

**Influence of granularity on the local transport properties in pure and BaHfO<sub>3</sub> doped YBCO films on technical templates**

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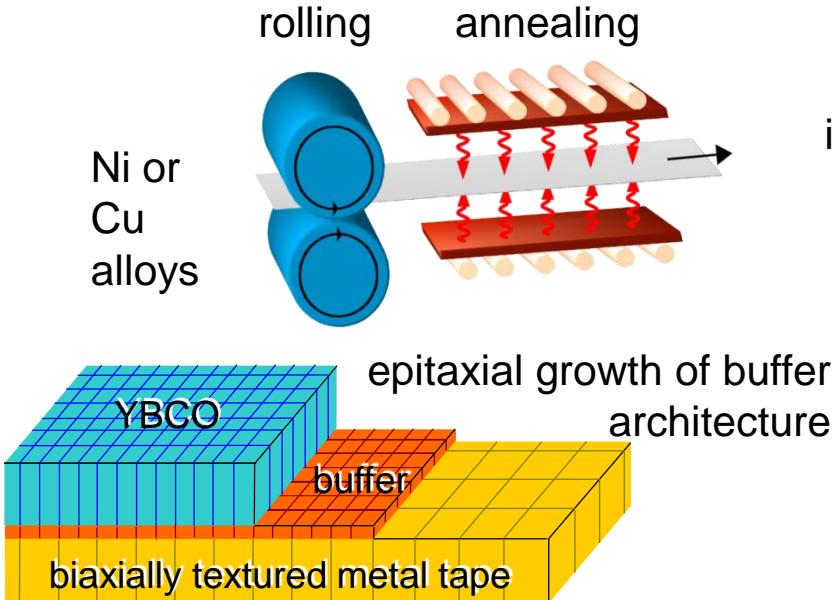
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We thank A. Usoskin (Bruker HTS) and M. Falter (D-Nano) for the provision of the buffered substrates.

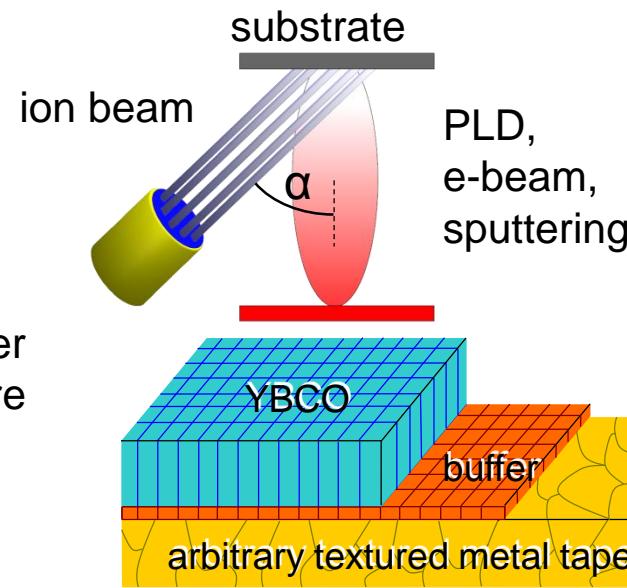
# Coated conductor development

## Rolling Assisted Biaxially Textured Substrates (RABiTS)



→ Based on biaxially textured substrates

## Ion Beam Assisted Deposition (IBAD)



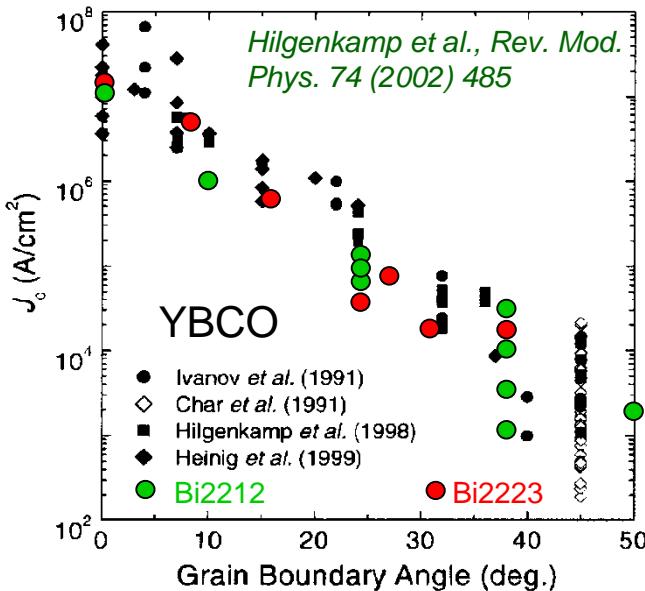
→ Based on biaxially textured buffer layers

European development of Superconducting Tapes: integrating novel materials and architectures into cost effective processes for power applications and magnets (EUROTAPES)  
(2012-2017)

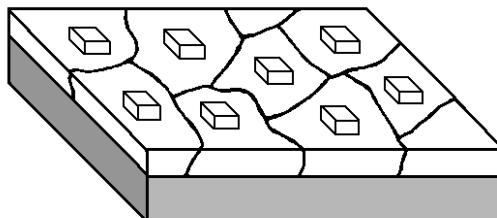


# Coated conductors: Local granularity

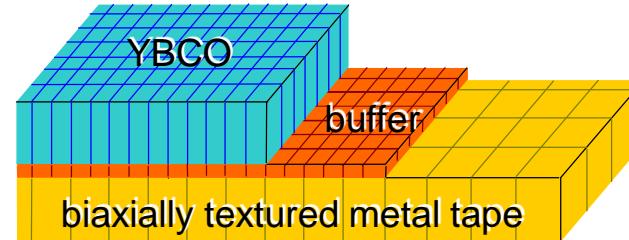
## Influence of grain boundaries



High  $J_c$  in polycrystalline materials require strong biaxial texture

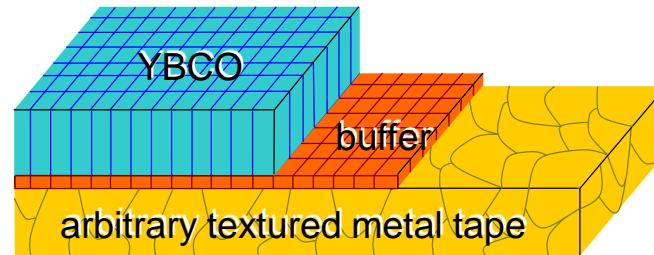


RABiTS



Based on biaxially textured substrates

IBAD/ABAD

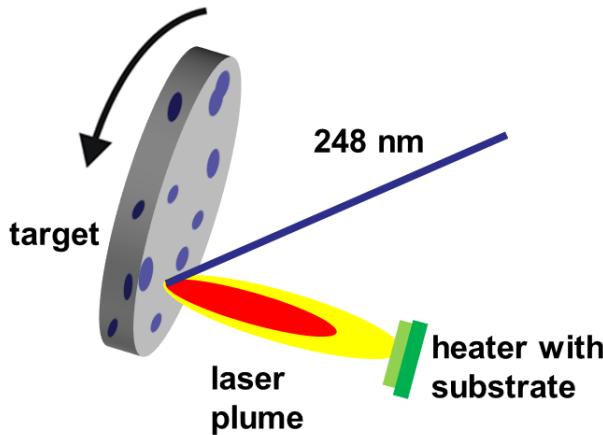


Based on biaxially textured buffer layers

→ Differences in grain boundary network

# Growth of YBCO coated conductors

## Pulsed laser deposition - PLD



- $f_{Dep} = 10 \text{ Hz} (\sim 1.2 \text{ nm/s})$
- Film thickness  $\sim 1 \dots 2 \mu\text{m}$
- Substrate: industrial tape



**Stainless steel / ABAD-YSZ / PLD-CeO<sub>2</sub>**  
**RABiT Ni-5 at.% W / CSD-La<sub>2</sub>Zr<sub>2</sub>O<sub>7</sub> / CSD-CeO<sub>2</sub>**  
**SrTiO<sub>3</sub> single crystal**

deutsche  
nanoschicht

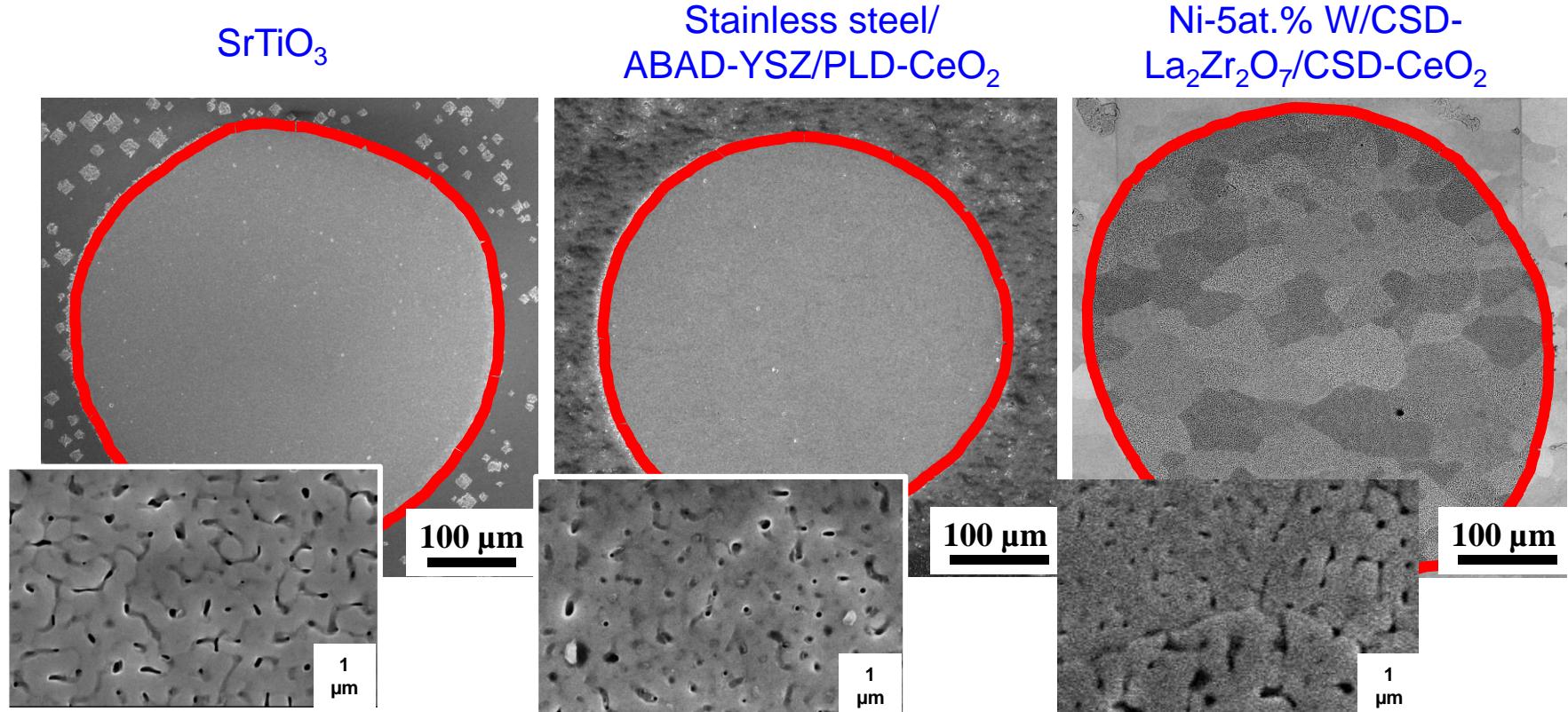
Targets from stoichiometric powders:

- Pure YBCO
- YBCO + 5 mol% BaHfO<sub>3</sub> (**BHO**)
- Similar deposition conditions

# Influence of granularity

Study of ~1  $\mu\text{m}$  thick PLD-YBCO layers

SEM surface images of etched spots

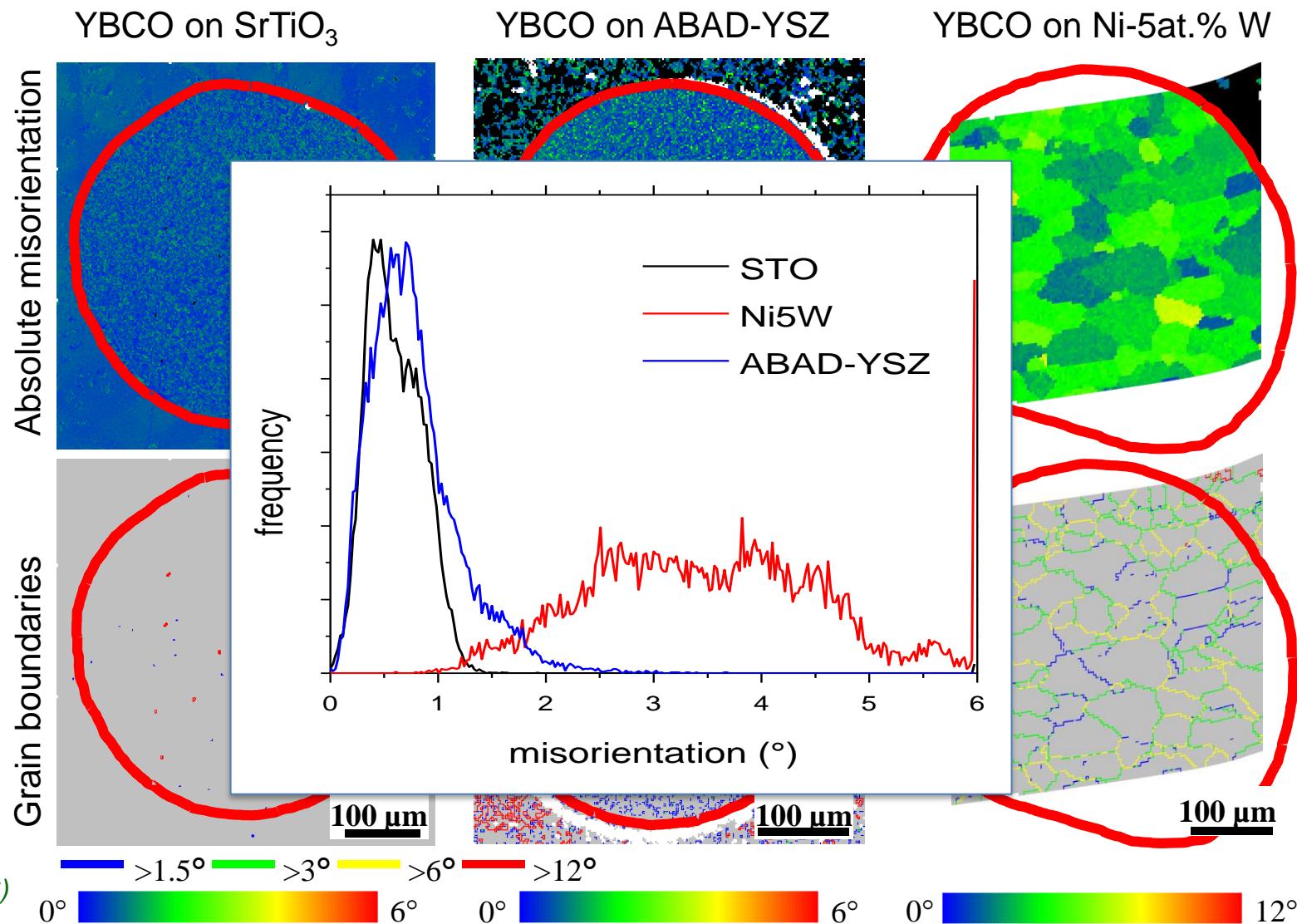


- Homogeneous structure on STO and ABAD-YSZ
- Varying microstructure on NiW

P. Pahlke et al., IEEE-TAS 26 (2016) 7201505

# Influence of granularity

EBSD

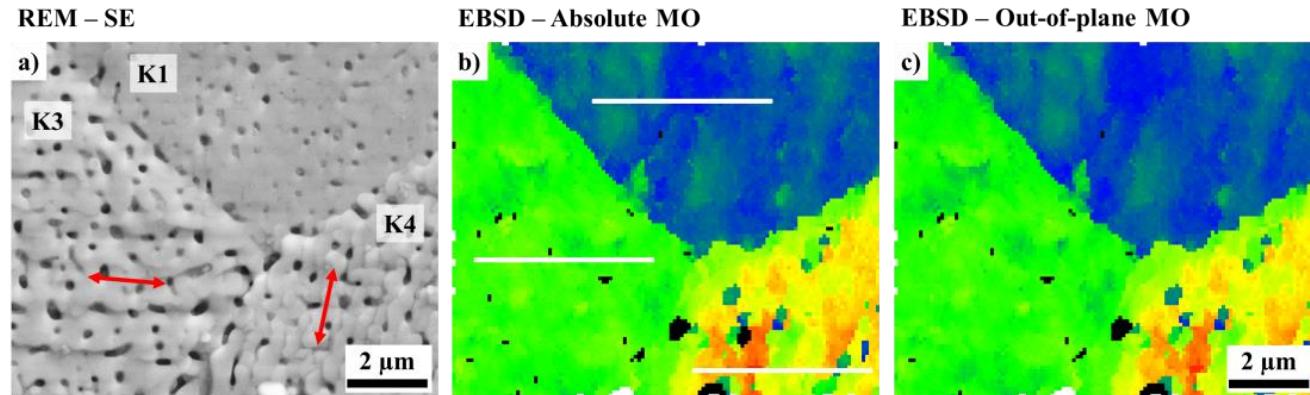


P. Pahlke et al.,  
IEEE-TAS 26 (2016)  
7201505

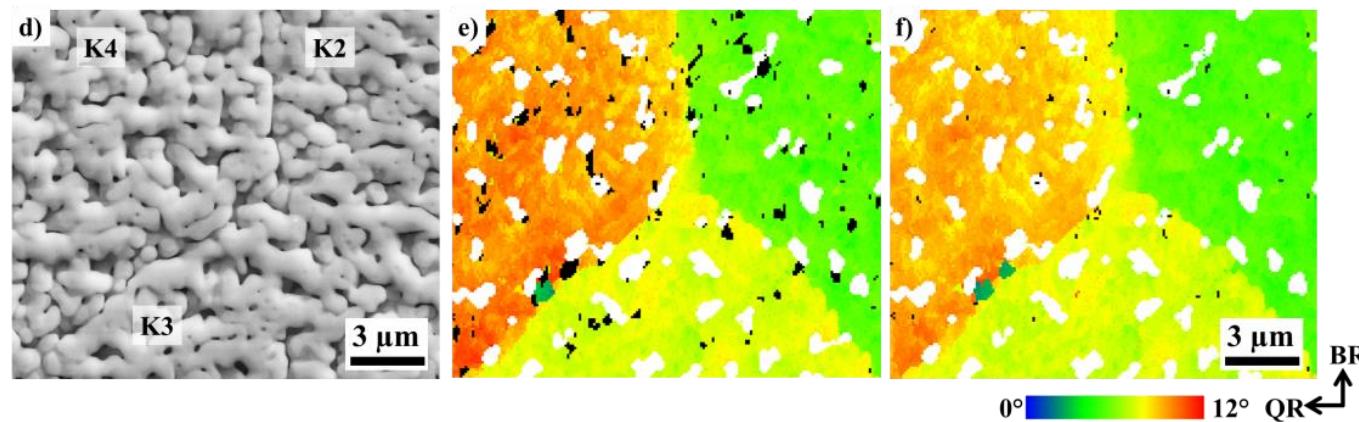
# Granularity of YBCO on Ni-W RABiTS

EBSD of PLD-YBCO layers with different thickness

400 nm YBCO



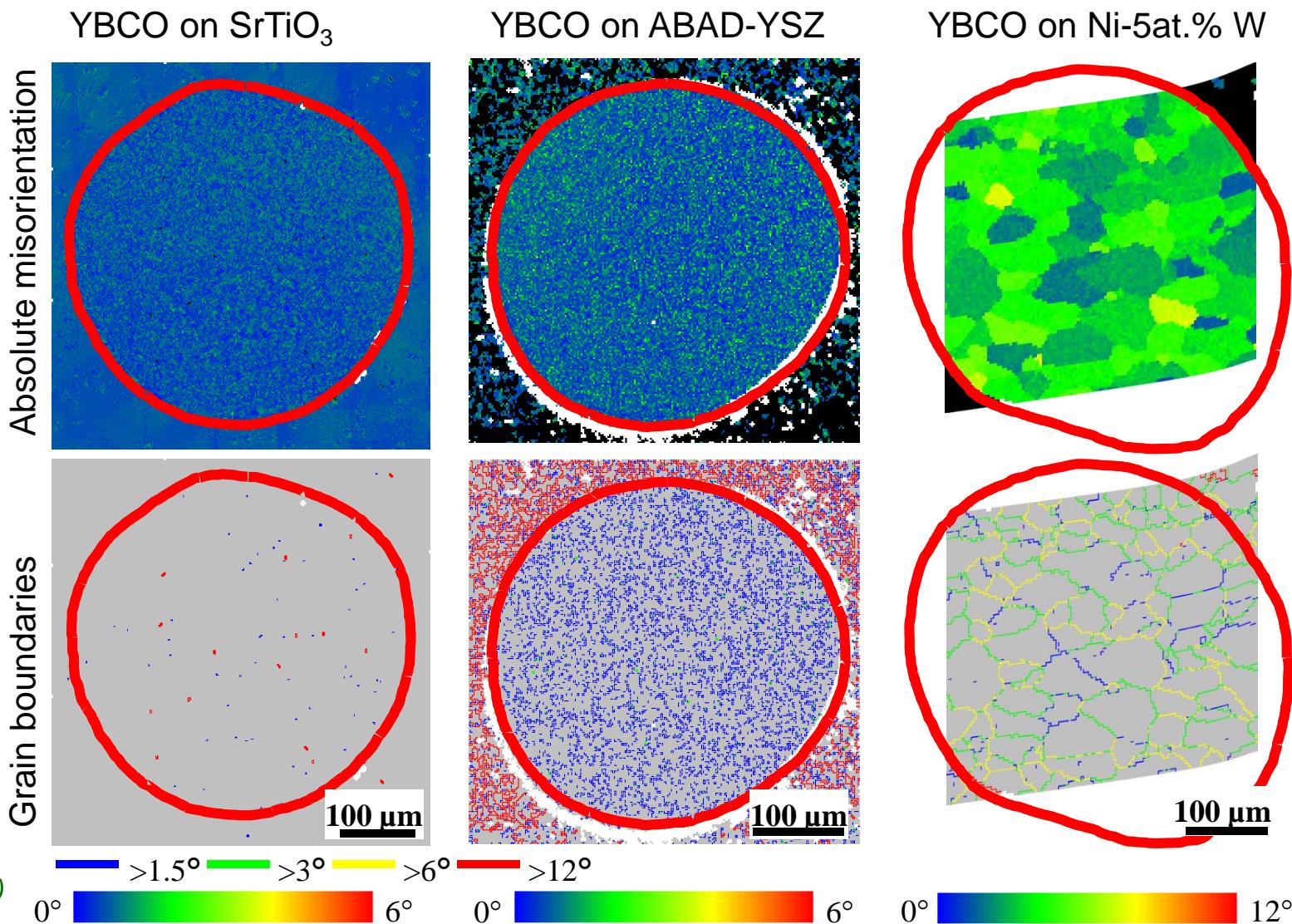
1200 nm YBCO



Higher roughness but improved intragrain texture

# Influence of granularity

EBSD

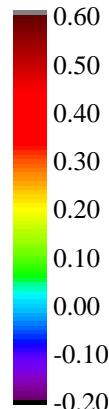
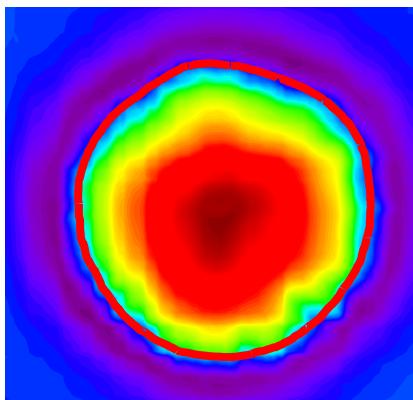


P. Pahlke et al.,  
IEEE-TAS 26 (2016)  
7201505

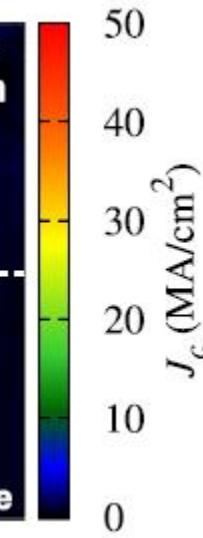
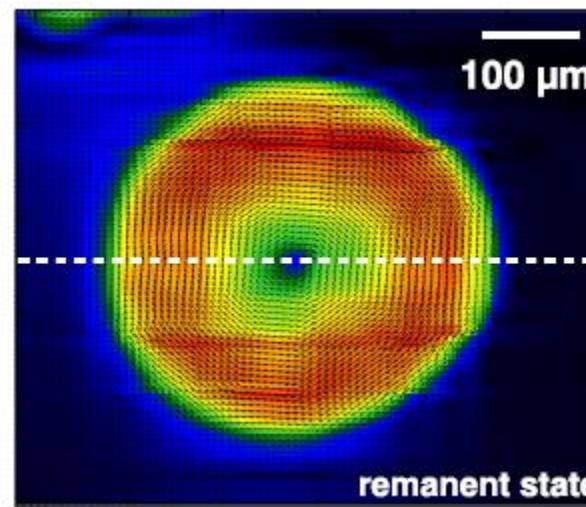
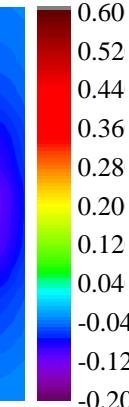
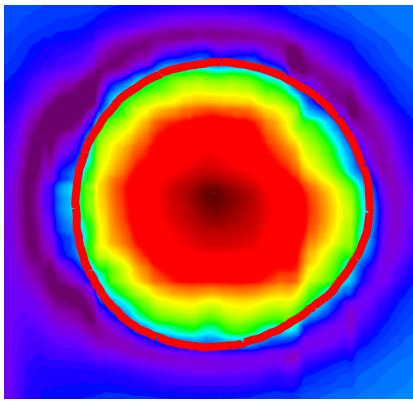
# Influence of granularity – local scale

SHPM mappings (Hall scan of trapped field profile at 4.2 K)

YBCO on STO



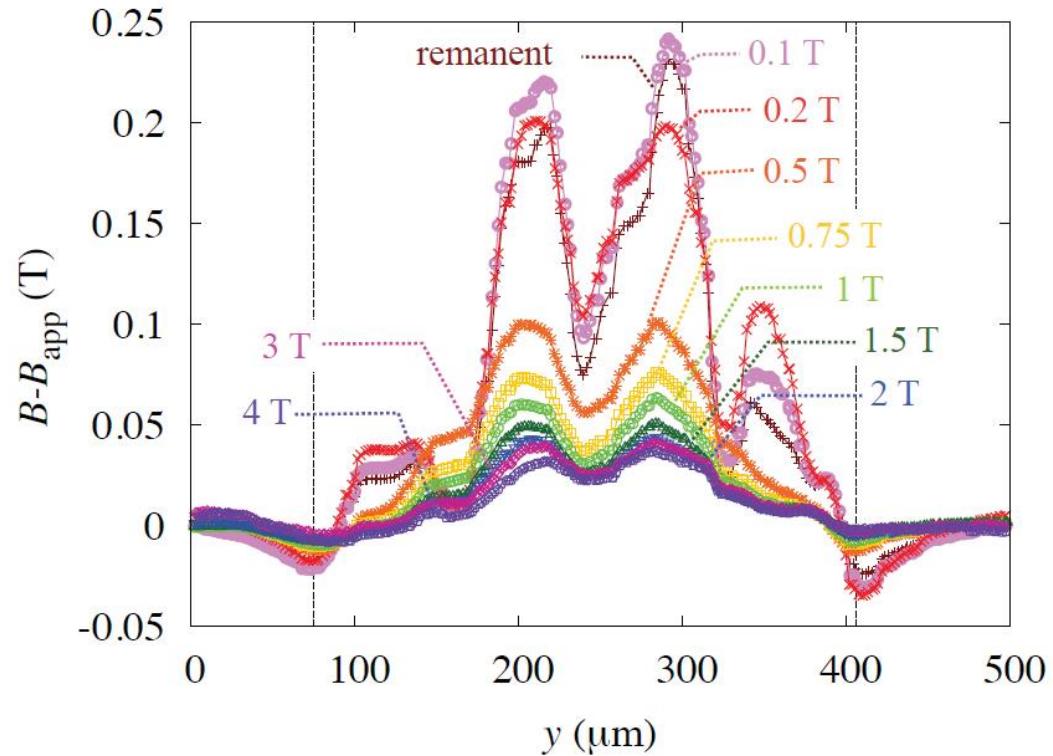
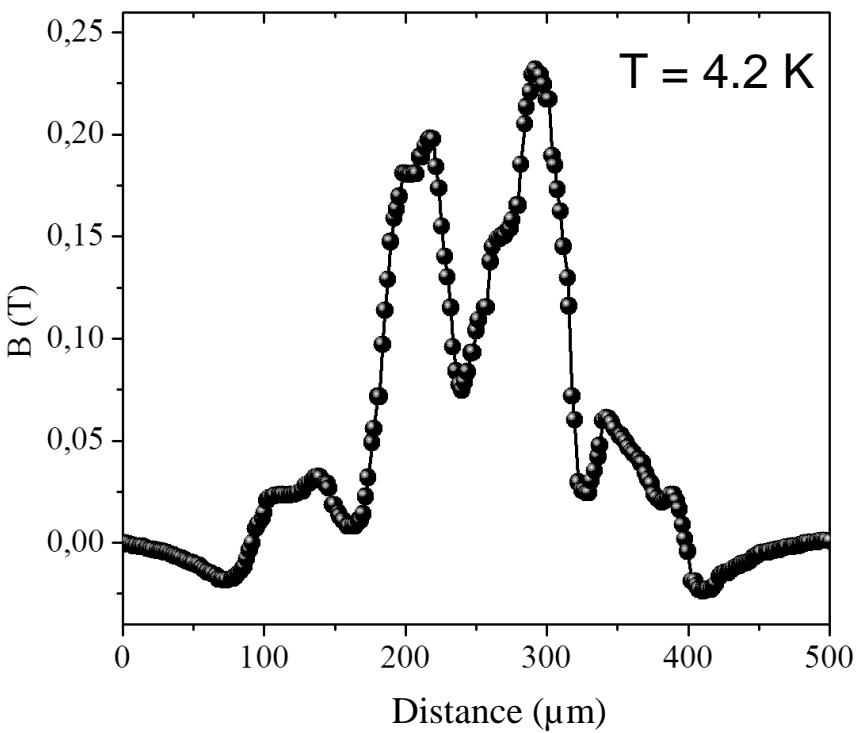
YBCO on ABAD-YSZ



M. Lao et al., Supercond. Sci. Technol. 30 (2017) 104003

# Influence of granularity – local scale

## SHPM mappings (Line scans)



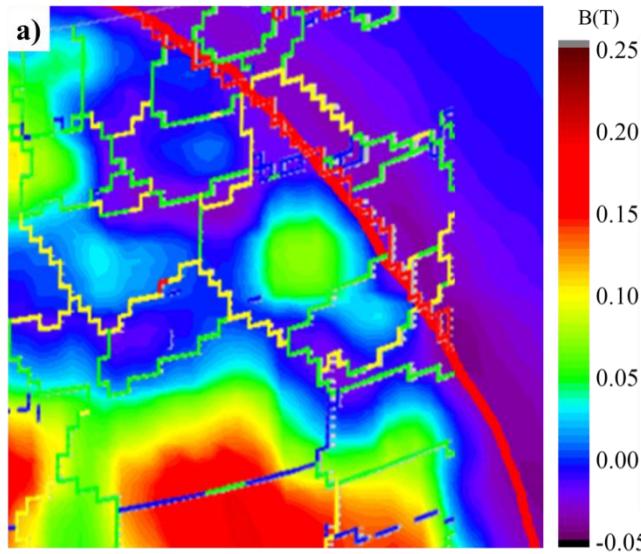
- Granularity is visible in the SHPM map
- Changes with magnetic field → reduced influence of the grain boundaries

M. Lao et al., Supercond. Sci. Technol. 30 (2017) 104003

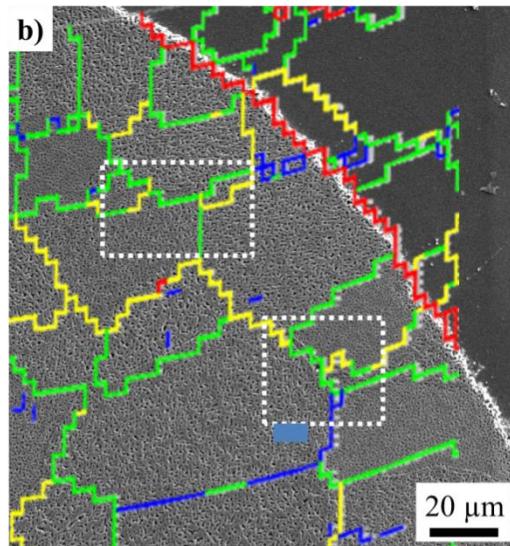
# Influence of granularity – local scale

## Correlation

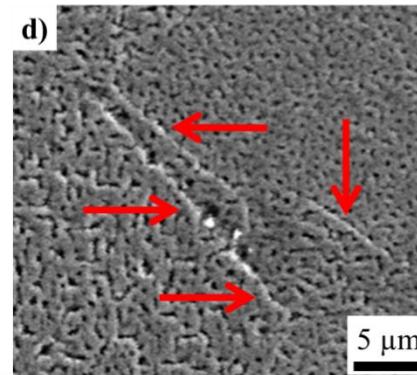
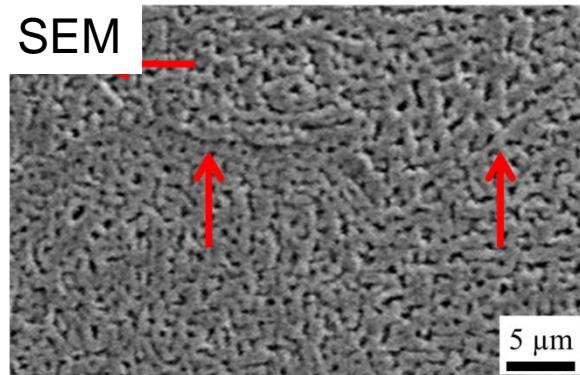
### SHPM/EBSD



### SEM/EBSD



### SEM



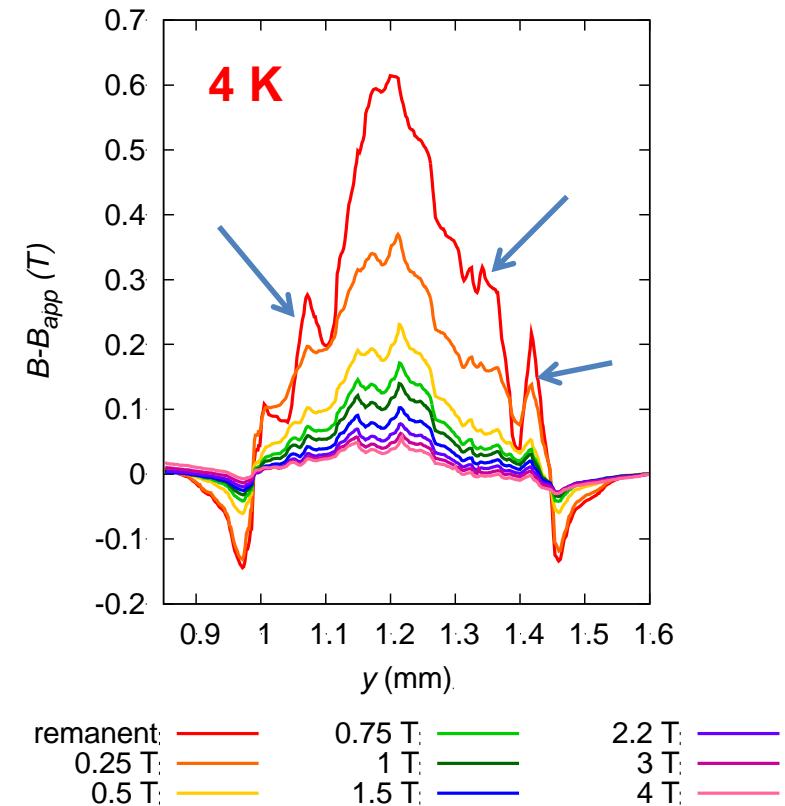
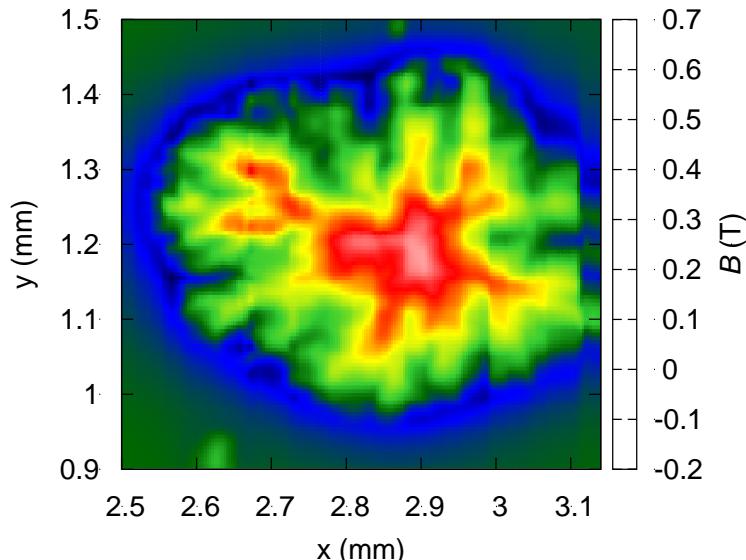
- Good match between different types of local analysis
- Regions with low (negative) remanent field: magnetic field can penetrate
  - No/weak superconductivity although  $\text{MO} < 6^\circ$
  - Possible reason: connectivity between two grains (precipitates, pores, non-coalesced YBCO islands)

*Not only total MO but also microstructure of GB need to be considered!*

# Influence of granularity – local scale

## CSD-YBCO on Ni-5at.%W

Remanent field profile at 4 K

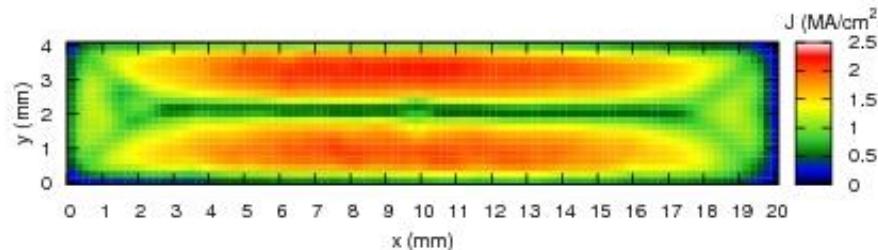


- Some signature of granularity + envelope of global  $J_c$
- Result of meandering grain boundaries

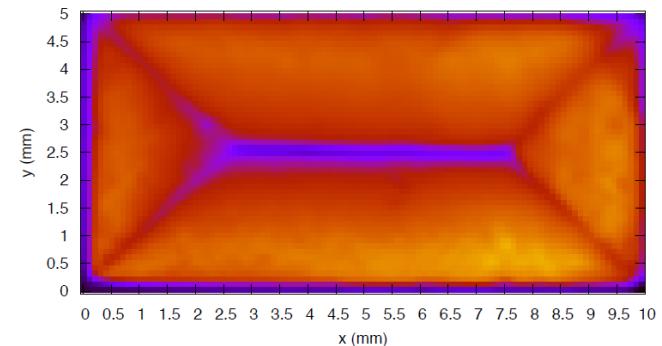
# Influence of granularity – global scale

SHPM mappings (Hall scan of trapped field profile at 77 K)

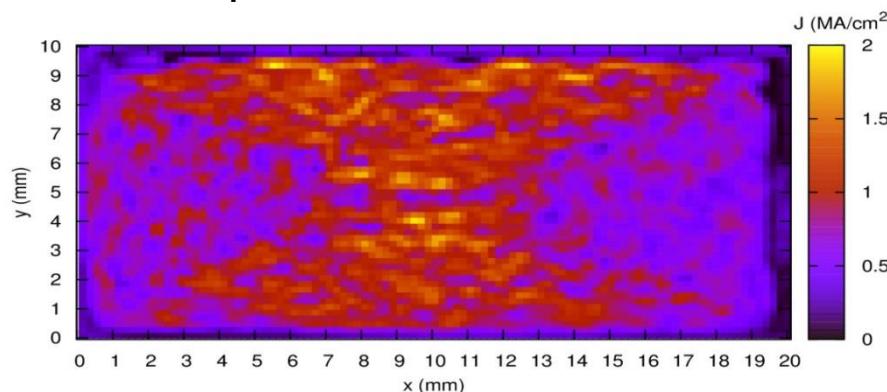
1.3  $\mu\text{m}$  YBCO on ABAD-YSZ



1.2  $\mu\text{m}$  BHO:YBCO on STO



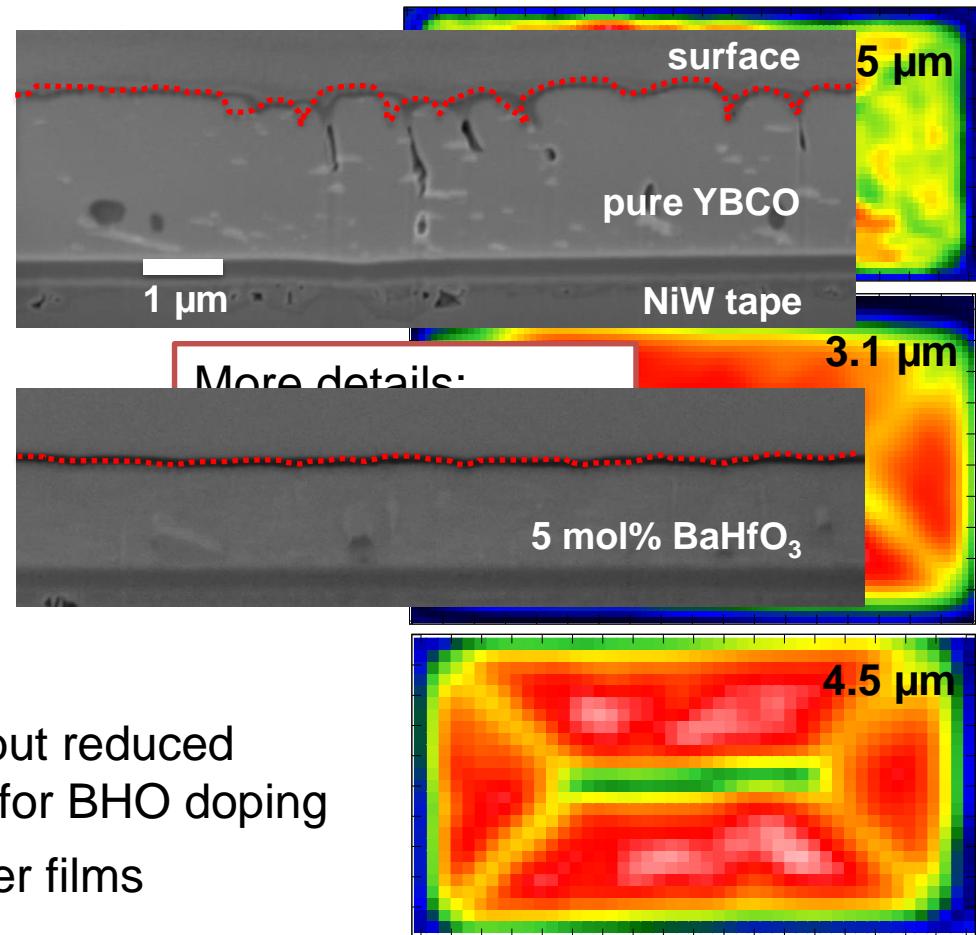
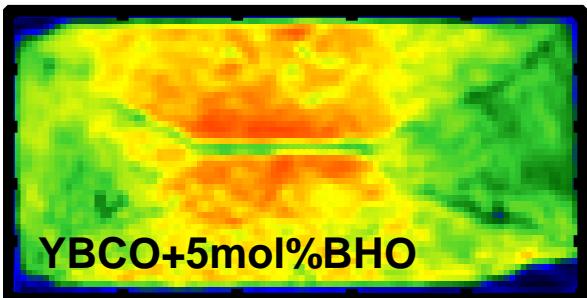
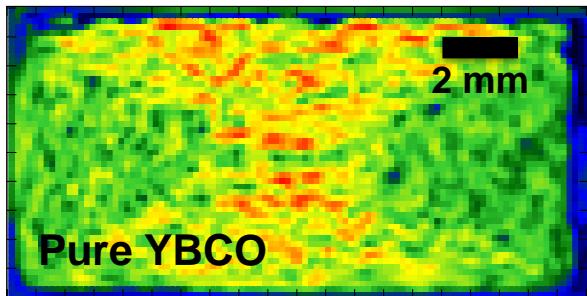
1.7  $\mu\text{m}$  YBCO on NiW



Granularity is still an issue for  
RABiTS-based coated conductors!

# Thick BaHfO<sub>3</sub> doped YBCO films on Ni-W

Hall scan measurements at 77 K



- Similar maximum  $J_c$ -values, but reduced granularity and homogeneity for BHO doping
- Reduced granularity for thicker films

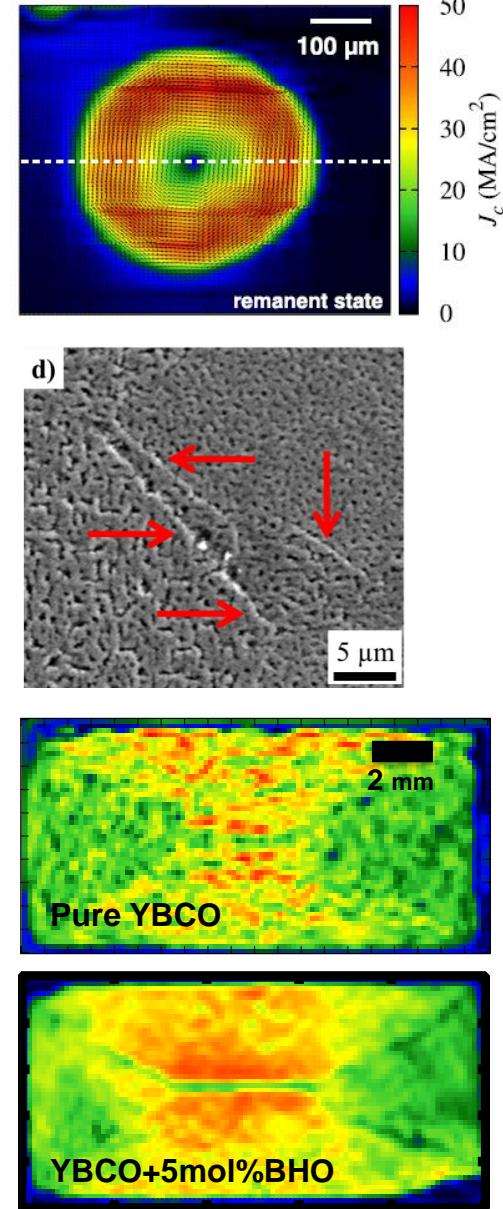
M. Sieger et al., IEEE TAS 25 (2015) 6602604

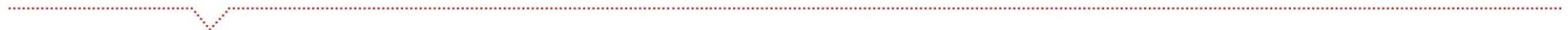
M. Sieger et al., IEEE TAS 26 (2016) 7500305

M. Sieger et al., IEEE TAS (EUCAS 2017) submitted

# Summary

- Granularity of ABAD-YSZ films almost similar to films on STO single crystals
- **Granularity** has an influence on local  $J_c$  in particular for RABiTS based coated conductors
- Intergrain  $J_c$  on RABiTS is influenced by **grain boundary angle** and by **local microstructure of the grain boundary**
- YBCO layers with artificial pinning centers show reduced granularity
- Influence of granularity is further **reduced in thick YBCO films**





# Thanks for your attention!