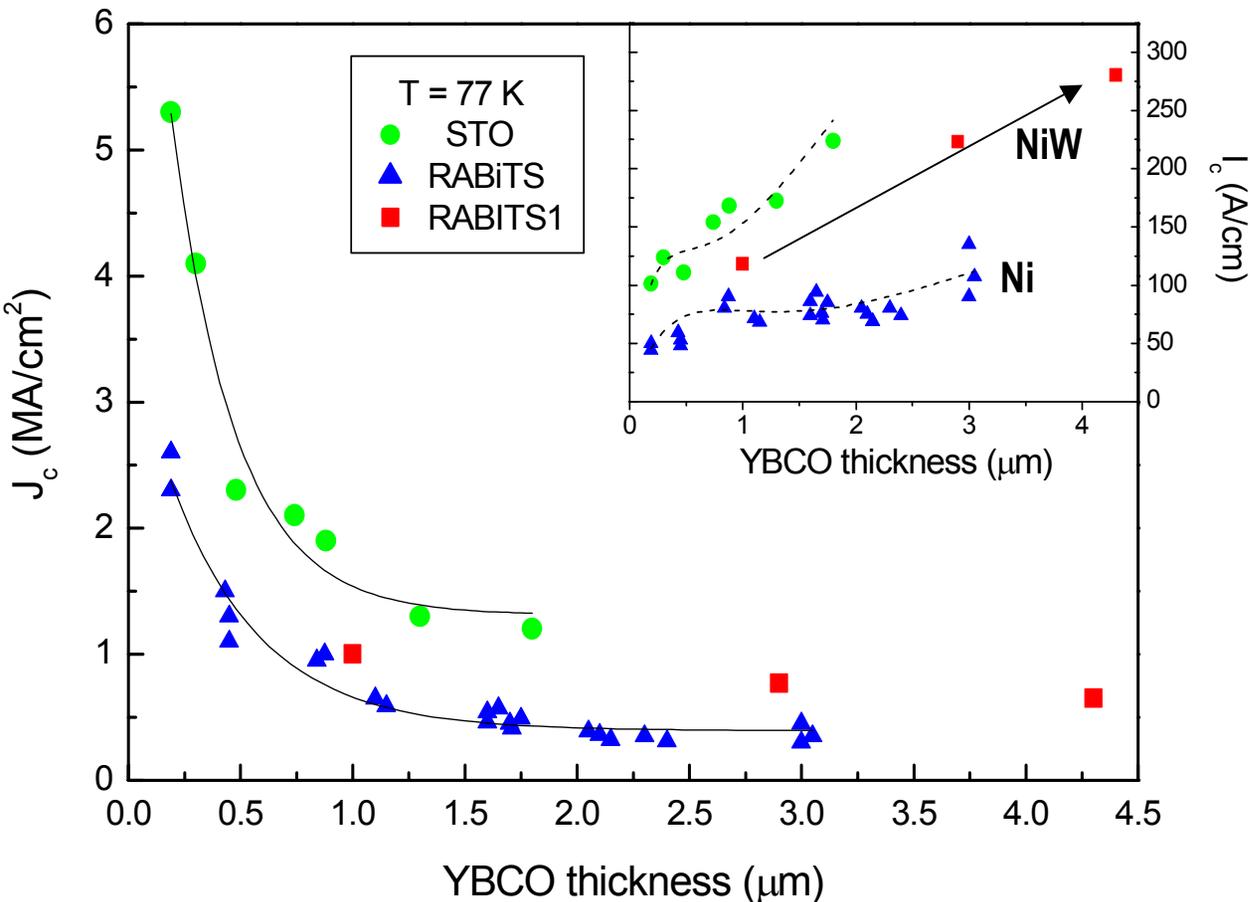


$$\Delta\omega = 5-6^\circ;$$
$$\Delta\phi = 7^\circ$$

Texture of NiW is significantly better than that Ni substrates used previously



J_c vs. Thickness for YBCO films by PLD



Experimental Conditions:

Excimer laser: 308 nm

Depn. Temp.: 790°C

Growth rate: 0.03-0.06 $\mu\text{m}/\text{min}$

Sample heating
may be restricting
the I_c

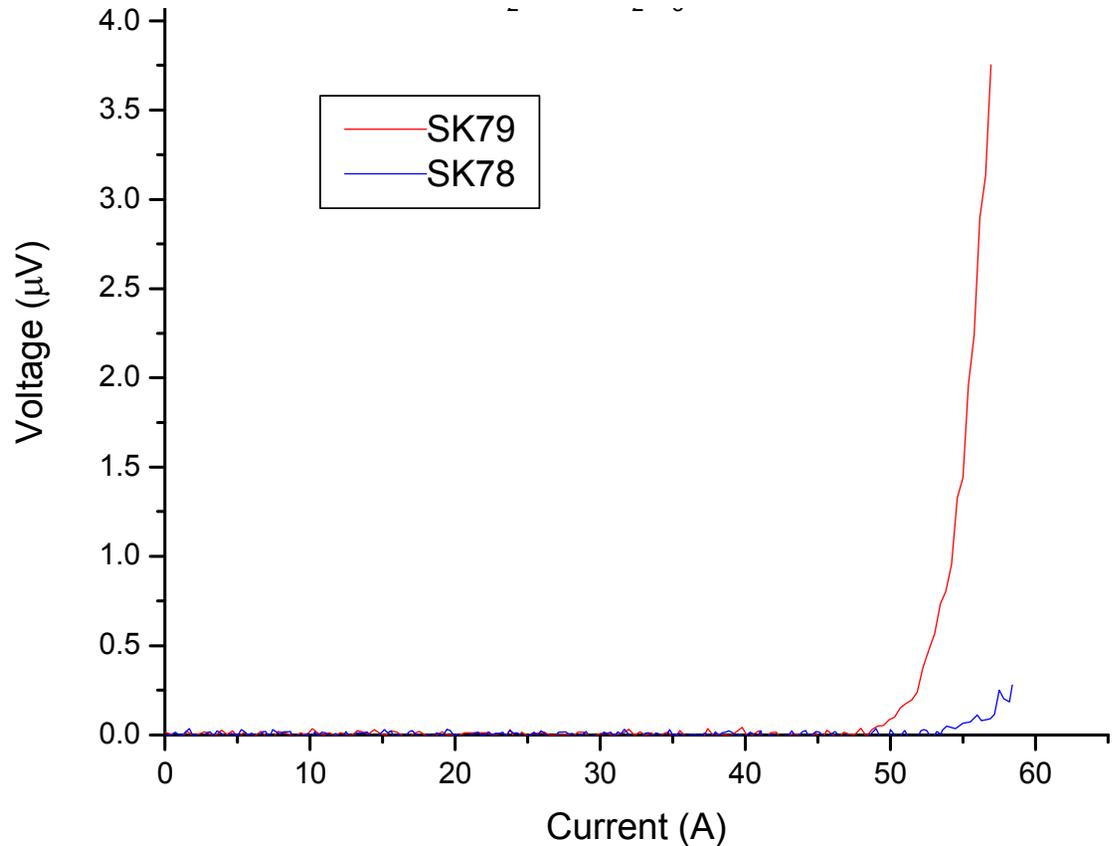
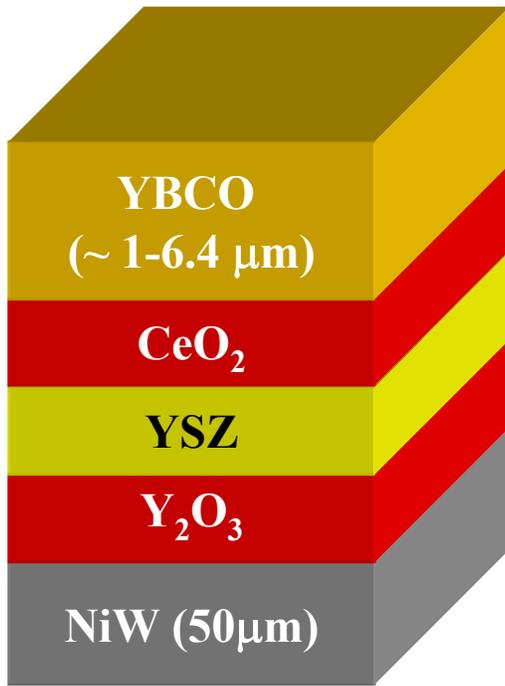
RABiTS: Ni/CeO₂(20nm)/YSZ (250nm)/CeO₂(20nm)
RABiTS1: Ni/Y₂O₃(150nm)/YSZ (150nm)/CeO₂(20nm)

Summary of Texture Data for YBCO on NiW RABiTS

YBCO thickness (μm)	$\Delta\phi$ Ratio YBCO (113) / NiW (111)	$\Delta\omega$ Ratio YBCO (005) / NiW (200)	a-axis fraction (I_a/I_c)	% Cube
1.0	0.90	0.79	0.0	92.5
2.9	1.03	0.78	0.1	93.5
4.3	1.09	0.89	0.2	87.9
6.4	0.96	0.91	0.1	95.8

- In-plane and out-of-plane textures are not degraded
- % Cube decreases – but variation related to poor background correction
- a-axis orientation increases but is still not very high

PLD YBCO films on buffered Ni-W substrates

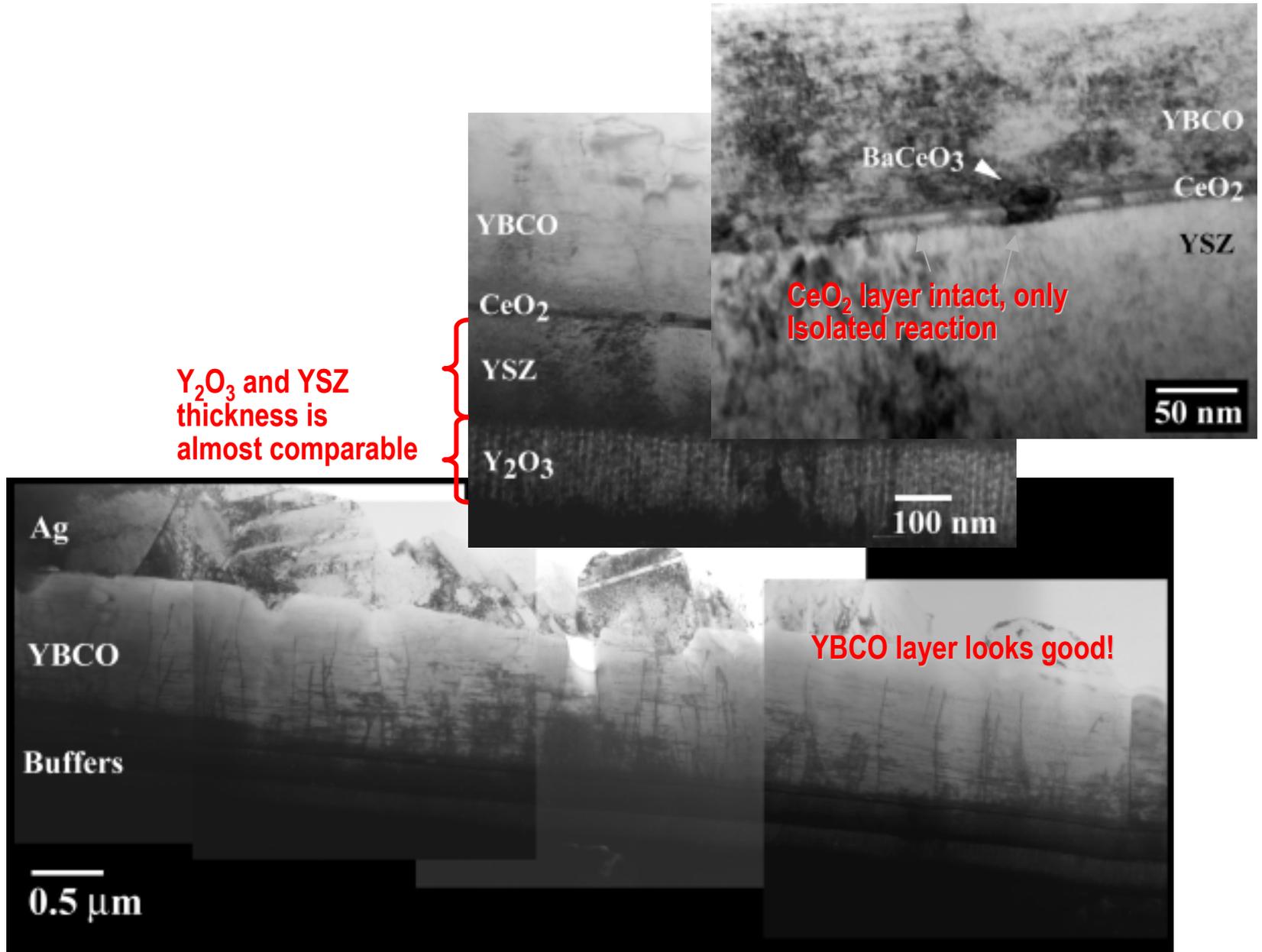


Sample No. SK78, 5 mm wide

YBCO Thickness: 1.00 μm

$I_c = 59\text{A}$ (self-field, 77K), $I_c/\text{width} = 118\text{ A/cm}$; $J_c = 1.18\text{ MA/cm}^2$

TEM of 1.0 μm PLD-YBCO/NiW



2.9 μm PLD-YBCO/NiW

Sample No. SK86, 2.5 mm wide

$I_c = 55.9\text{A}$ (self-field, 77K)
 $I_c/\text{width} = 224\text{ A/cm}$; $J_c = 0.8\text{ A/cm}^2$

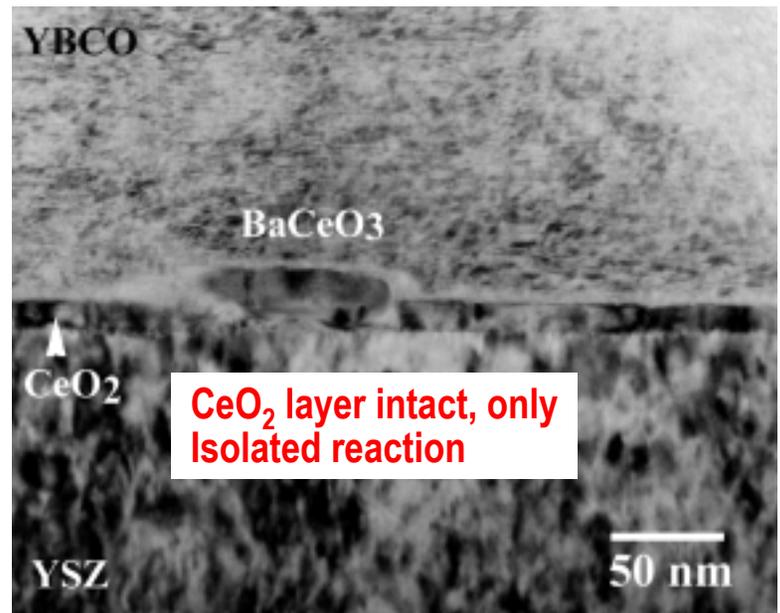
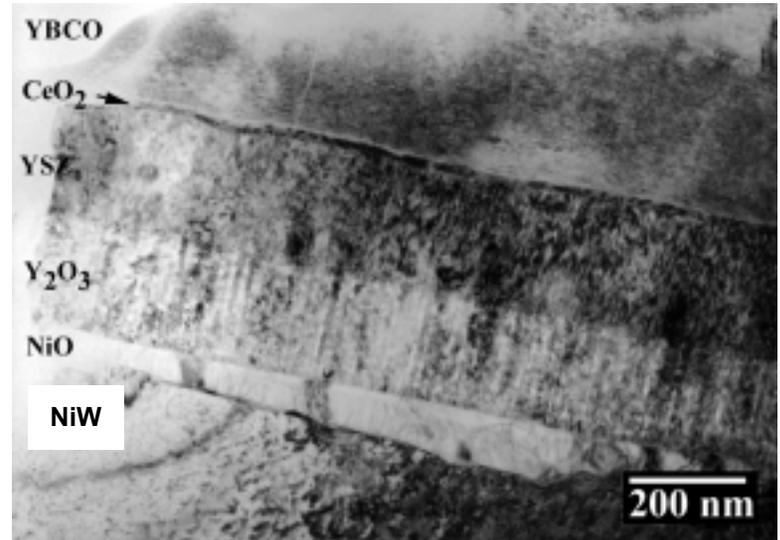
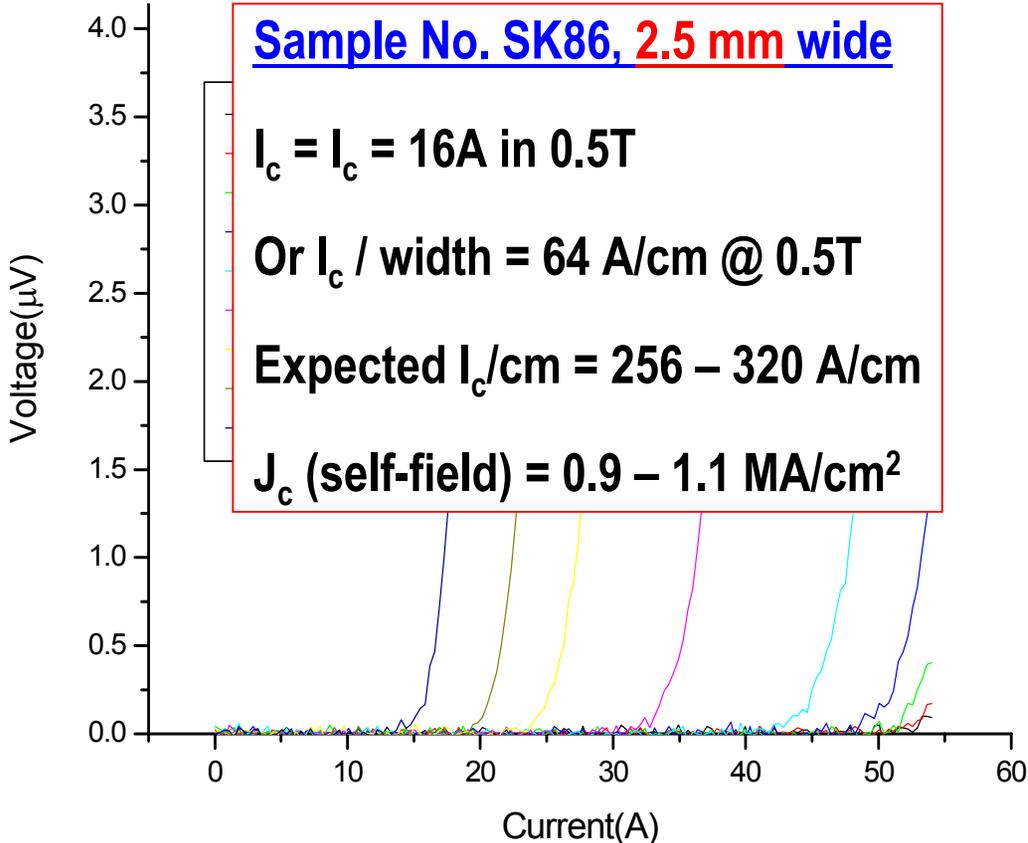
Sample No. SK86, 2.5 mm wide

$I_c = I_c = 16\text{A}$ in 0.5T

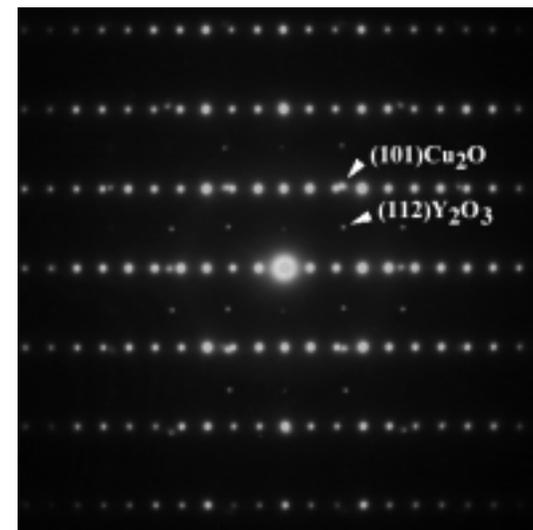
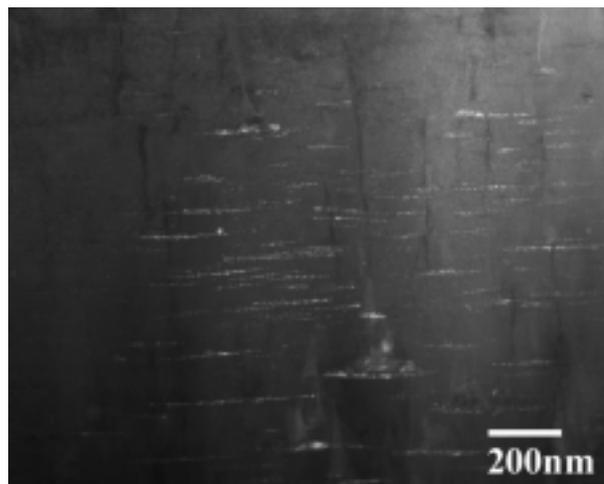
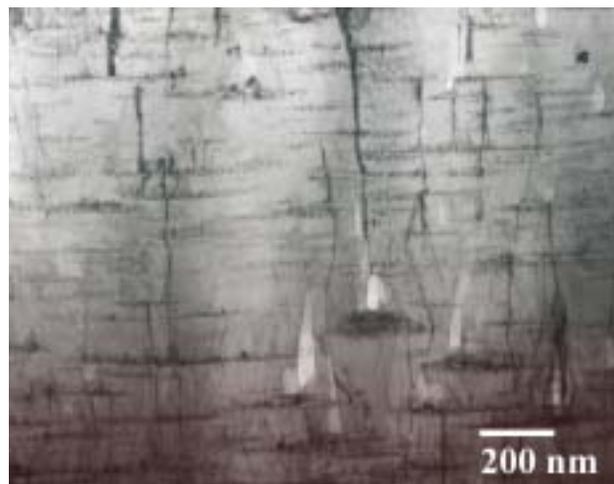
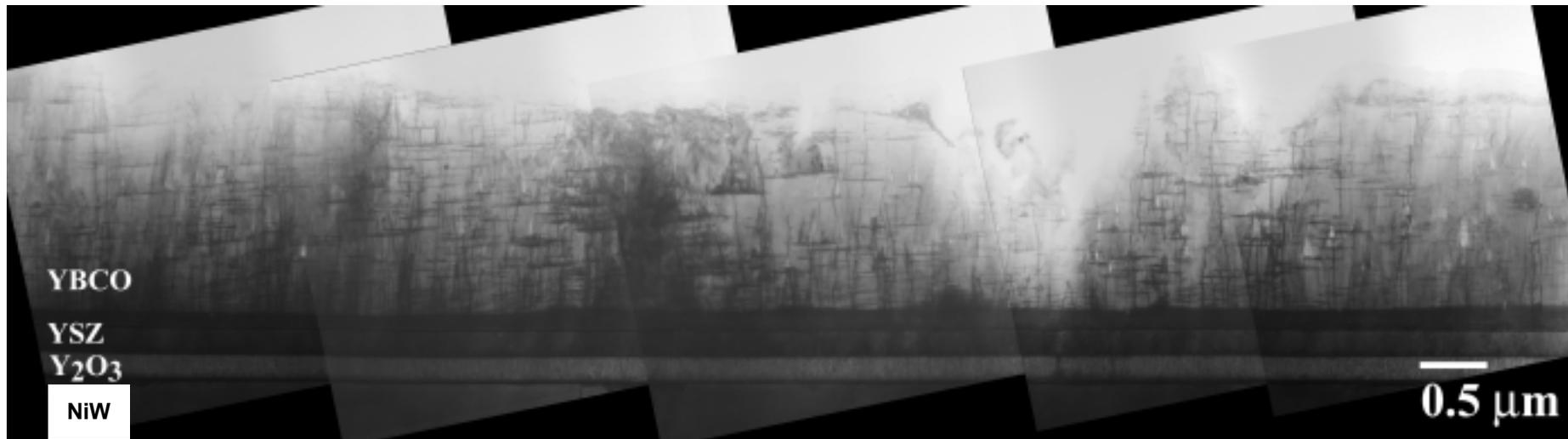
Or $I_c / \text{width} = 64\text{ A/cm}$ @ 0.5T

Expected $I_c/\text{cm} = 256 - 320\text{ A/cm}$

J_c (self-field) = $0.9 - 1.1\text{ MA/cm}^2$



TEM of 2.9 μm PLD-YBCO/NiW



4.3 μm PLD-YBCO/NiW

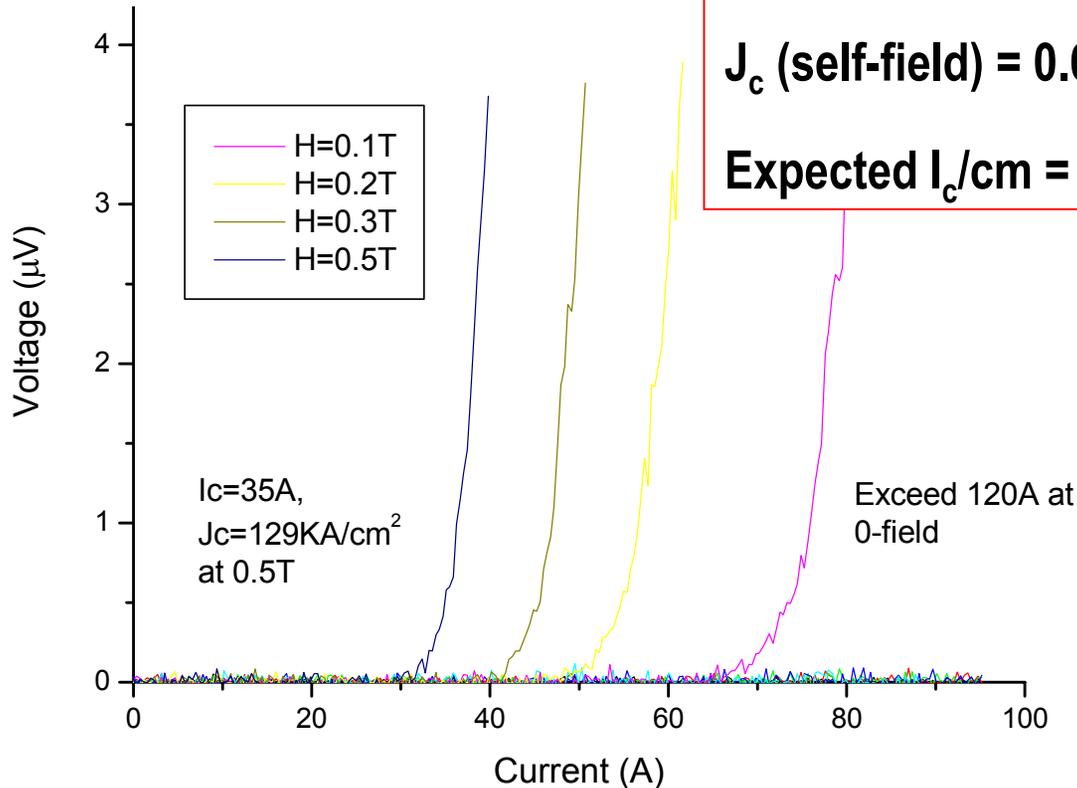
Sample No. SK97, 5 mm wide

$I_c =$ Exceeded 120A (self-field, 77K); $I_c = 35\text{A}$ in 0.5T

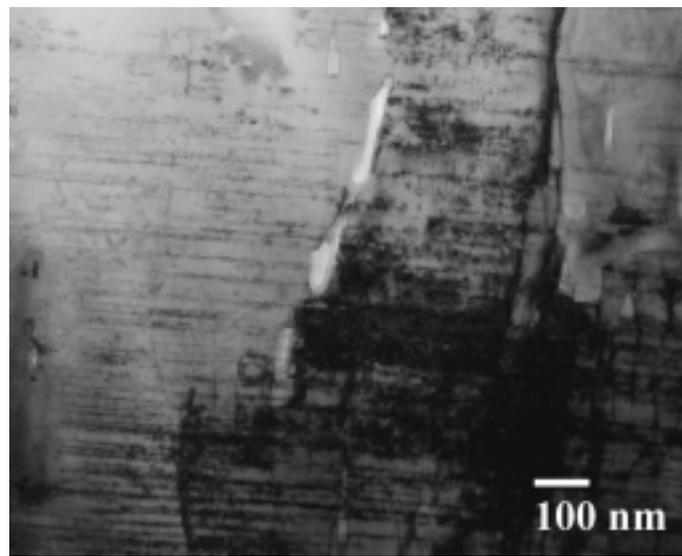
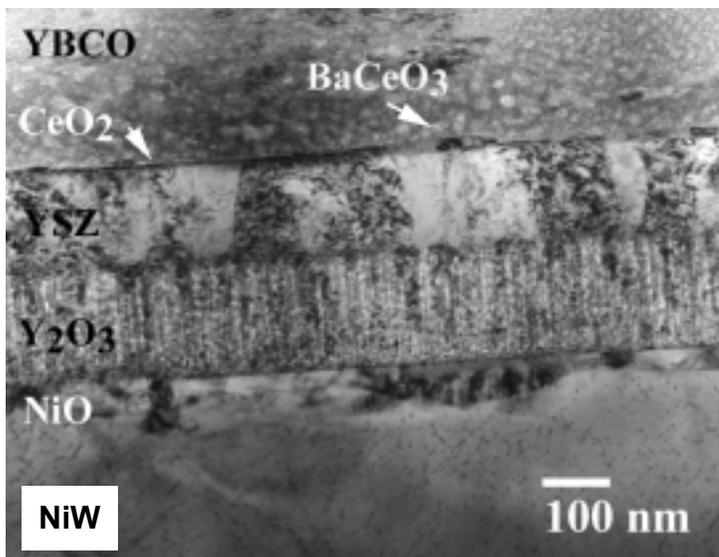
Expected self-field $I_c = 140\text{-}175\text{A}$

J_c (self-field) = $0.65 - 0.81 \text{ MA/cm}^2$

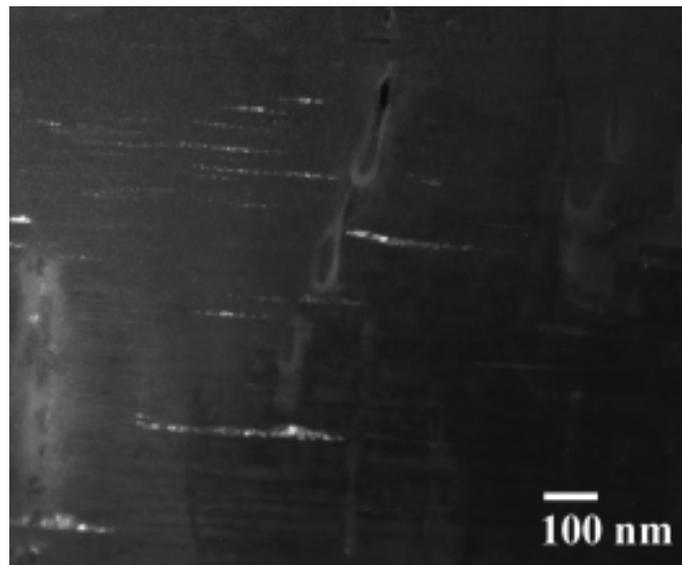
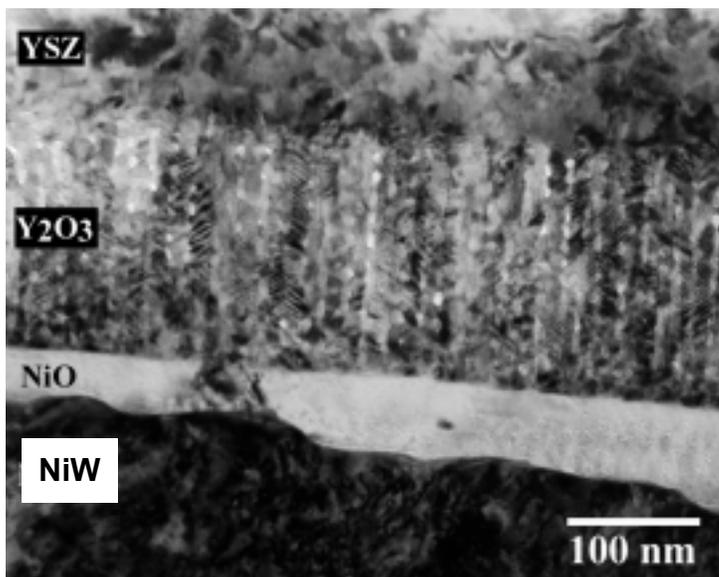
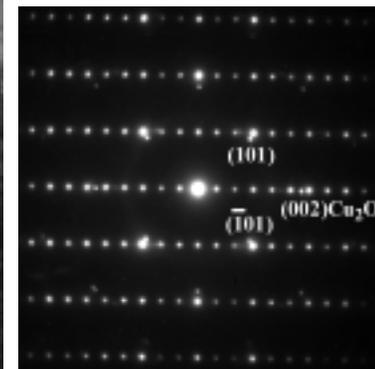
Expected $I_c/\text{cm} = 280 - 350 \text{ A/cm}$



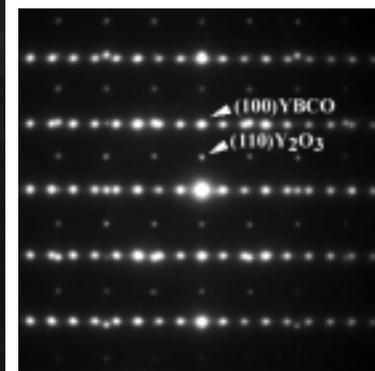
TEM of 4.3 μm PLD-YBCO/NiW



YBCO [010] //
Cu₂O[010]



YBCO [010] //
Y₂O₃[110]



Raman Microprobe Spectra from the 4.3 micron YBCO sample

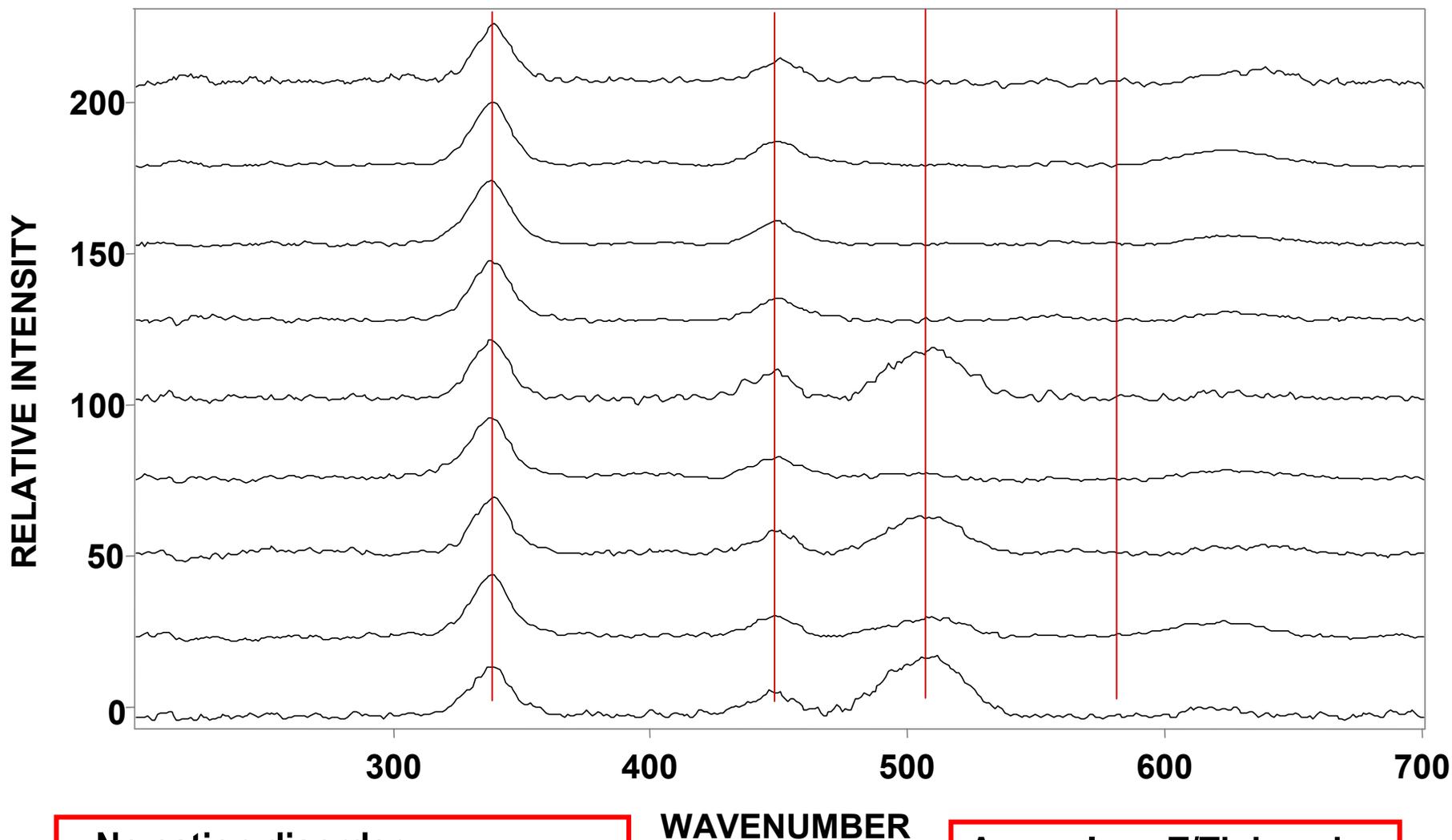
(V. Maroni, ANL)

O2+/O3-

T/T' (?)

O4

“CD”

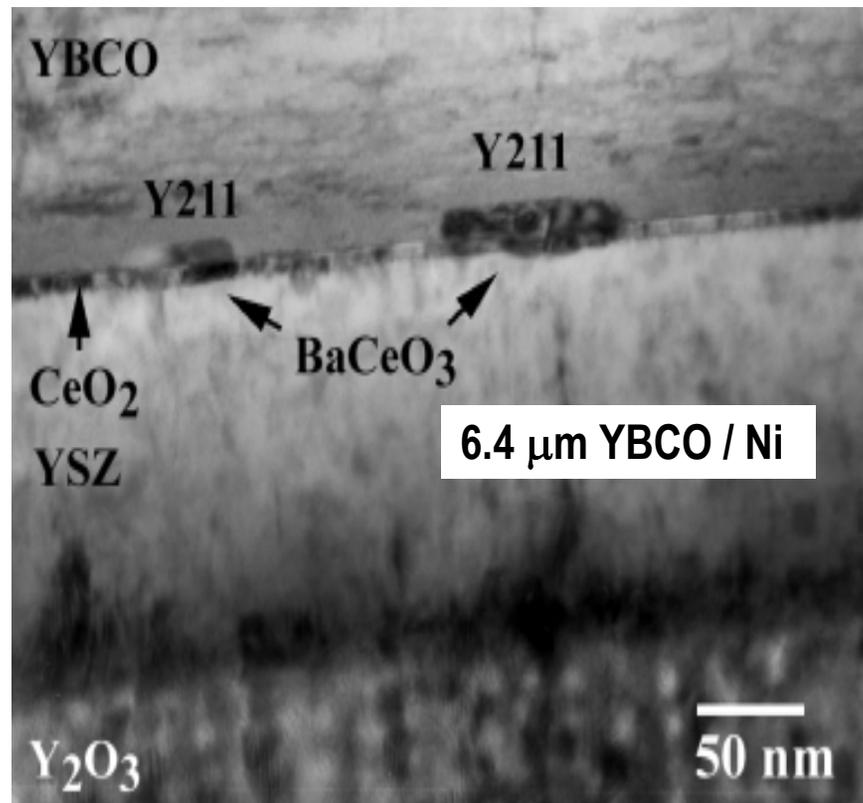
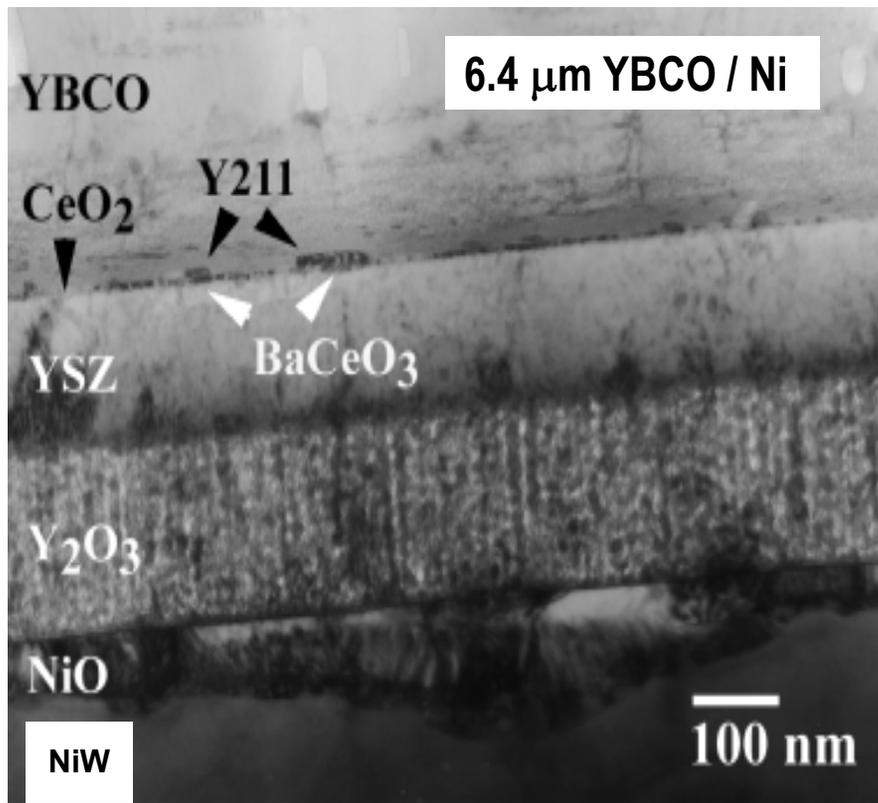


- No cation disorder
- a-axis grains in some locations

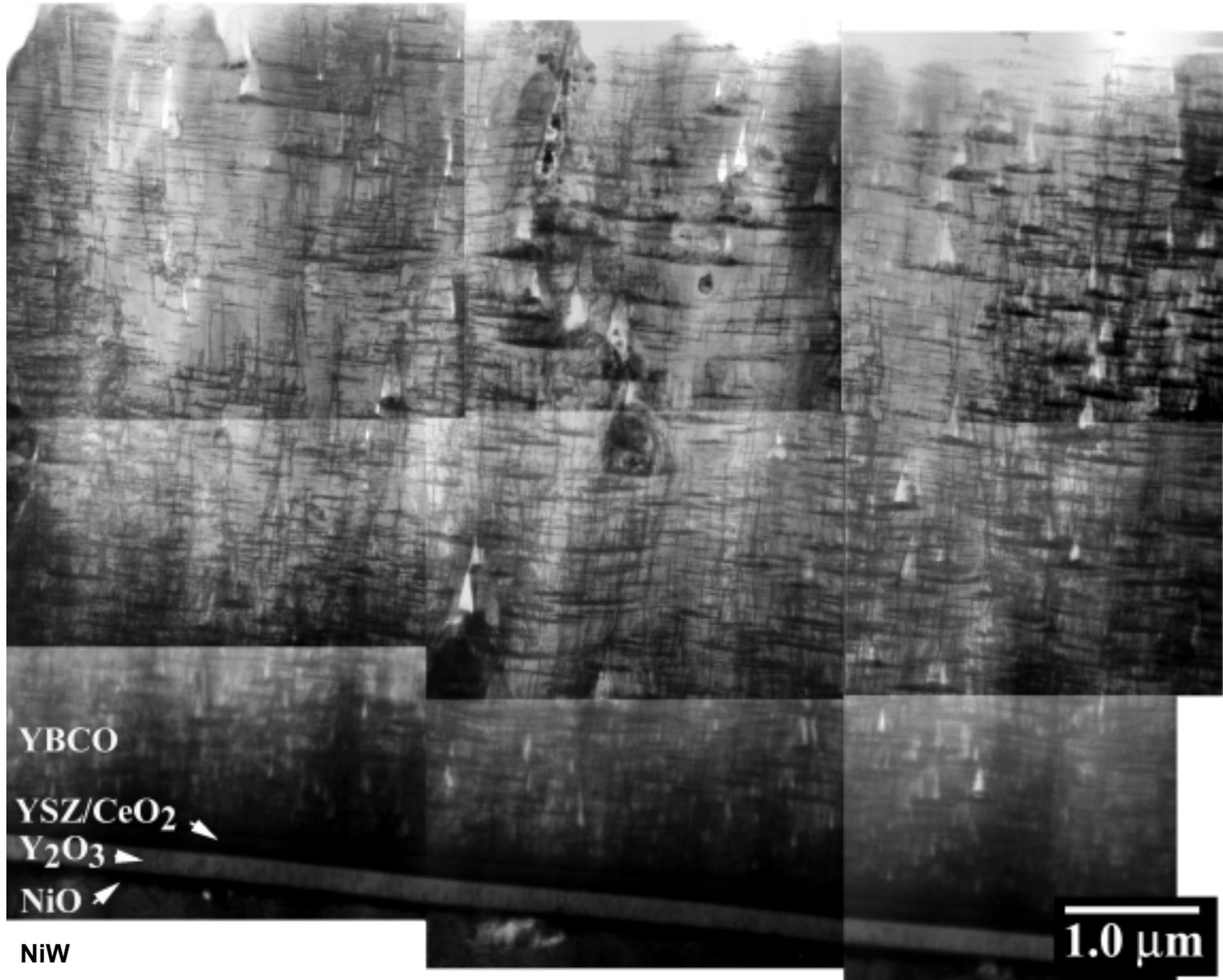
Anomalous T/T' domains present

6.4 μm PLD-YBCO/NiW

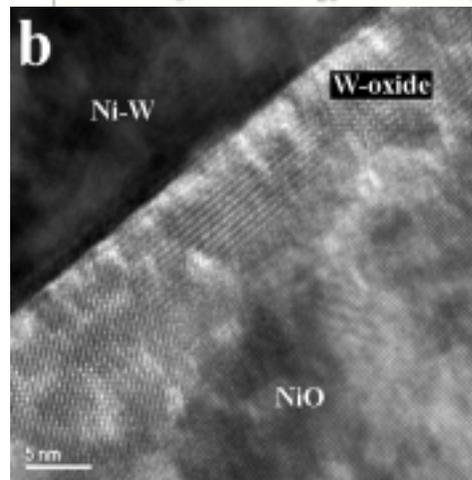
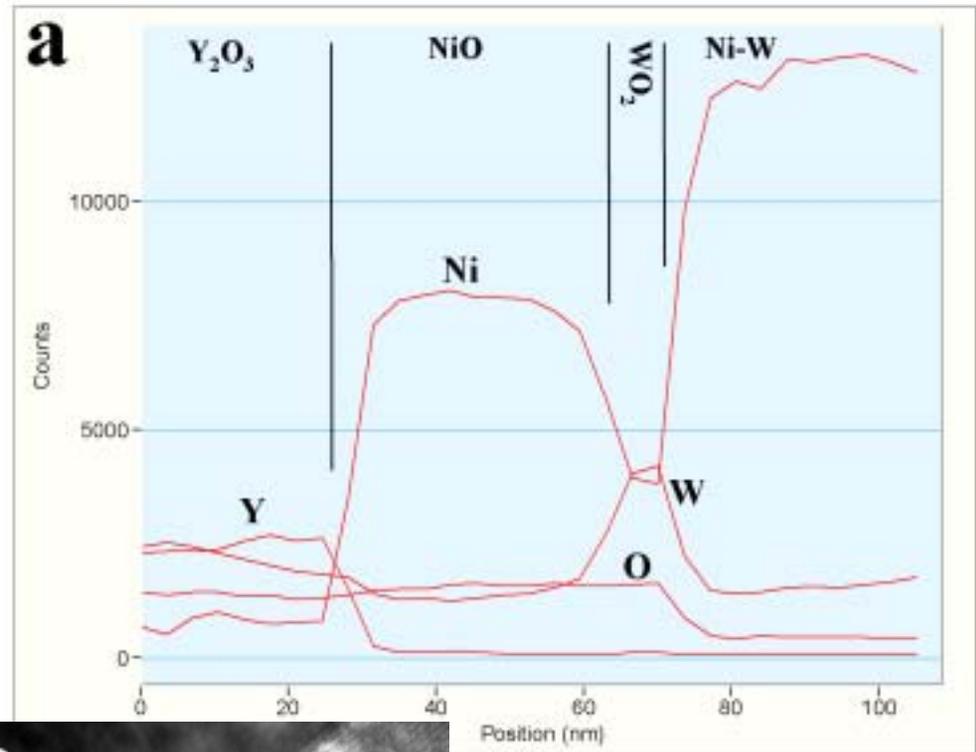
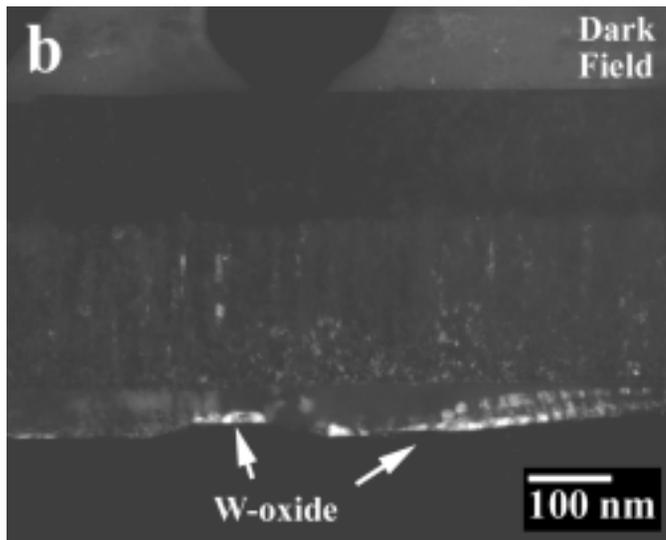
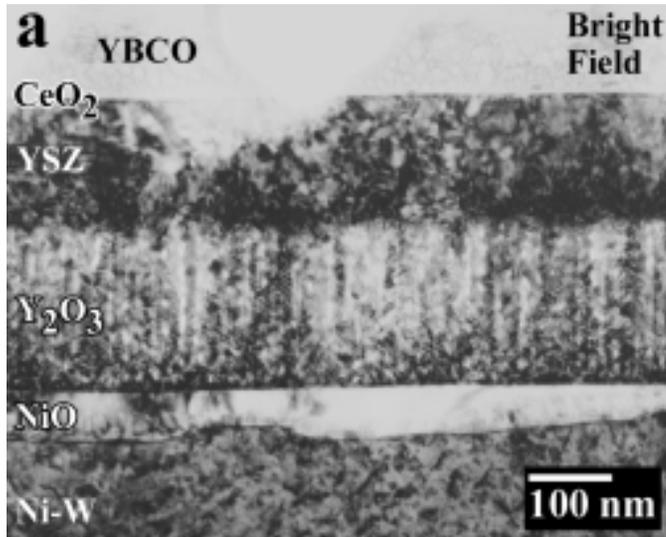
Transport J_c : Sample was damaged during measurement due to high- I_c



YBCO film looks homogeneous through the entire cross-section of 6.4 μm



Passivating tungsten oxide layer



For YBCO samples ranging in thickness from 1-6.4 μm :

NiO: 35-40 nm

WO₂/WO₃: 8-10nm

Summary of Current Limiting Mechanisms for Single Layer, YBCO Thick Films by PLD

- ❖ It is possible to grow thick, single layer, YBCO on RABiTS with no drastic change in microstructure and performance (1 – 6.4 μm)
- ❖ Primary mechanisms for J_c reduction with YBCO thickness vary significantly with substrate properties

YBCO/STO: Growth of a-axis grains, broadening of the in-plane texture

YBCO/Ni: Degradation of % cube texture, formation of second phases, reaction with cap layer and formation of porosity

YBCO/NiW: Texture and microstructure quite intact even for a 6.4 μm YBCO film!

- Oxygen deficiency is the major defect!
- Substrate texture and buffer layer characteristics are very important
- I_c /width of 280-350 A/cm for a 4.3 μm film demonstrated

Summary of Texture Data for YBCO on NiW RABiTS

	YBCO- ω	YBCO- ϕ	NiW- ω	NiW- ϕ	Cube % (YBCO)	a-axis fraction(I_a/I_c)
1.0μm	4.7	6.6	5.9	7.3	92.5	0.01
2.9μm	4.6	7.3	5.9	7.1	93.5	0.05
4.3μm	5.3	8.2	5.9	7.5	87.9	0.19
6.4μm	5.1	7.7	5.6	8	95.8	0.1

- In-plane and out-of-plane textures are not degraded
- % Cube decreases – but variation related to poor background correction
- a-axis orientation increases but is still not very high