Preparation of superconducting $GdBa_2Cu_3O_{7-x}$-$BaHfO_3$ nanocomposite films by CSD with improved electrical performances

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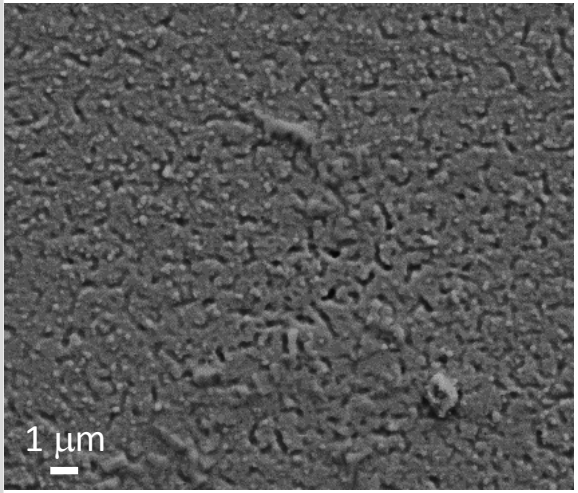
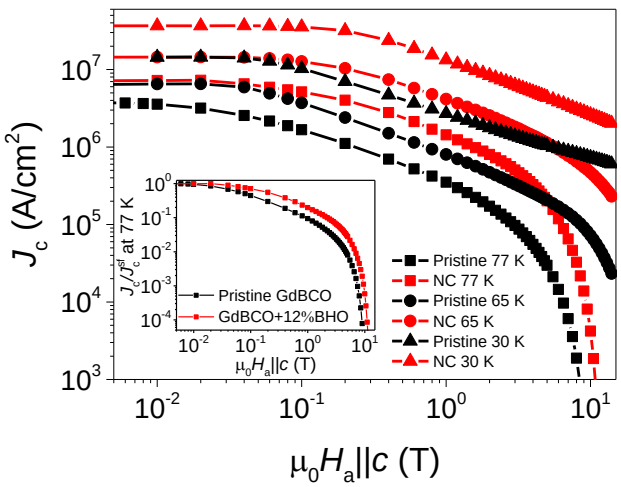
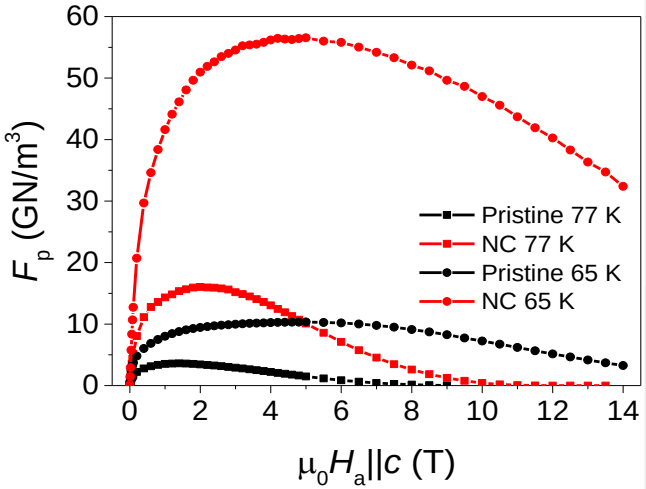
INSTITUTE FOR TECHNICAL PHYSICS; SUPERCONDUCTING MATERIALS AND APPLICATIONS

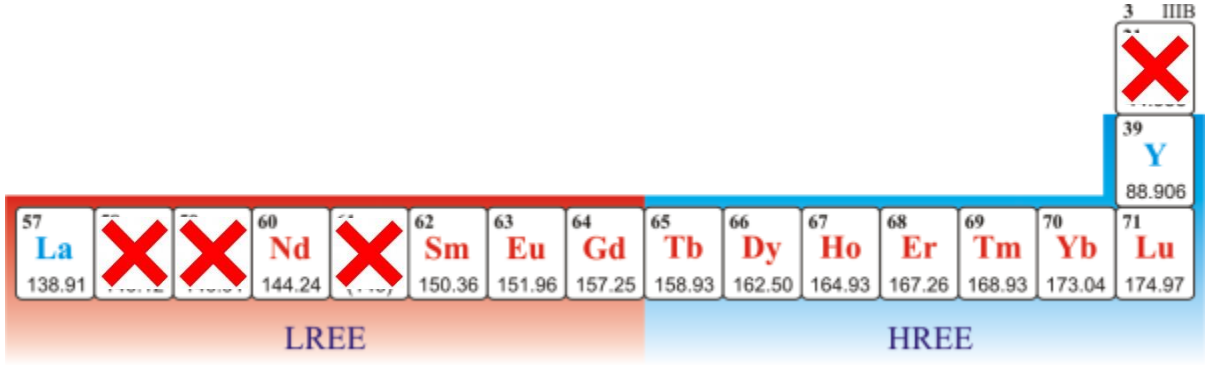


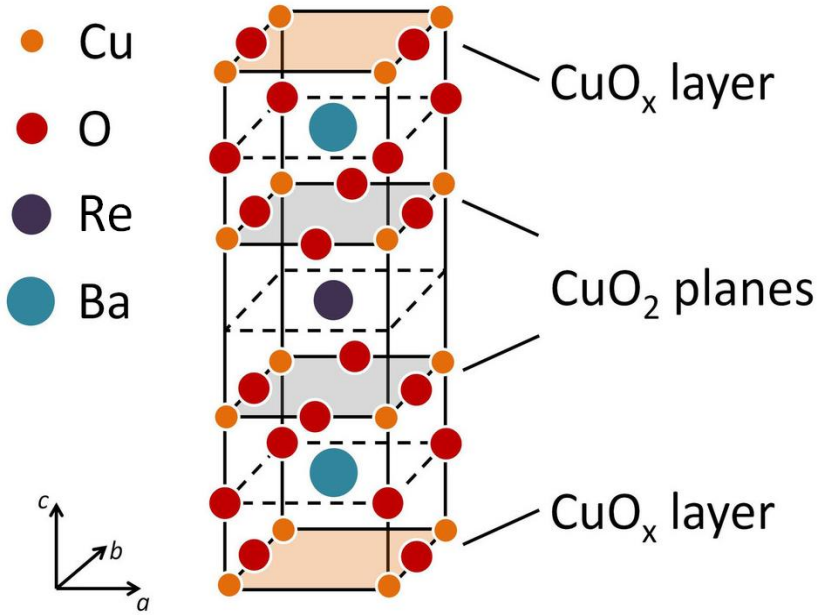




*Motivation-RE*BCO compounds

- Different *RE*BCO compounds: change of *RE* ion in the structure

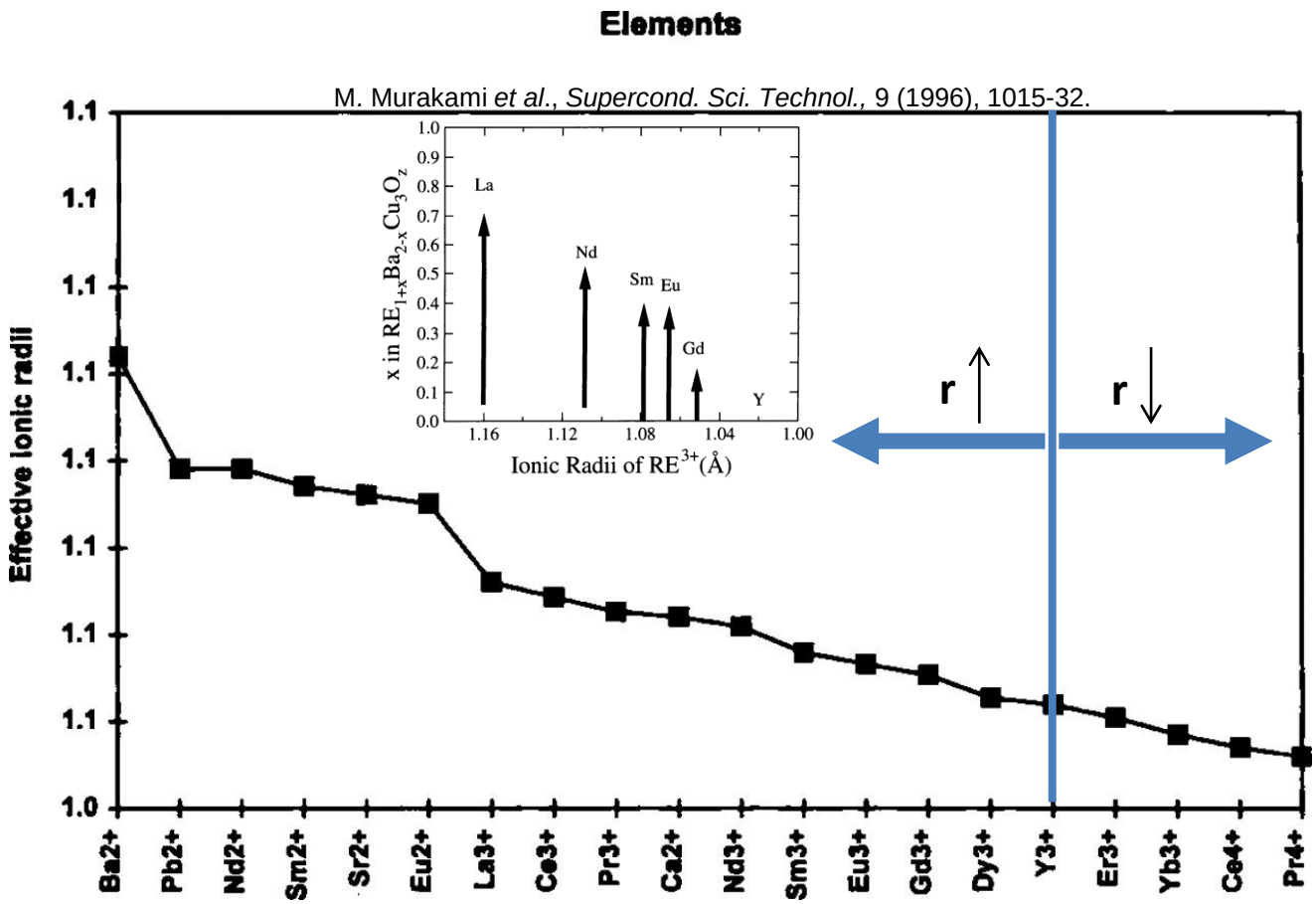




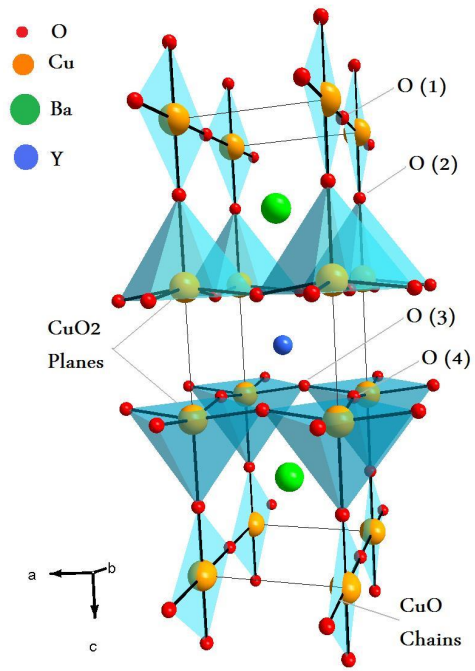
Motivation- Alternative *RE*BCO compounds (I)

- Substitution of Y^{3+} by other RE ions: the change in ionic radius makes the structure more unstable
- Larger ionic radius→ larger T_c

M. Murakami *et al.*, *Supercond. Sci. Technol.*, 9 (1996), 1015-32.

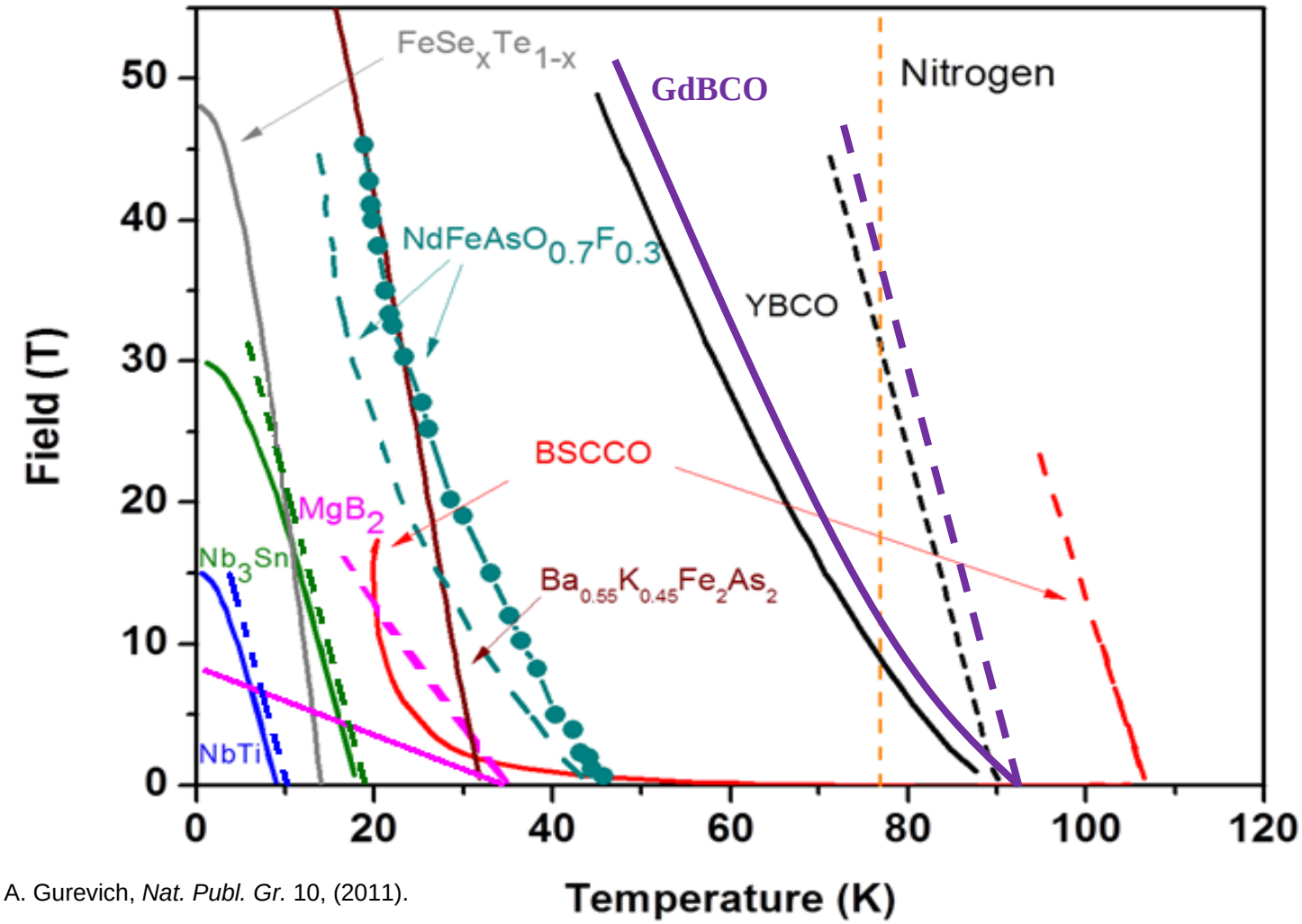


L. E. Mordberg *et al.*, *Eur. J. Mineral.* 12, (2000).



Motivation- Alternative *RE*BCO compounds (II)

- Larger T_c→ displacement of the IL towards higher *B* and *T*



A. Gurevich, *Nat. Publ. Gr.* 10, (2011).

Workplan

Improve in-field performances

↓

$GdBa_2Cu_3O_7$ + 12%mol $BaHfO_3$ films

↓

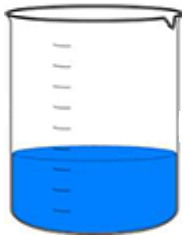
STO

Large scale

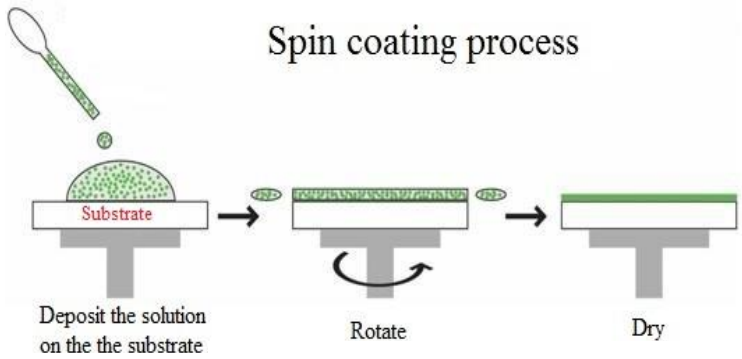
↓

Buffered metallic tapes

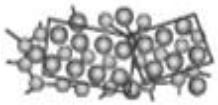
CSD method: TFA route + acetylacetone



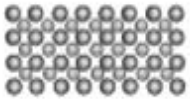
a) Chemical precursor solution preparation



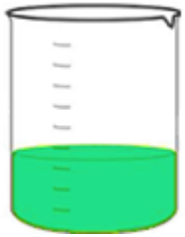
b) Deposition



c) Pyrolysis
(Remove the organic content; amorphous nanocrystalline matrix)

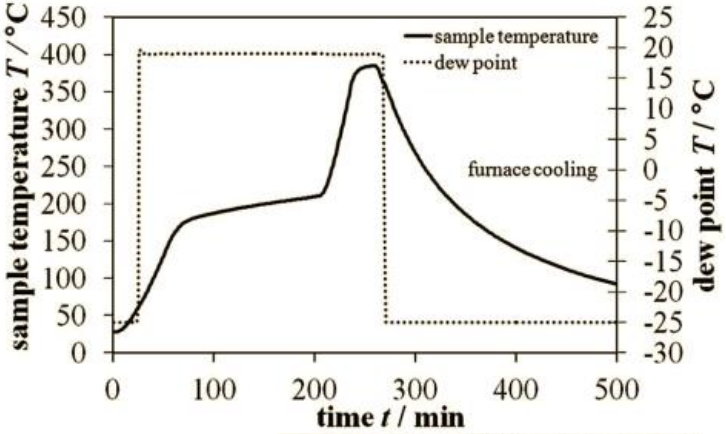


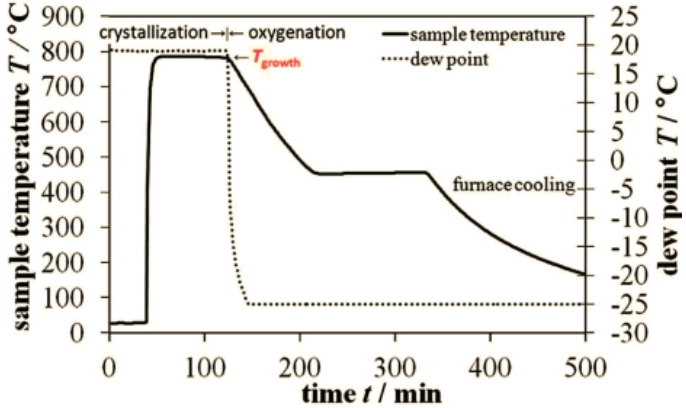
d) Growth
(c-axis oriented YBCO)



*RE*BCO precursor salts + NPs precursor salts+

acetylacetone (acac)

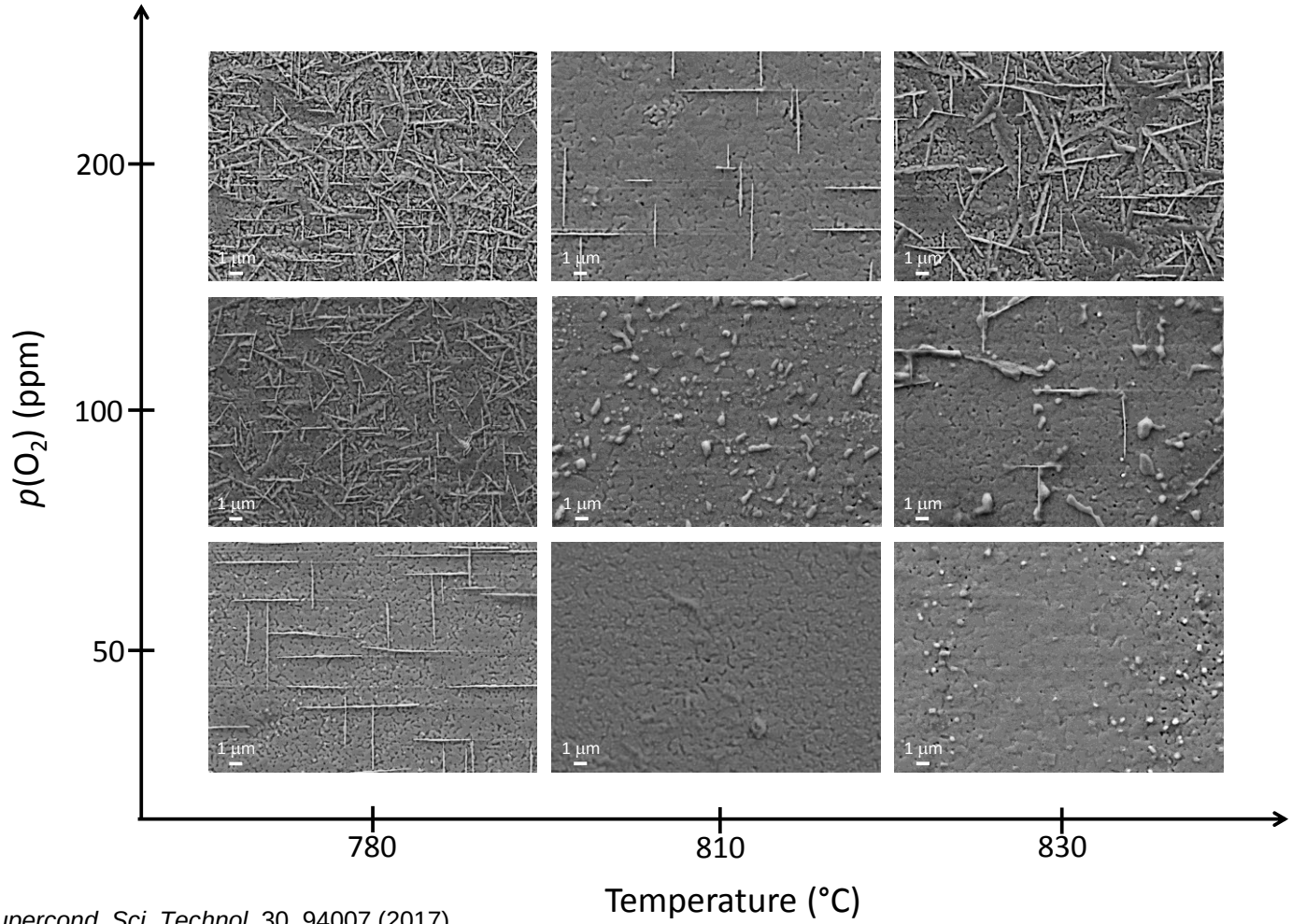




M. Erbe *et al.*, J. Mater. Chem. A 2, 4932 (2014).

Structural properties and surface morphologhy of GdBCO-BHO nanocomposite films on STO

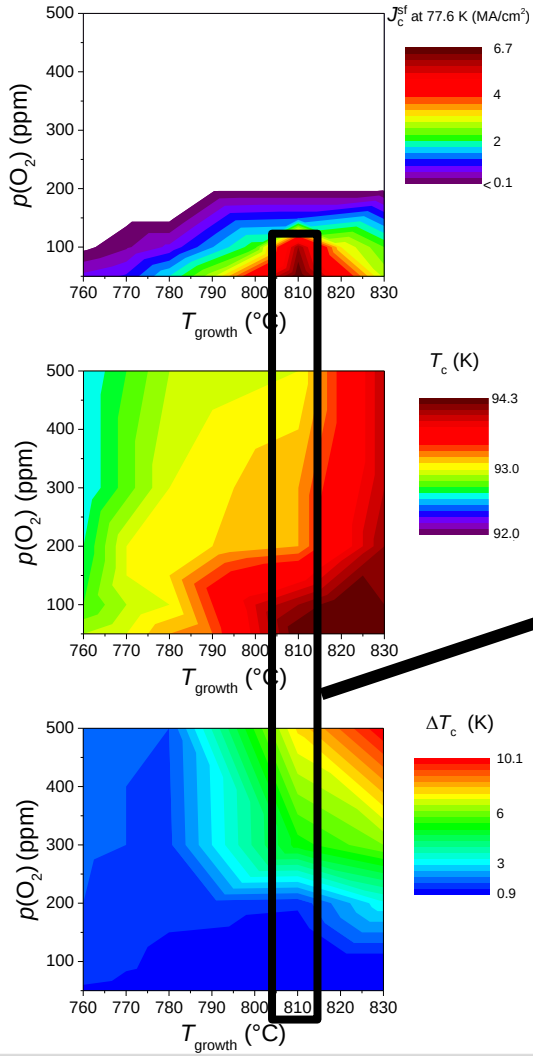
- Pure epitaxial growth only in a narrow window of parameters.
- Same trend is observed in the SEM pictures.

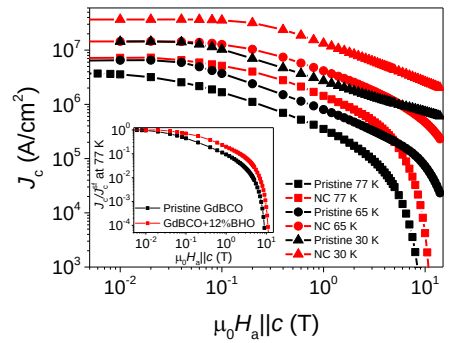


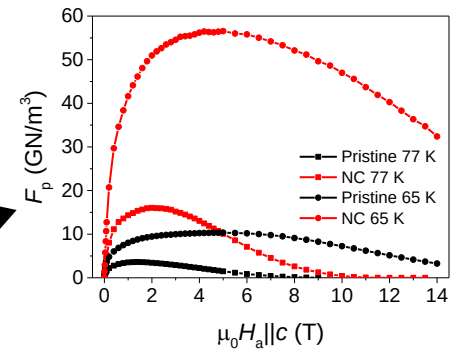
P. Cayado *et al., Supercond. Sci. Technol.* 30, 94007 (2017).

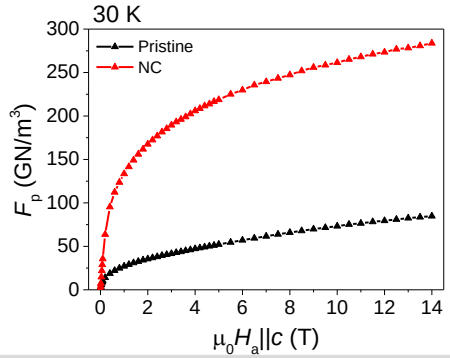
Superconducting properties of GdBCO-BHO nanocomposite films on STO

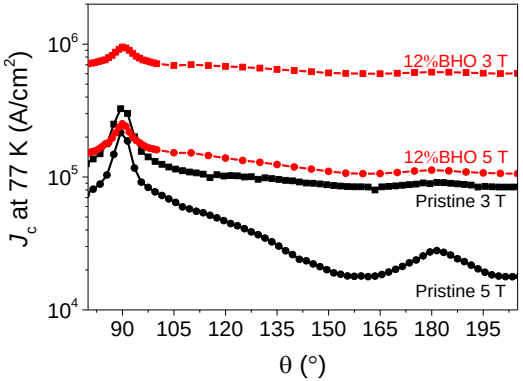
- Largest J_c and T_c and lowest ΔT_c at 810 °C and 50 ppm.











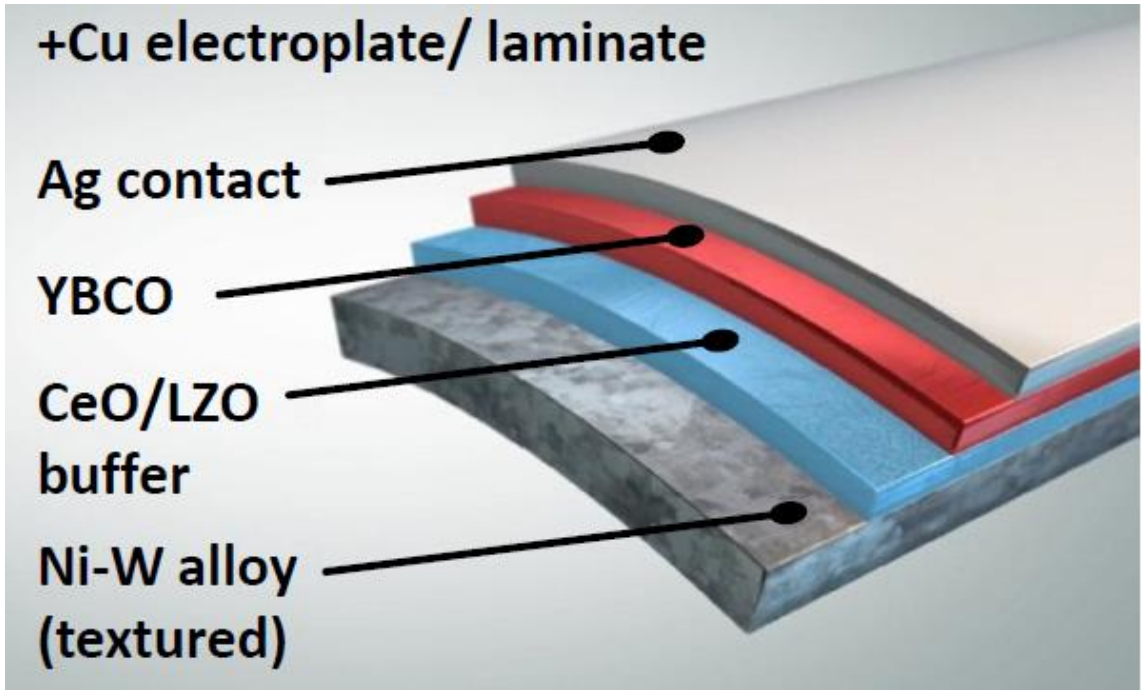
- J_c^{sf} : **7.3 MA/cm²** at 77 K, **14.5 MA/cm²** at 65 K and **36.8 MA/cm²** at 30 K
- F_{pmax} : **16.0 GN/m³** (2 T) at 77 K and **56.5 GN/m³** (5 T) at 65 K
- γ_J=**1.6**

P. Cayado *et al.*, *Supercond. Sci. Technol.* 30, 94007 (2017).

Buffered metallic tape architecture

- Supplier: Deutsche Nanoschicht GmbH (D-Nano)

D-Nano substrates

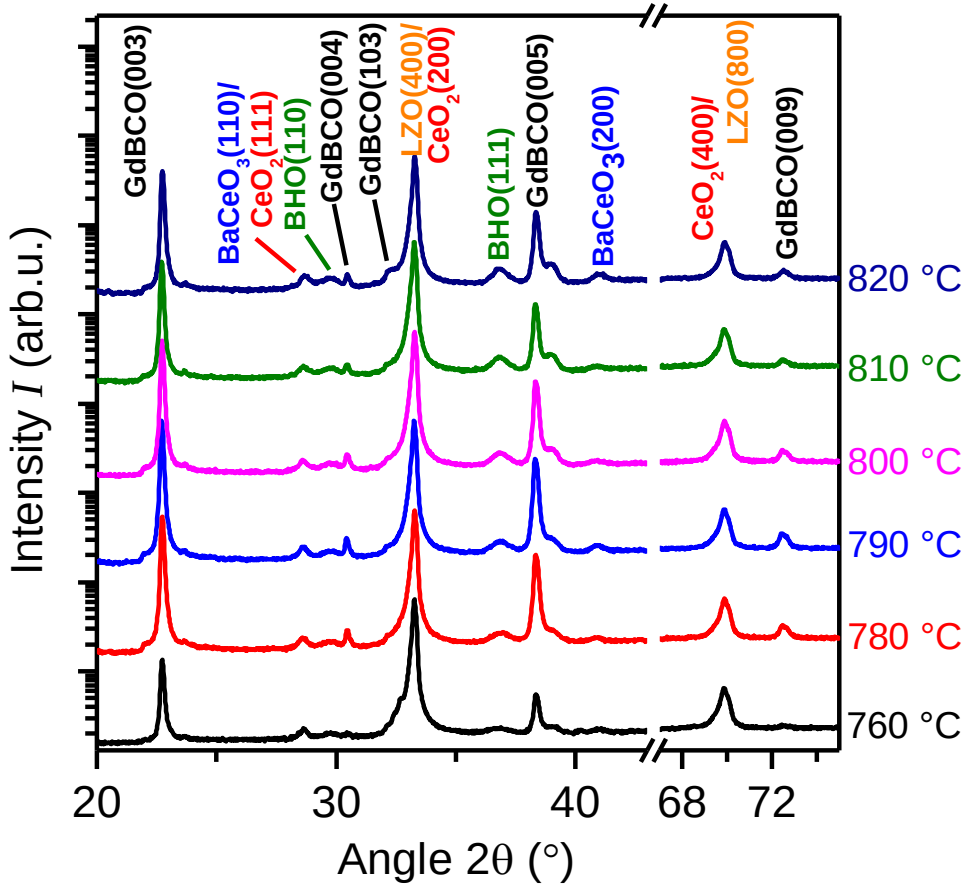


© deutsche nanoschicht

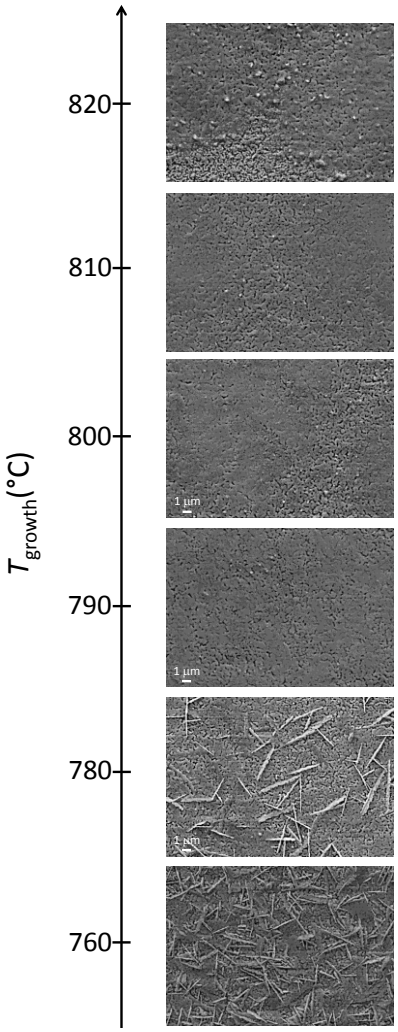
RABiTS

Structural properties and surface morphologhy of GdBCO-BHO nanocomposite films on Tape

- Purely epitaxial growth and smoother surface at 790 °C.



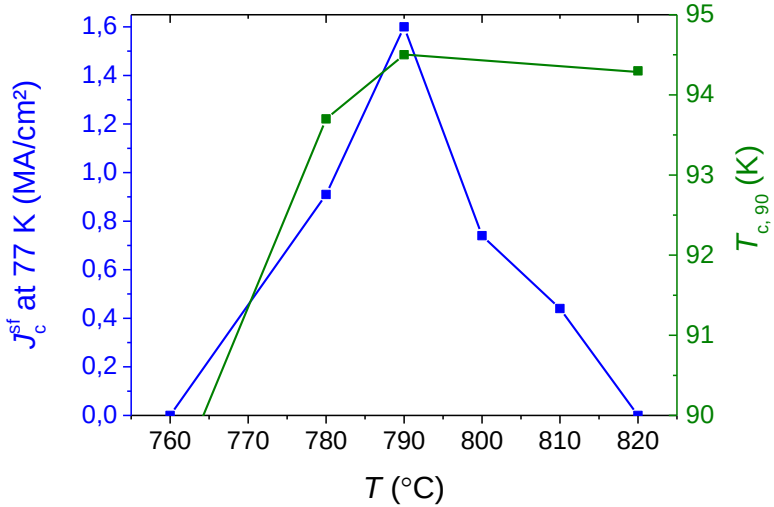
Constant $p(O_2)$: 50 ppm

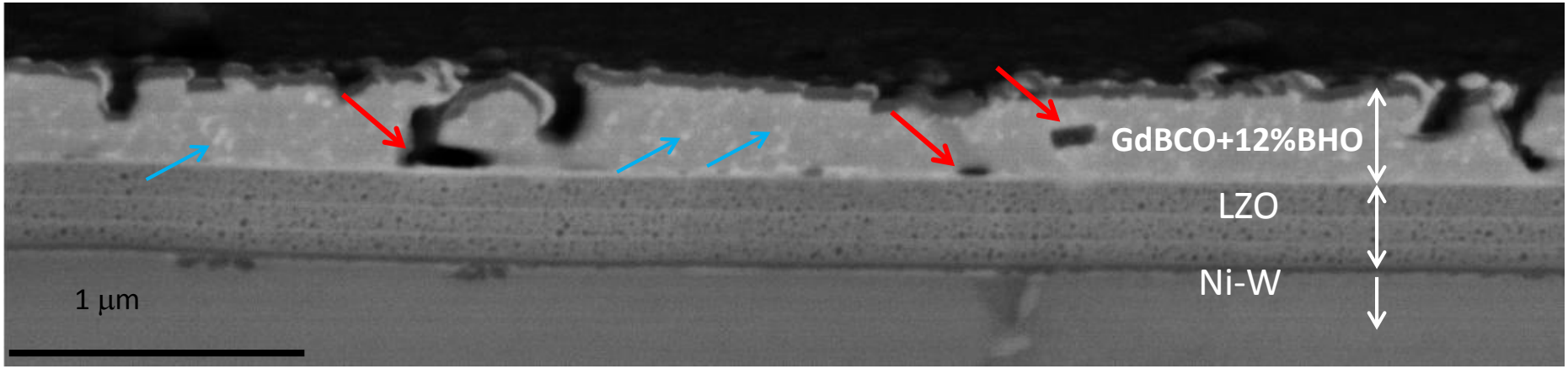


P. Cayado *et al.*, *Supercond. Sci. Technol.* 30, 94007 (2017).

Relationship structural/superconducting properties

- The T_c reach similar values as on STO (94.5 K).
- A value of J_c^{sf} at 77K of 1.6 MA/cm² is achieved at 790 °C.
- J_c still limited by the large amount of pores.





P. Cayado *et al.*, *Supercond. Sci. Technol.* 30, 94007 (2017).

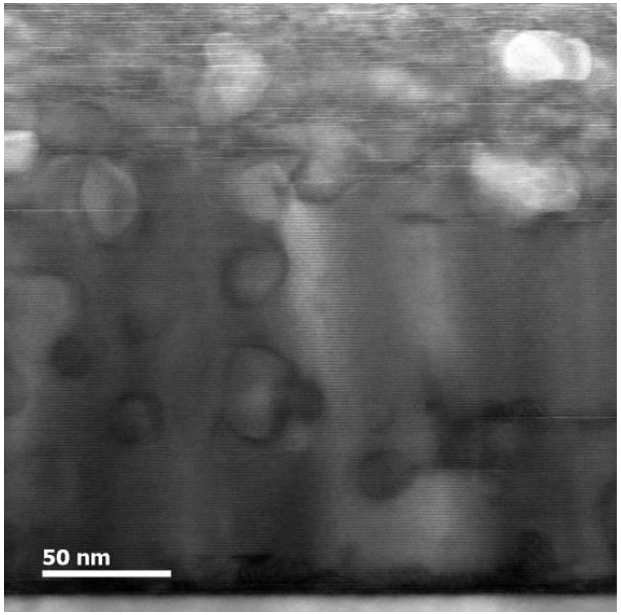
Conclusions

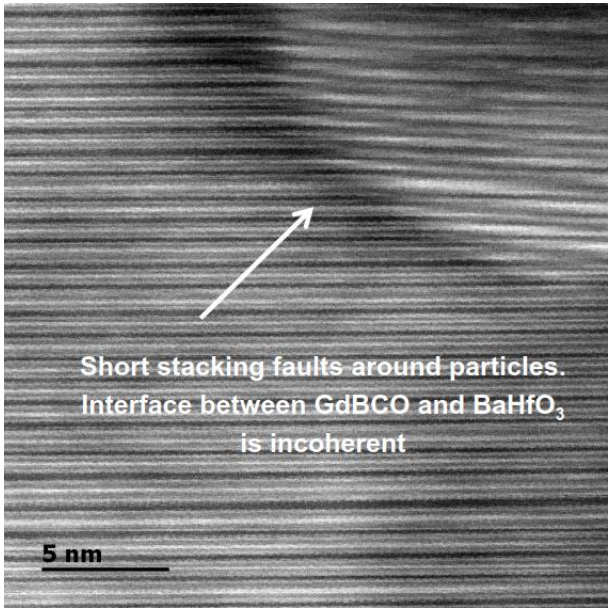
- Pure epitaxial GdBCO+12%mol BHO films on STO are achieved only in a narrow window of processing parameters (optimum conditions: 810 °C, 50 ppm).

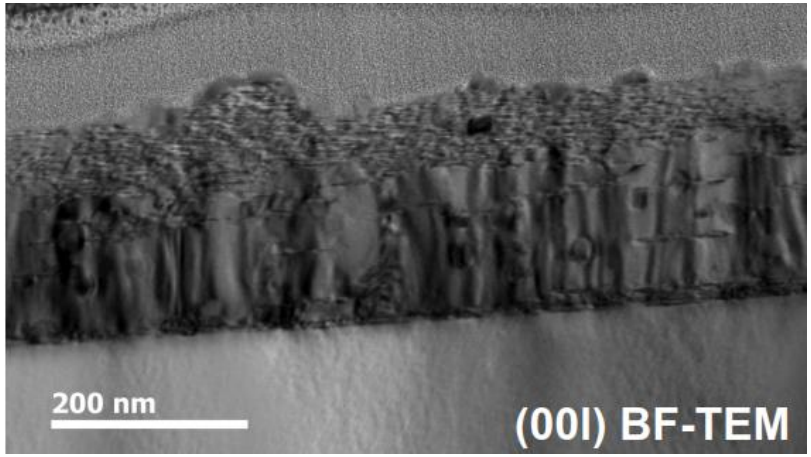
- The superconducting properties of the GdBCO+12%mol BHO films on STO are excellent:
  - J_c^{sf} : **7.3 MA/cm²** at 77 K, **14.5 MA/cm²** at 65 K and **36.8 MA/cm²** at 30 K
  - F_{pmax} : **16.0 GN/m³** (2 T) at 77 K and **56.5 GN/m³** (5 T) at 65 K
  - γ_J=**1.6**

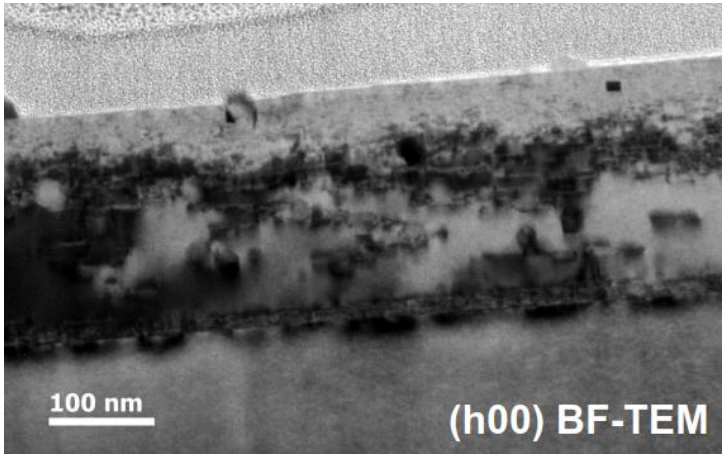
- Epitaxial GdBCO+12%mol BHO films were achieved on tapes but the superconducting properties (Best: T_c=94.5 K, J_c at 77 K=1.6 MA/cm² and ΔT_c=1 K) are still limited for the large amount of pores present in the matrix.

TEM images


50 nm


Short stacking faults around particles.
Interface between GdBCO and $BaHfO_3$
is incoherent
5 nm


200 nm
(00l) BF-TEM


100 nm
(h00) BF-TEM

Reactivity on tapes