Ex situ BaF_2 process: Issues and Prospects of High I_c Thick YBCO Coatings

Thickness dependence of J_c

Ron Feenstra, A. A. Gapud, D. K. Christen, E. D. Specht, J. D. Budai, A. Goyal, F. A. List, L. Heatherly, P. M. Martin, D. M. Kroeger

Oak Ridge National Laboratory

Oak Ridge, Tennessee

- **D. M. Feldmann, D. C. Larbalestier, *University of Wisconsin***
- **T. G. Holesinger, P. N. Arendt, *Los Alamos National Laboratory***

2003 Wire Development Workshop, Session IV: Thick YBCO Film Growth
January 21-22, St. Petersburg, Florida

Outline

status

baseline $J_c(t)$ dependence
- texture-independent

"dead" layers ?

materials/processing dependent origin of $J_c(t)$

future

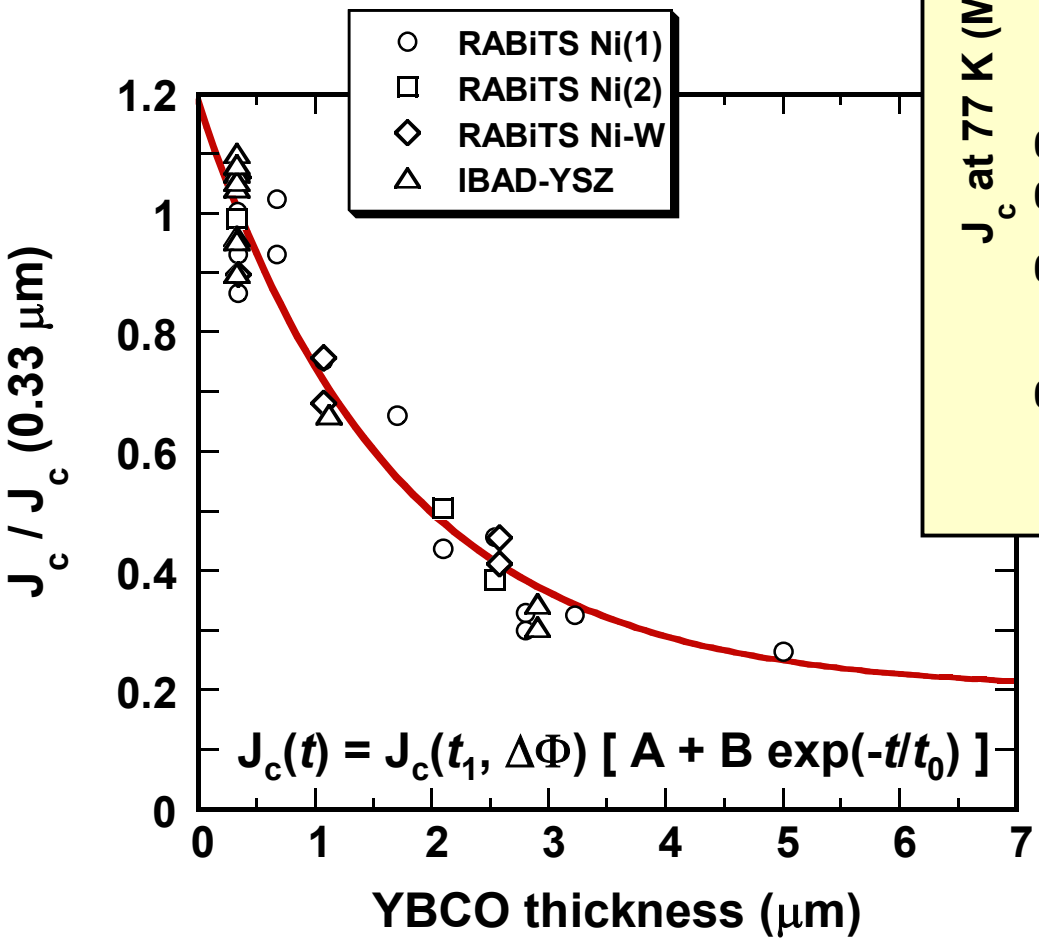
> 500 A/cm conductor ?

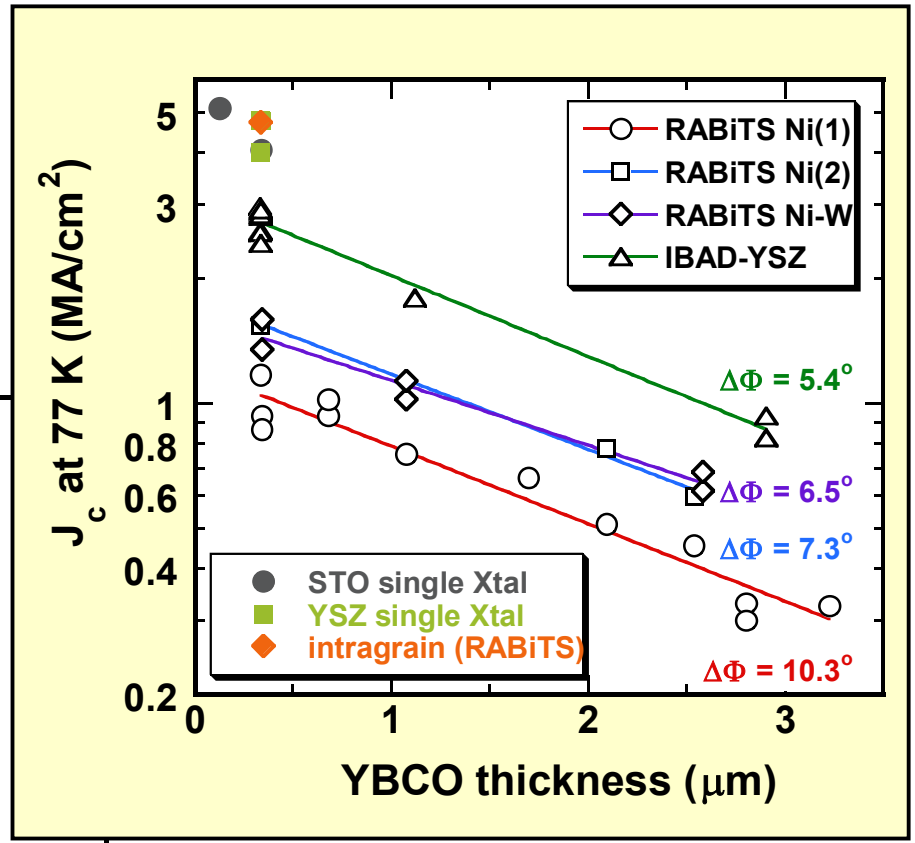
"loose ends" $\Rightarrow$ new directions

high I_c, improved $J_c(H)$

perspective

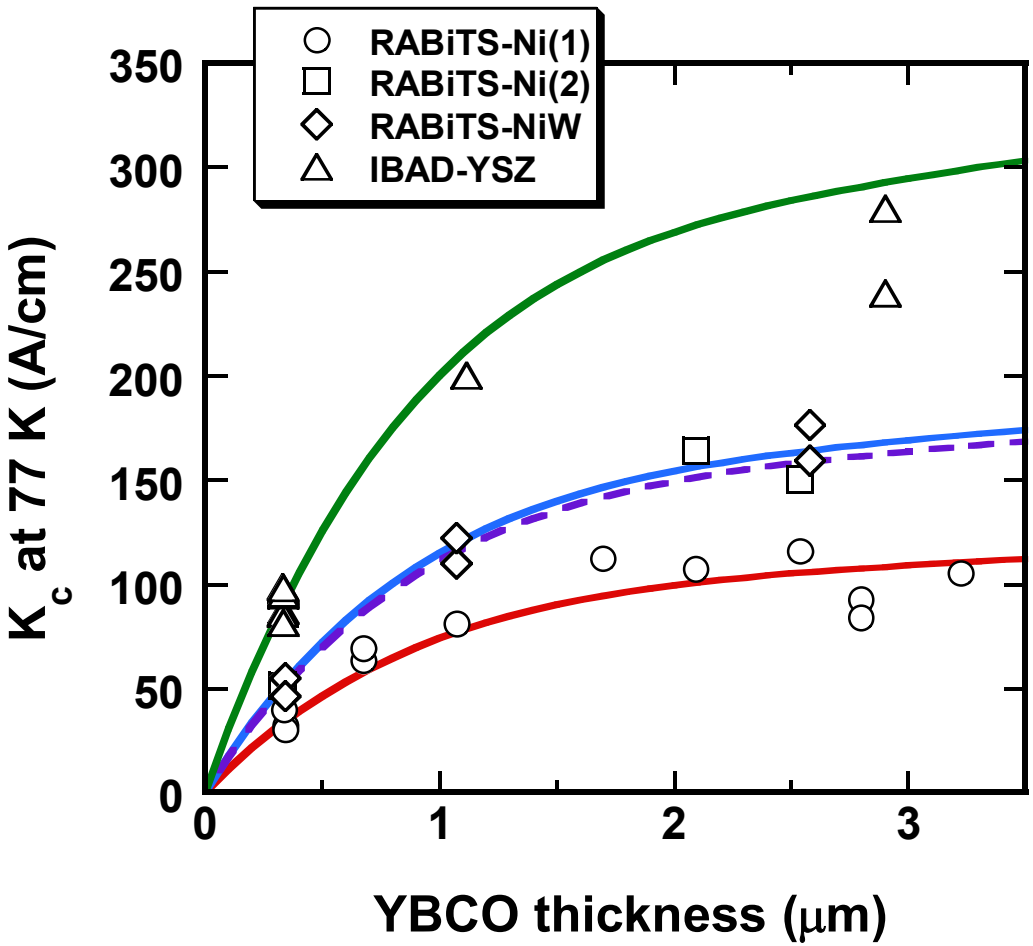
Baseline $J_c(t)$ dependence has been determined





- substrate independent
- J_c in thick YBCO is GB limited

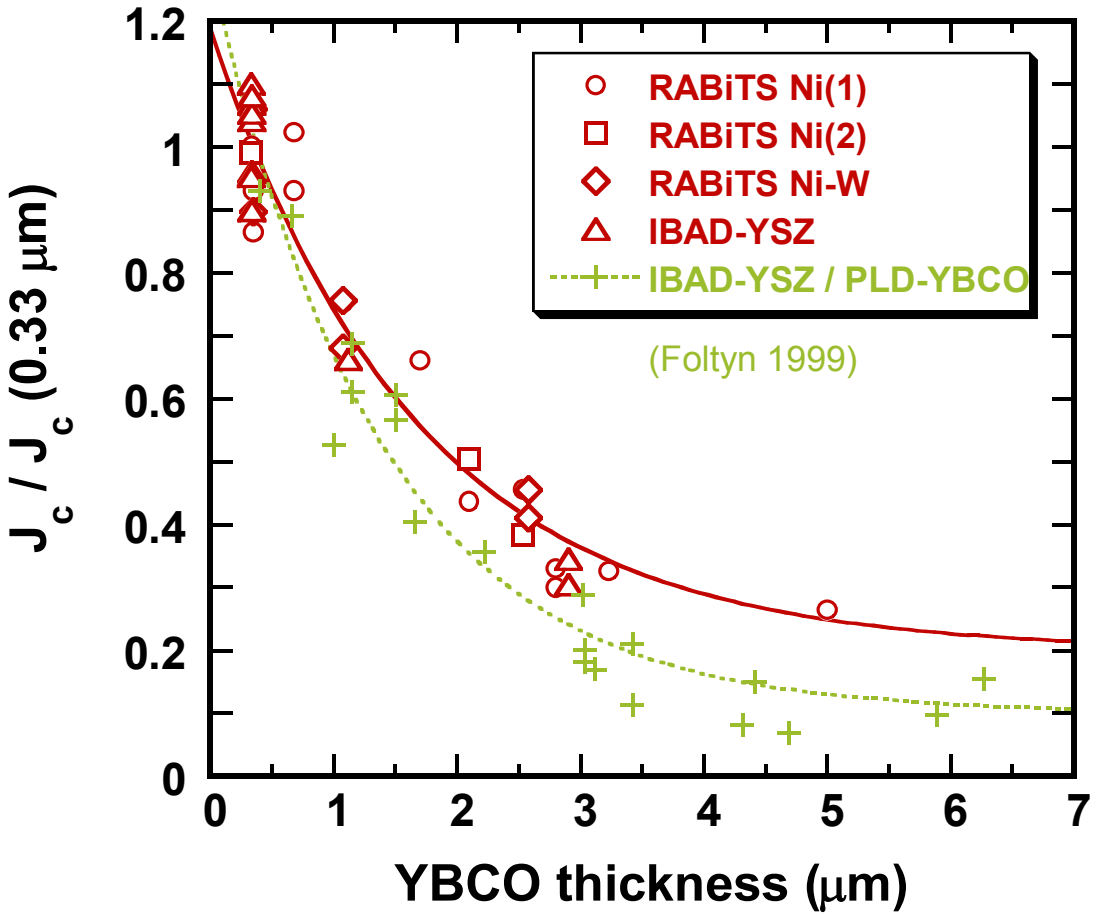
Monotonic I_c increase with YBCO thickness



same $I_c(t)$-dependence

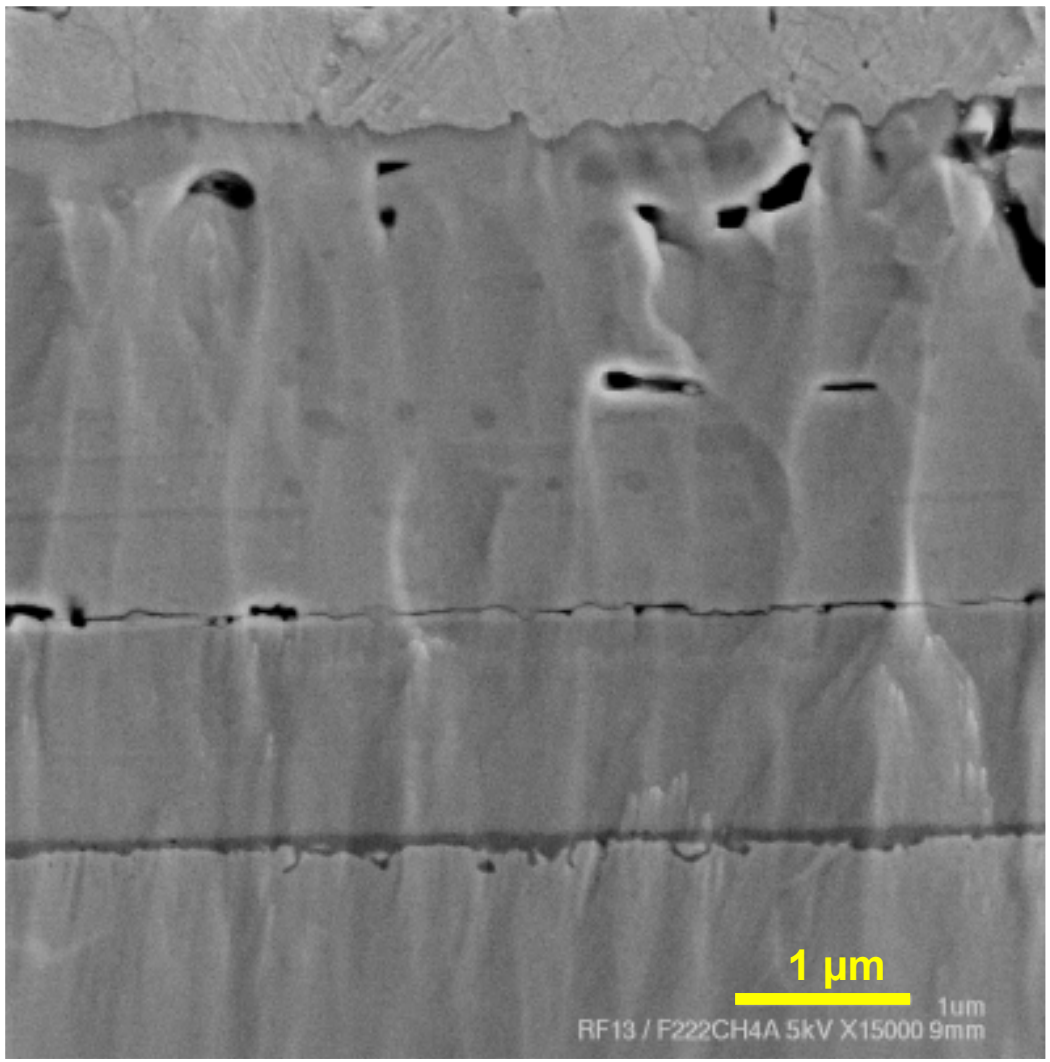
I_c magnitude scales with substrate texture

Comparison BaF_2 *ex situ* – PLD (*in situ*)



- similar J_c decrease from "thin" to 1.5 μm
- different saturation J_c in thick YBCO
  - distinct mechanisms for J_c decrease

Ex situ YBCO exhibits dense microstructure through entire thickness



Silver

2.9 µm YBCO

CeO_2

IBAD YSZ

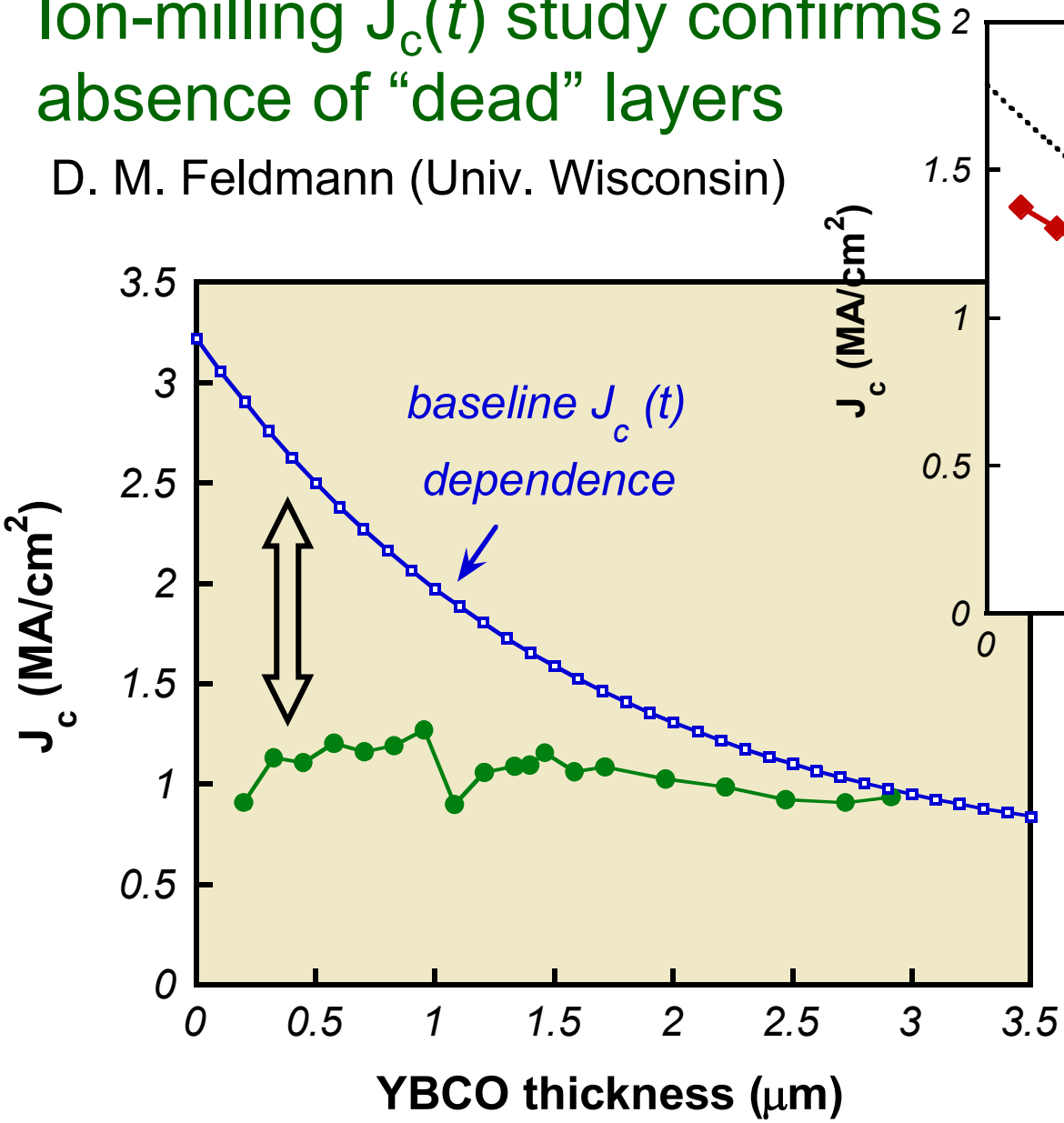
Cr_2O_3

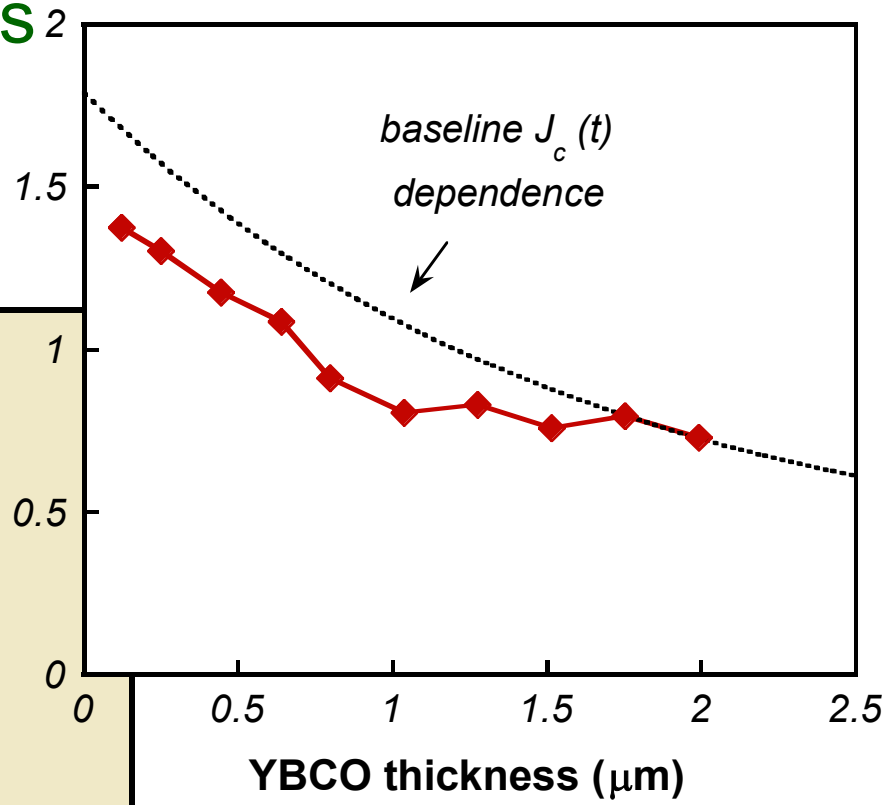
Ni-alloy substrate

T. G. Holesinger, LANL

Ion-milling $J_c(t)$ study confirms absence of "dead" layers

D. M. Feldmann (Univ. Wisconsin)

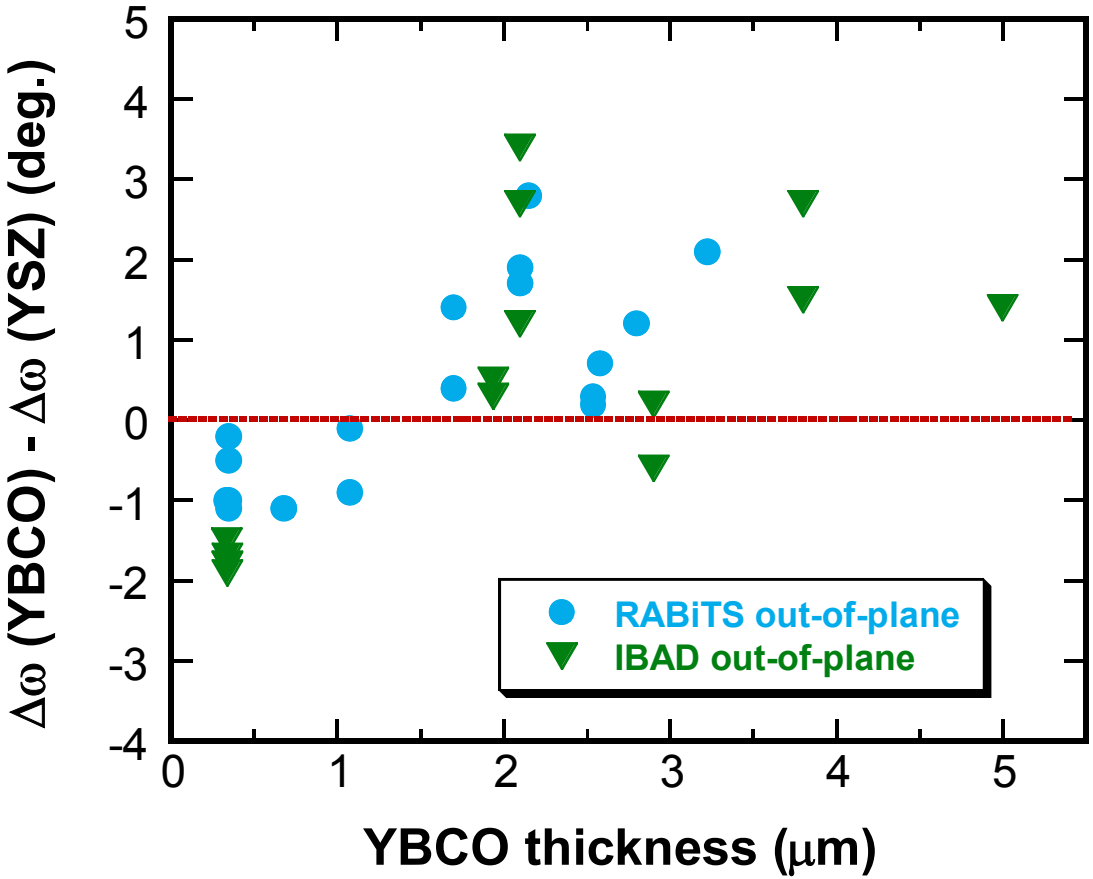




- J_c of bottom YBCO depends on precursor thickness/ processing

Possible structural origin of $J_c(t)$ dependence

XRD indicates enhanced disorder in thick YBCO
-- reduced "healing" effect from anisotropic growth

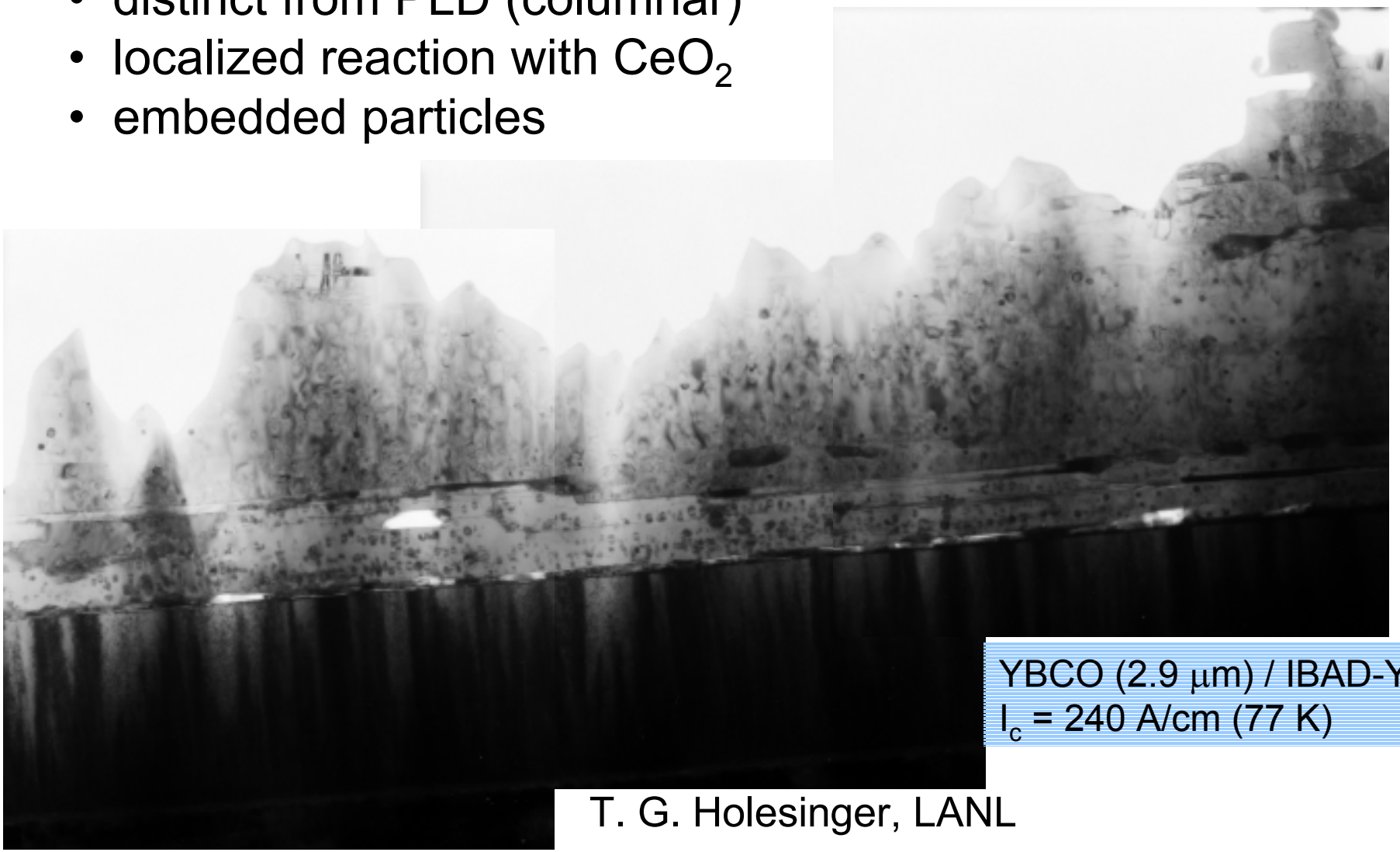


additional out-of-plane tilts in YBCO relative to substrate

YBCO improved relative to substrate

TEM shows layered structure of *ex situ* YBCO

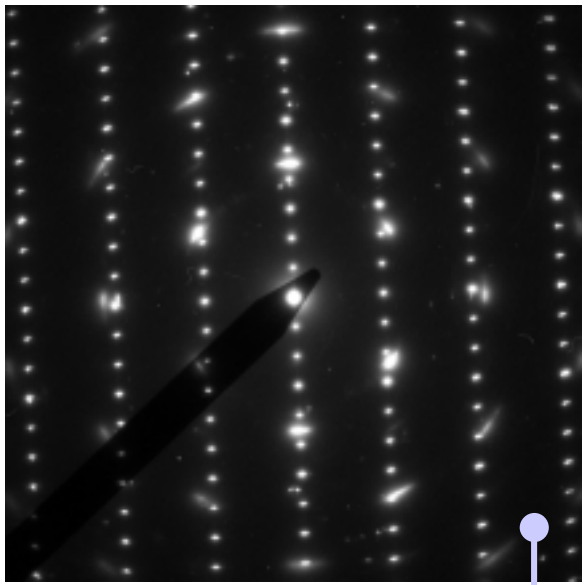
- distinct from PLD (columnar)
- localized reaction with CeO_2
- embedded particles

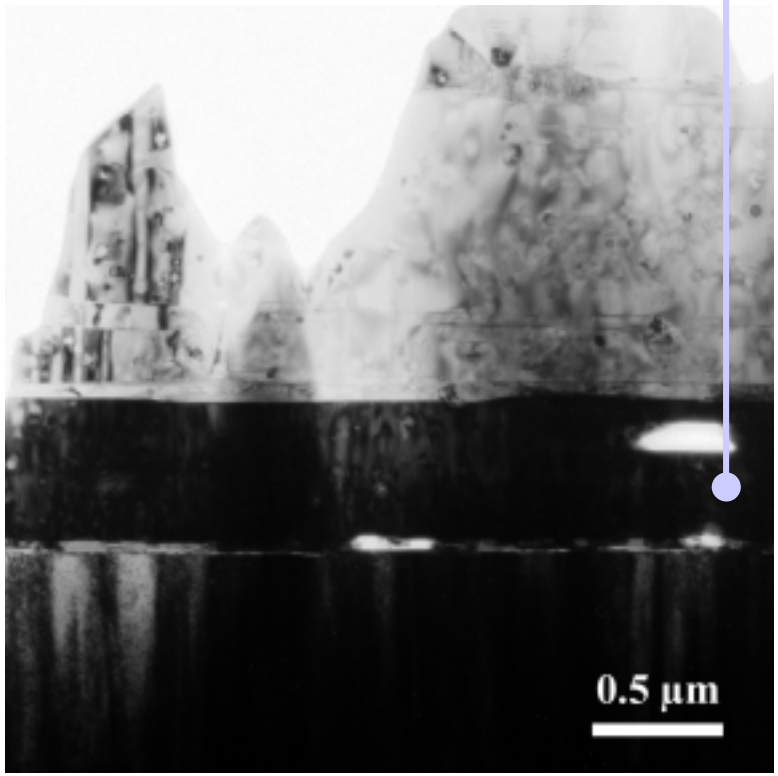


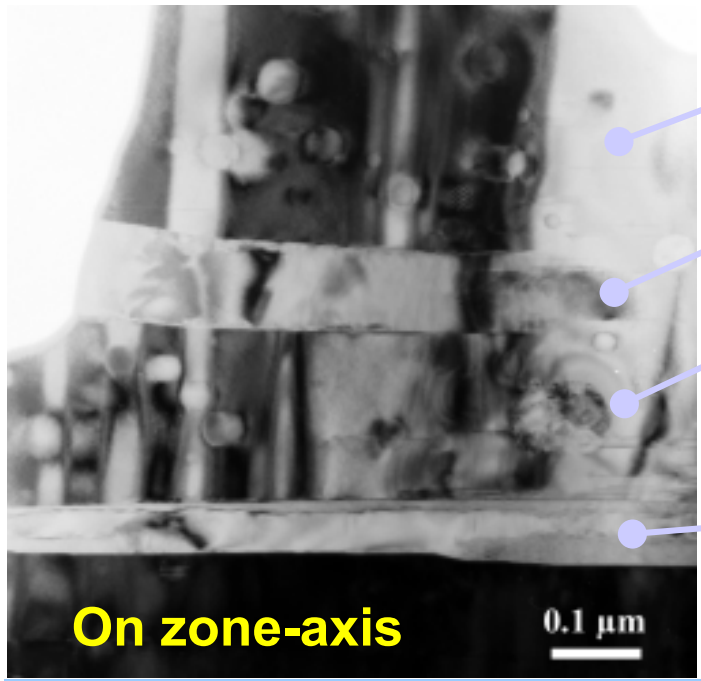
YBCO (2.9 μm) / IBAD-YSZ
I_c = 240 A/cm (77 K)

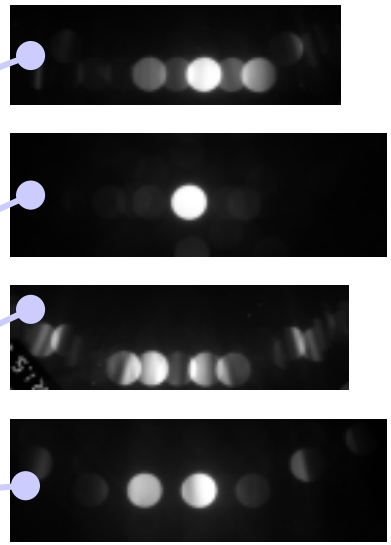
T. G. Holesinger, LANL

Microdiffraction ⇒ out-of-plane tilts in YBCO grains relative to bottom grain (aligned with substrate)









YBCO (2.9 μm) on IBAD-YSZ
I_c = 240 A/cm (77 K)

T. G. Holesinger (LANL)

Summary—Prospects for higher I_c

- Baseline J_c-thickness dependence has been determined
  - *characteristic of current processing (NOT: universal)*
  - *substrate independent (RABiTS, IBAD-YSZ, texture, …)*

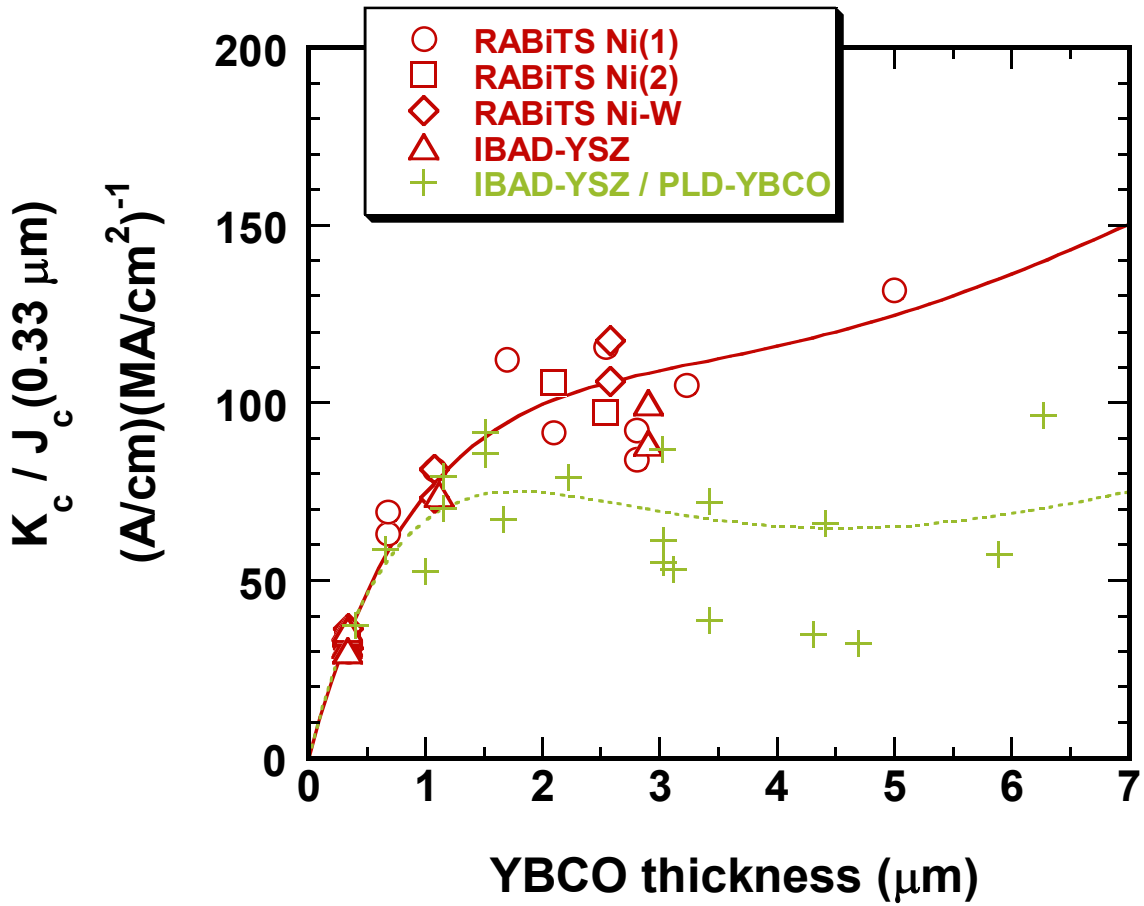
- Absence of "dead" layers suggests feasibility of $t > 3$ μm

- Imperfect epitaxial growth suggested as possible origin of strong $J_c(t)$ dependence

➢ Weaker $J_c(t)$ dependence may result from improved processing
  - NEED: *better understanding of ex situ conversion reaction*
  - "loose ends" may point to future directions/capabilities

Enhancing I_c by increasing YBCO thickness

1. confirm thick film potential (> 5 μm)
2. reduce thickness (improved processing/substrate texture)



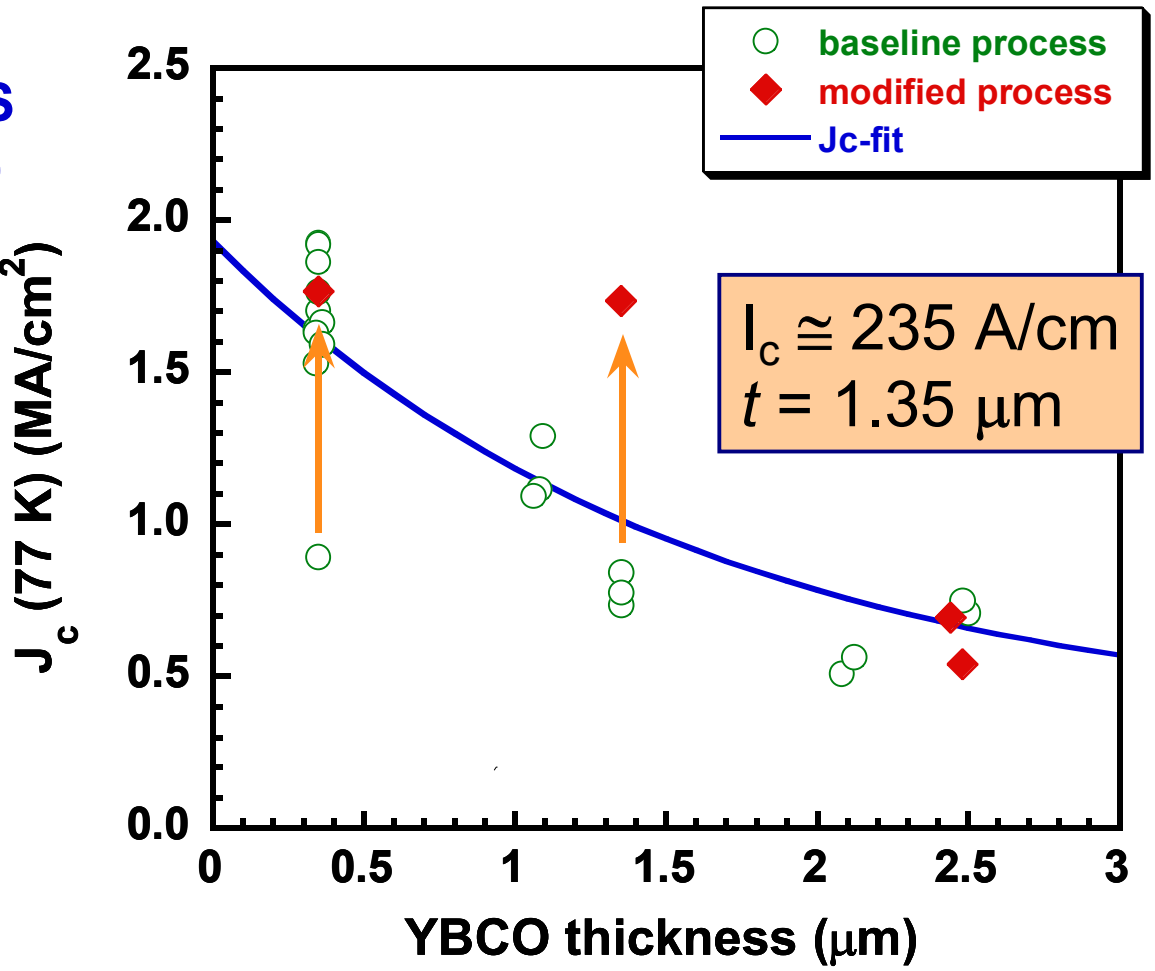
J_c(thin) MA/cm^2	I_c A/cm
1	150
2	300
3	450
4	600

(T = 77 K)

“Loose end” #1

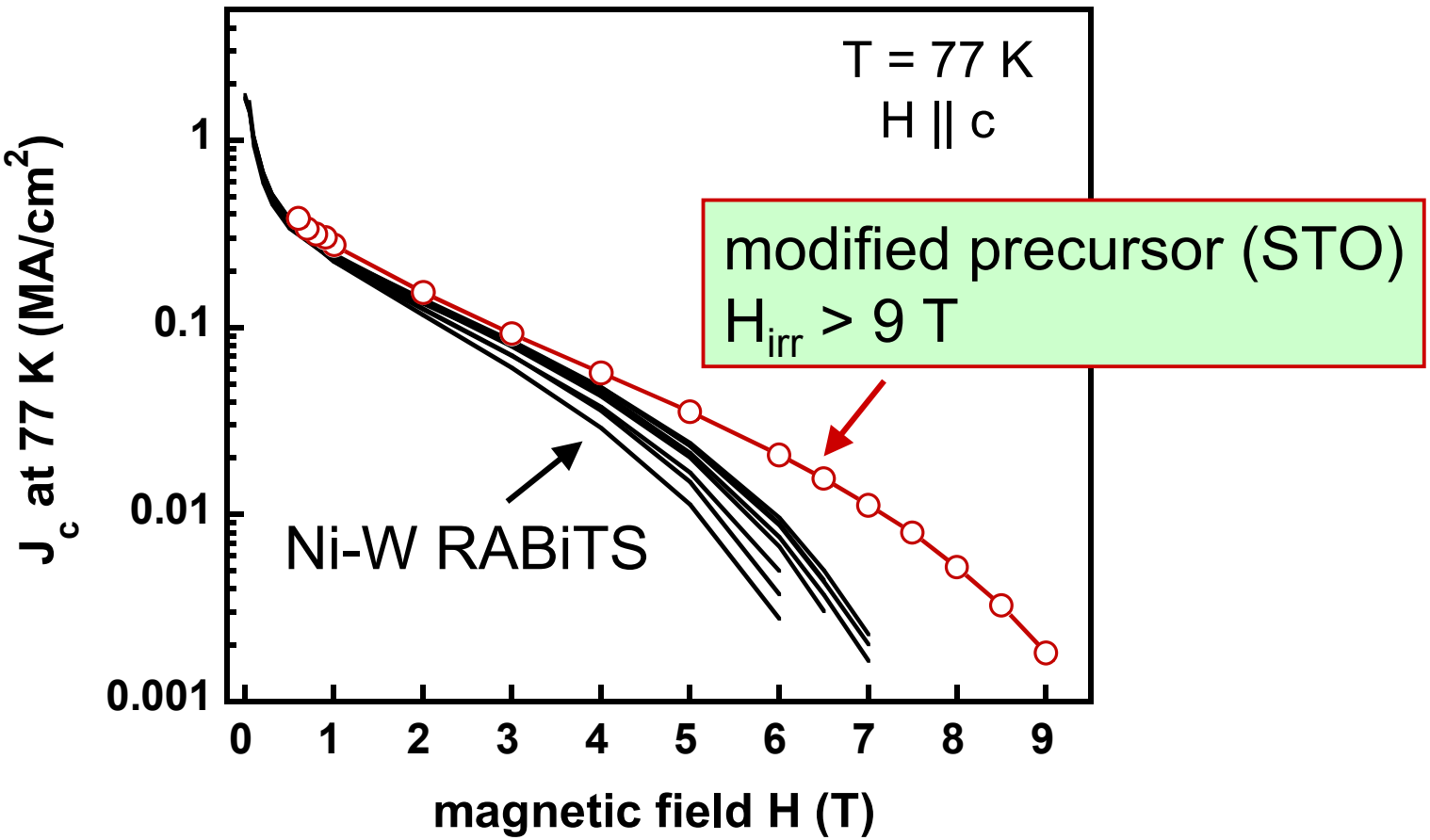
High I_c through precursor/processing modification

Ni-W RABiTS (reel-to-reel)



“Loose end” #2
High H_{irr} through precursor/processing modification

High I_c + high H_{irr} ⇒ high H-field, 77-K operation



Perspective

YBCO Coated conductors are still in early stage of development

Much improvement expected from diligent process refinement and serendipitous discoveries

- operation at 77 K
- near single-crystal texture
- 500-1000 A/cm, high irreversibility field (10 T)
- large application sphere