2MO4-07 Multi-deposited inkjet printed YBCO on IBAD-MgO architectures for coated conductors

A. Calleja, V.R. Vlad, E. Bartolomé, M. Vilardell, A. Meledin, X.Obradors, T. Puig, S. Ricart, A. Molodyk, G. Van Tendeloo

Tuesday, 19th September 2017

OXOLUTIA

www.oxolutia.com

Location of facilities/equipments

Administration

Private investor: industrial

La Farga Group
yourCoppersolutions

ICMAB CSIC

Parc de Recerca UAB

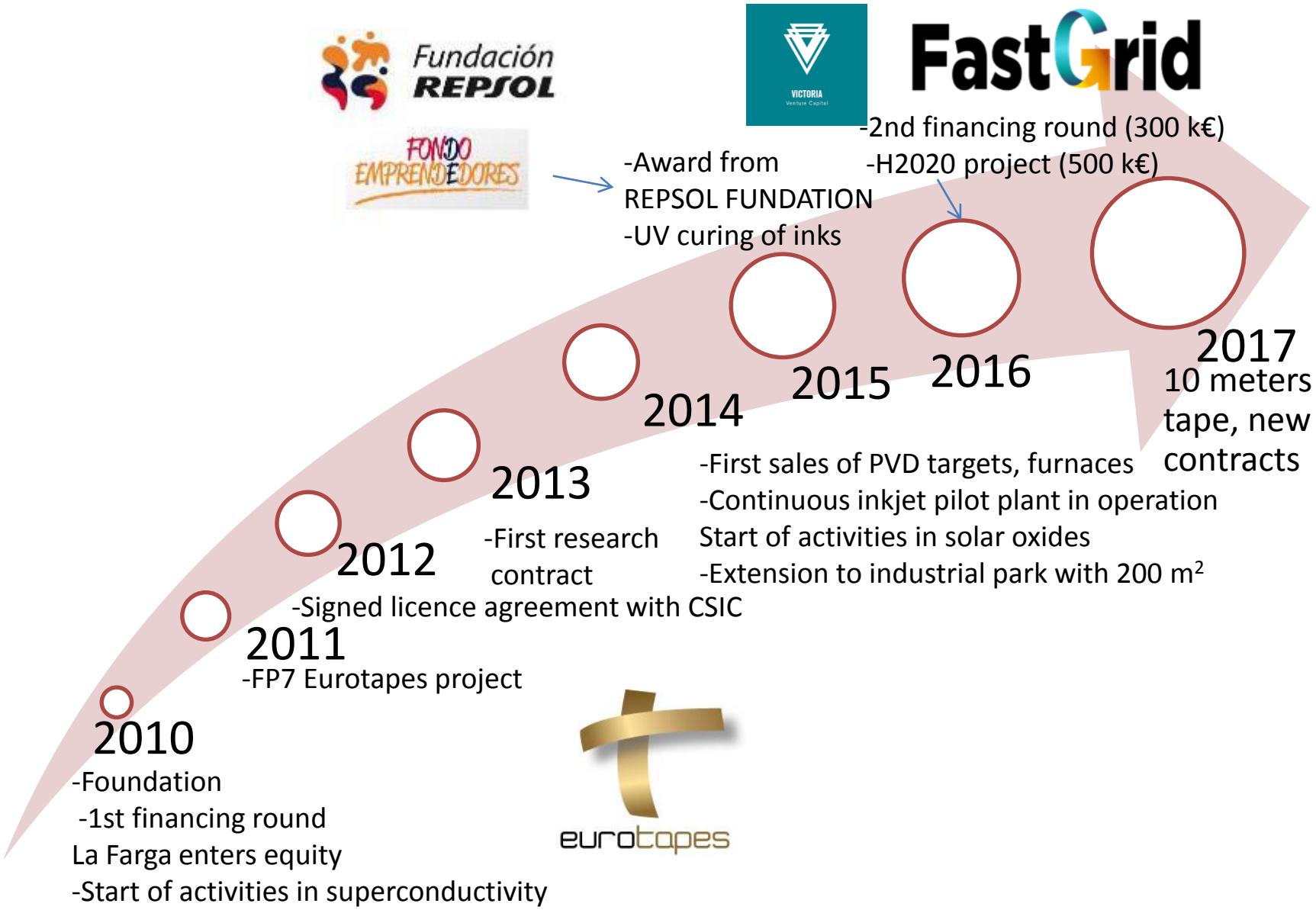
+200 m² industrial
site 5 km away+ 500 m2 (to be inaugurated)

Venture capital

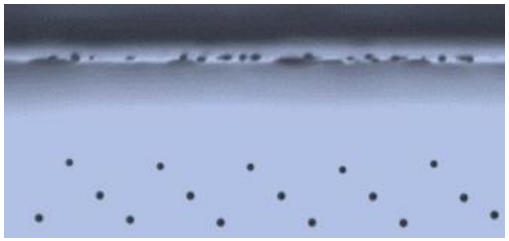
VICTORIA
Venture Capital

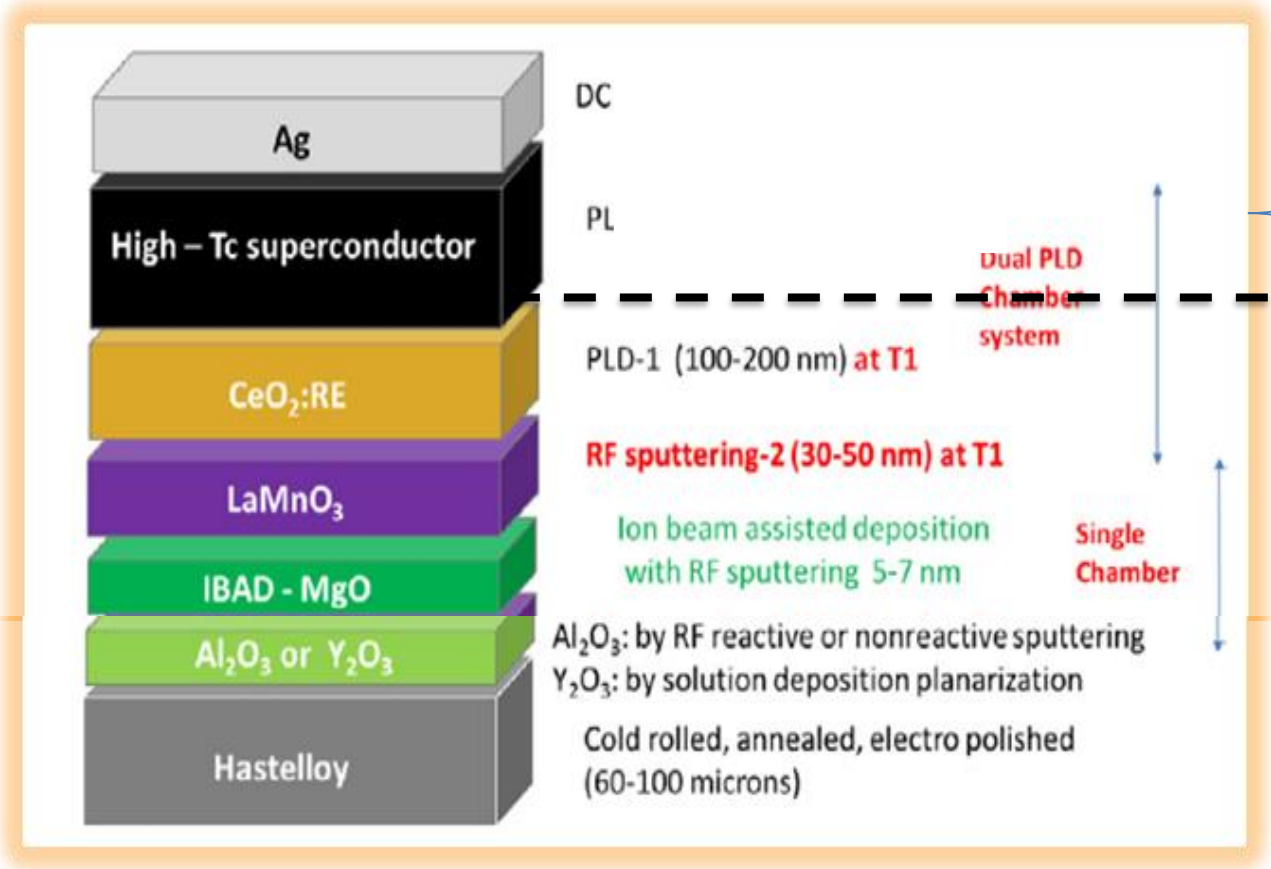
-Spin-off technology-based company founded in 2010
-Specializing in scale-up of chemically-derived nanostructured functional oxide thin films.
-Staff: 8 people now + student internships
-Turnover around 250.000 € in 2016 and (project grants, and products sold worldwide: PVD targets and customized furnaces)

Achievements



Tape arquitecture





OXOLUTIA

SuperOx

PILOT PLANT FOR REEL-TO-REEL INKJET DEPOSITION AND PYROLYSIS

Gas extraction system for the removal/filtering of ink solvents and decomposition products

Low-F YBCO multi-deposition pyrolysis in R2R mode by Inkjet Printing: 10 layers, 1 µm thickness

FIB cut

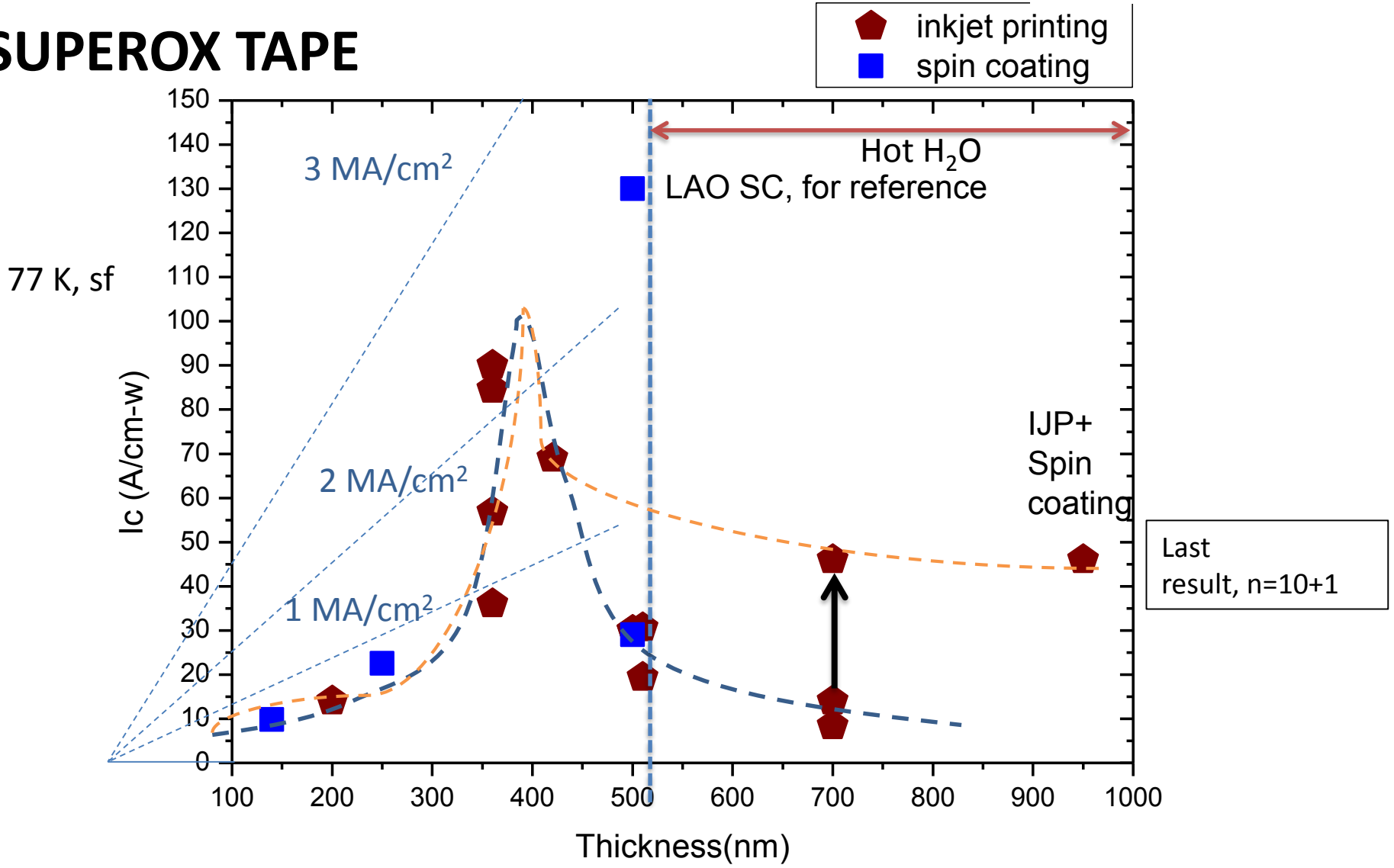
~ 1.4 µm low fluorine YBCO (10 layers)

200 nm CGO

Compact layers after pyrolysis obtained by inkjet printing multi-deposition

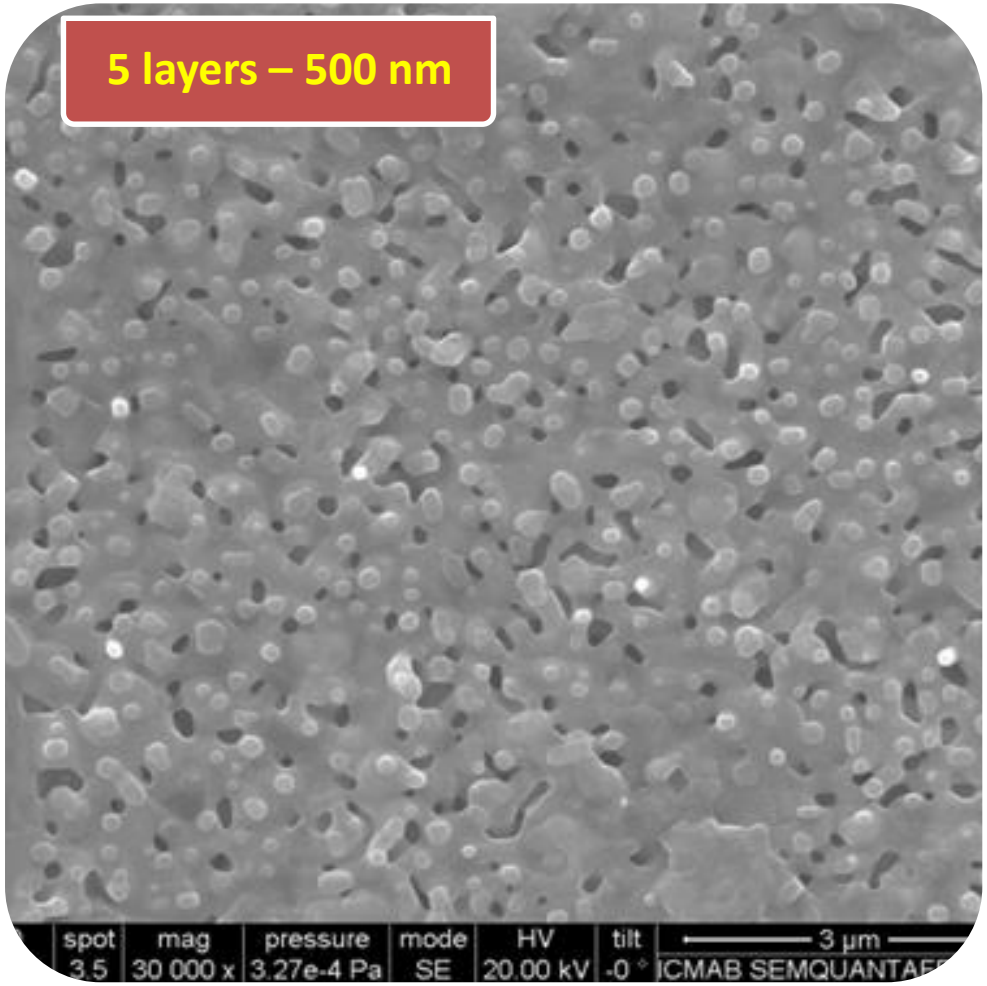
Cu-rich interlayers are visible between the multideposited YBCO films.

MAP OF RESULTS ON MULTI-DEPOSITED SUPEROX TAPE

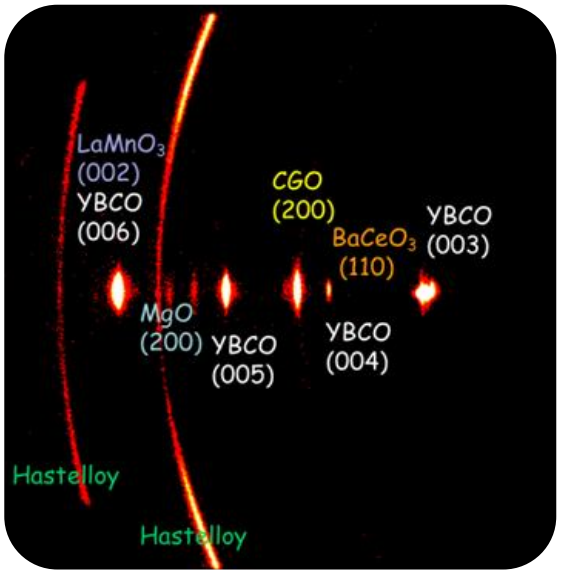


Observations: still n=5 is highest in Ic. Slower pyrolysis ramps in O_2 produce flatter samples and this is main limitation for Ic enhancement. Growth conditions become more and more relevant too for top results in thicker films

Characterization of the YBCO samples by IJP and pyrolyzed in R2R mode



FESEM



XRD²

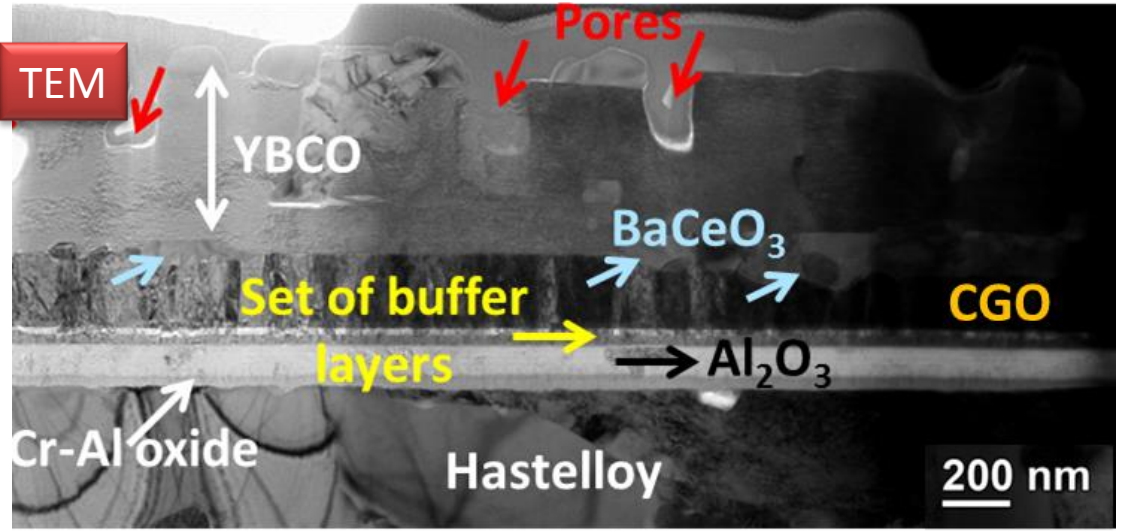
Fully c-axis oriented

J_c(77K,sf) ≈ 2 MA/cm²

I_c = 90 A/cm-width

Record I_c obtained at OXOLUTIA by inkjet printing and still large room for improvement in the short term

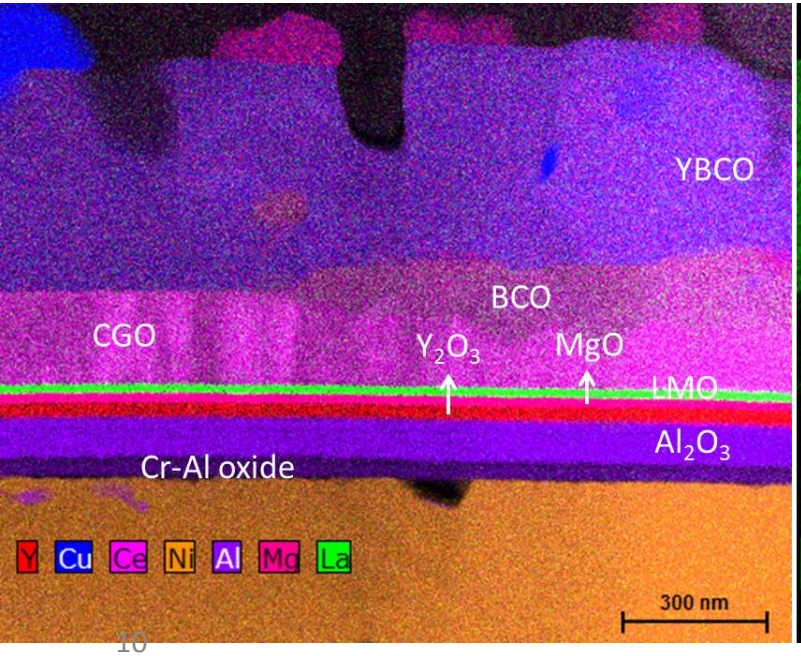
Deeper look into the microstructural and magnetic characterization of the LF-YBCO IJP films

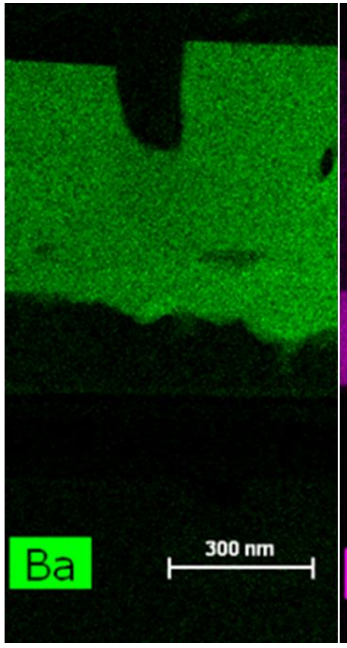


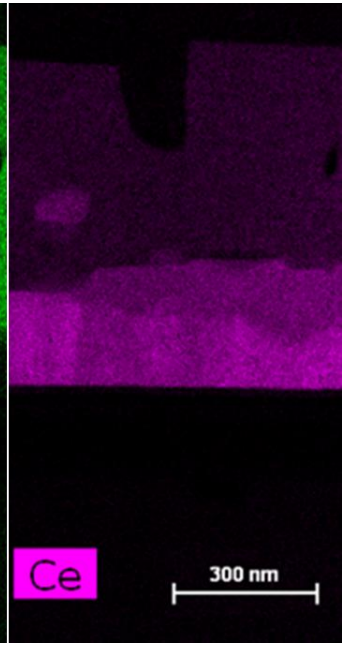
eurotapes

Electron Microscopy for Materials Science
University of Antwerp

Low-resolution TEM cross-section image of the sample, shows the different layers of the CC. We note there is some presence of a reactive phase at the interface between the cap CGO and the YBCO layers, identified to be $BaCeO_3$ (BCO).







Around 30-40 nm BCO, can be also appreciated from the EDX maps of Ba and Ce.

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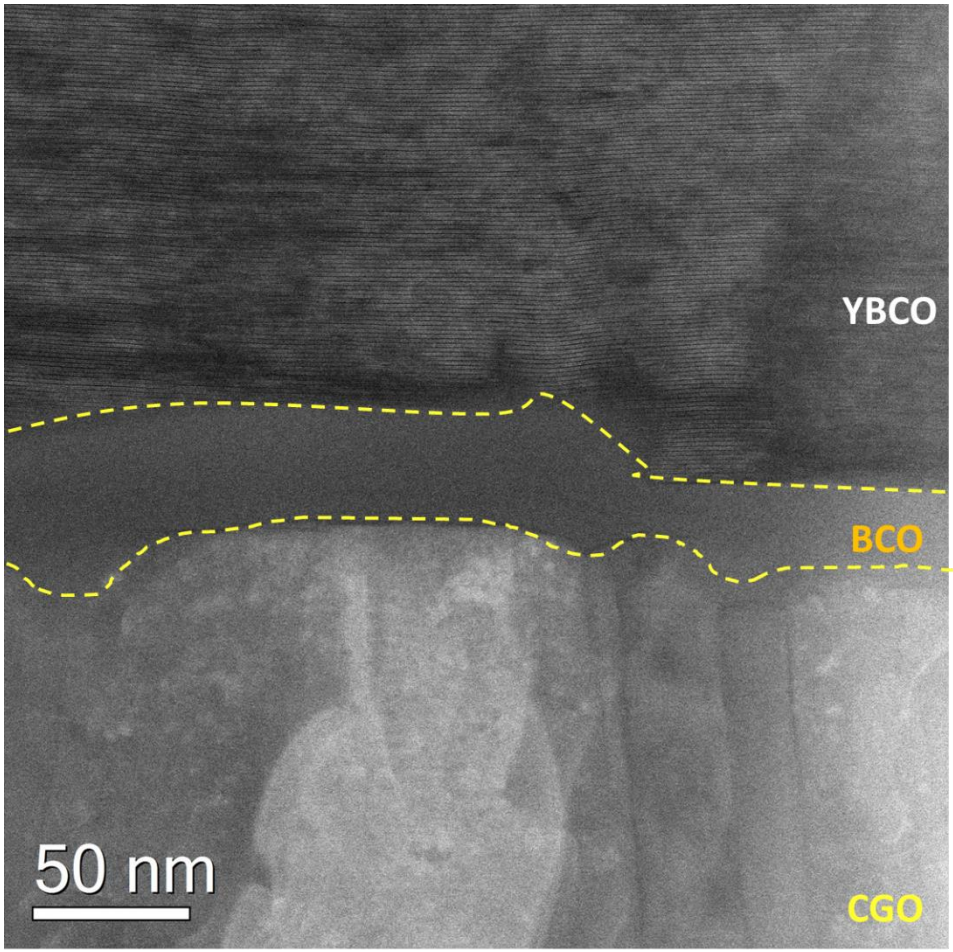
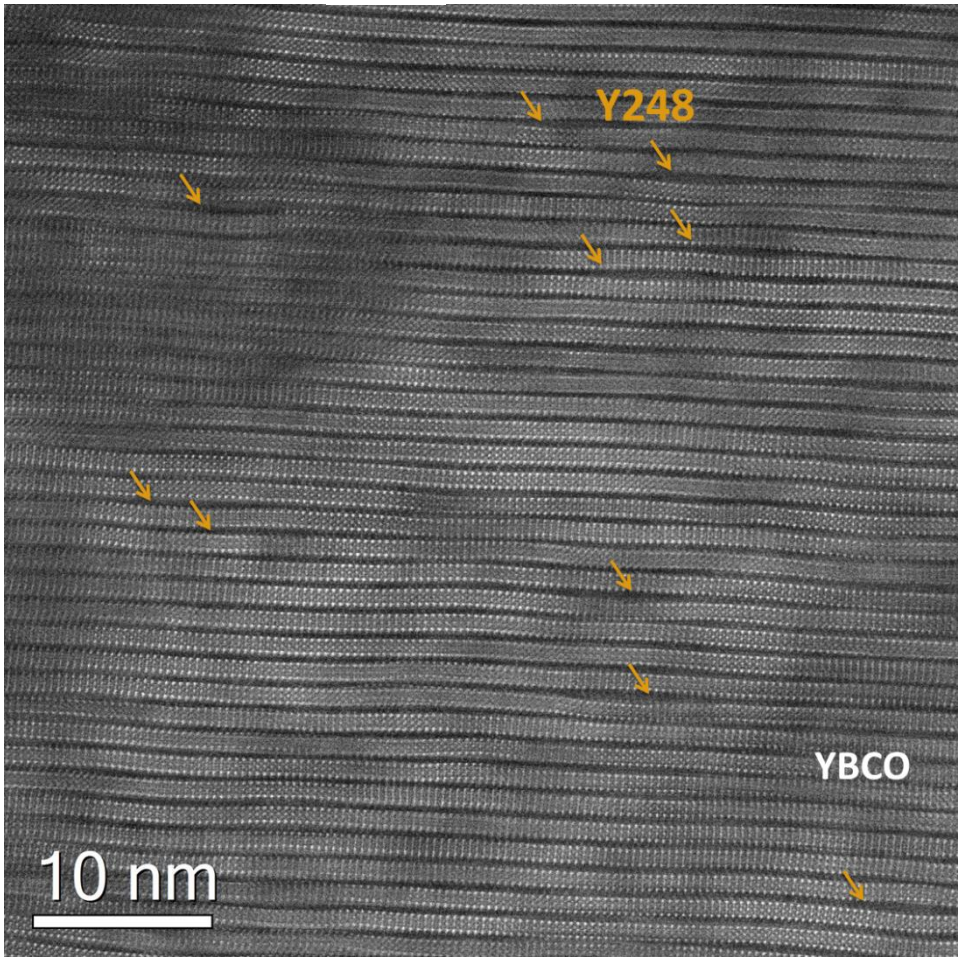
To be published

Deeper look into the microstructural and magnetic characterization of the LF-YBCO IJP films



The formed BCO doesn't seem to disturb the epitaxial growth of YBCO on top; the major part from the 200 nm of CGO remains unreacted.

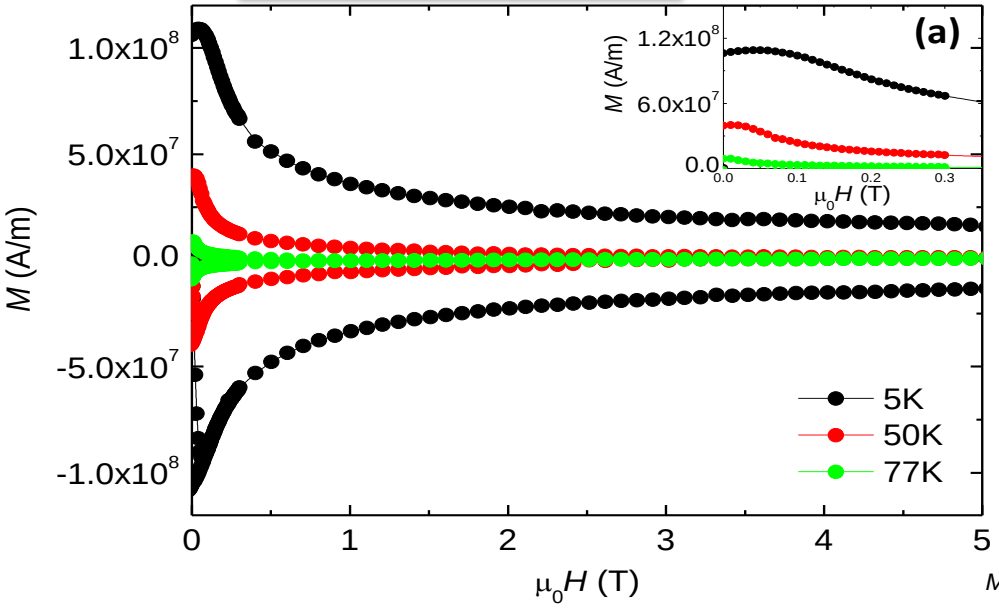


High density of short Y248 intergrowths with some triple Cu chains. ➡ Y125 (R. Guzman et al. APL(2013)

V.R. Vlad et al. - **Inkjet printing multideposited YBCO on CGO/LMO/MgO/Y_2O_3/Al_2O_3/Hastelloy tape for 2G Coated Conductors**
To be published

Magnetic characterization

DC measurements

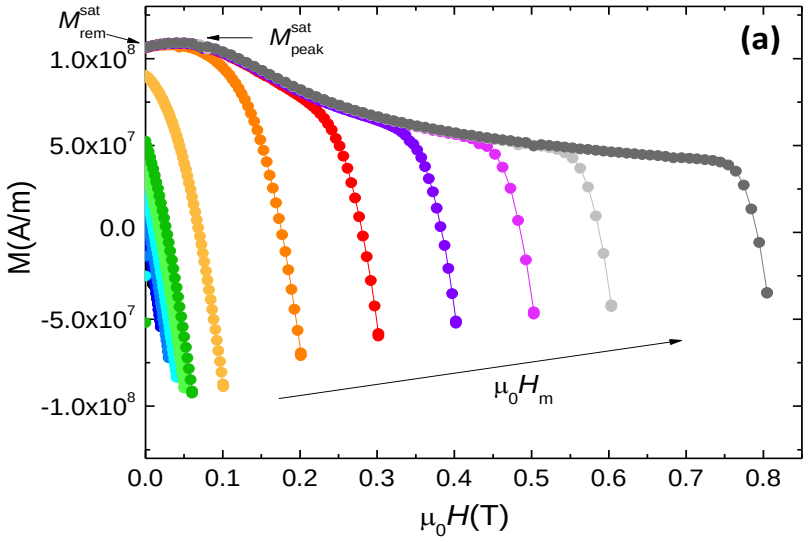


J_c^{GB}=15,9 MA/cm² at 5K
J_c^{GB}=6.06 MA/cm² at 5K
J_c^{GB}=1.23 MA/cm² at 77K

In collaboration with E. Bartolomé

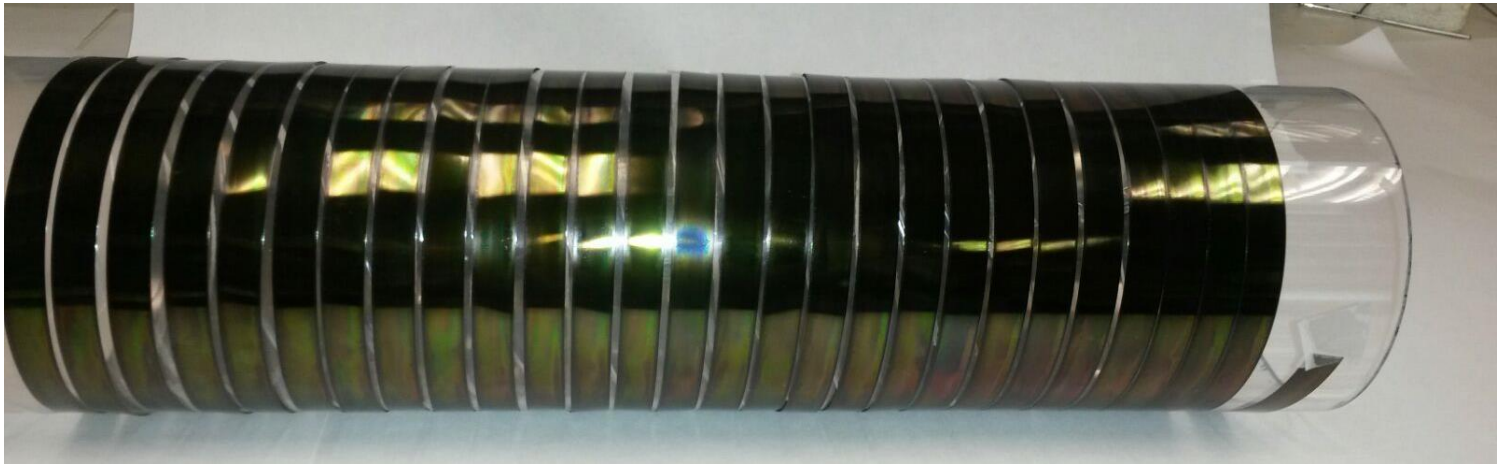
Granularity analysis
<2a>=0.80±0.05 μm
J_c^{G}=49±2 MA/cm² at 5K
J_c^{GB}=15,9 MA/cm² at 5K

J_c^{GB}/J_c^{G}=0.3



V.R. Vlad et al. - **Inkjet printing multideposited YBCO on CGO/LMO/MgO/Y_2O_3/Al_2O_3/Hastelloy tape for 2G Coated Conductors**
To be published

SCALE-UP TO 10 METERS: REEL-TO-REEL INKJET DEPOSITION AND PYROLYSIS OF YBCO^{TFA}



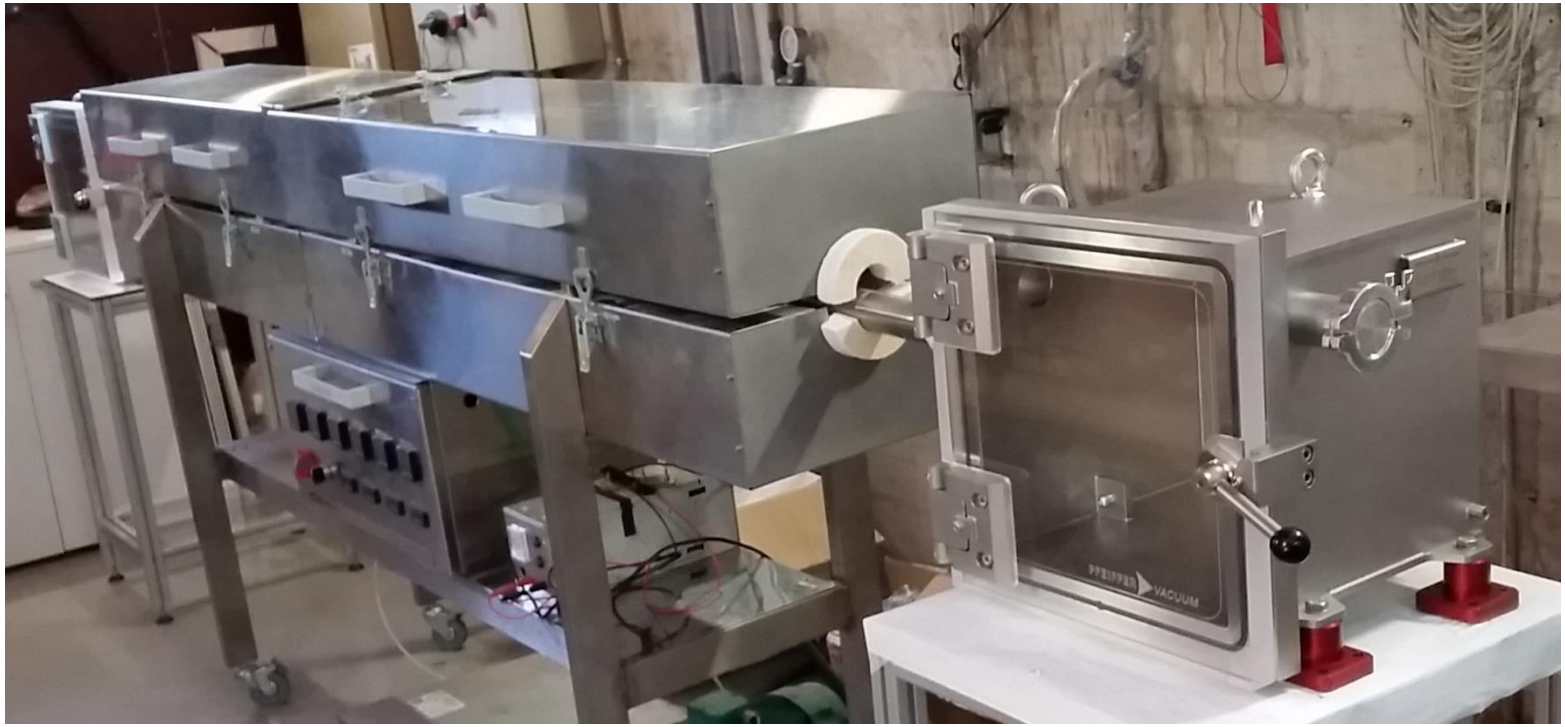
-SUPEROX substrate.

-**2** inkjet+pyrolysis cycles.

-Nominal thickness (as-grown): **450 nm** approx.

-Inkjet deposition speed: **3.5 m/h**, **1** printhead

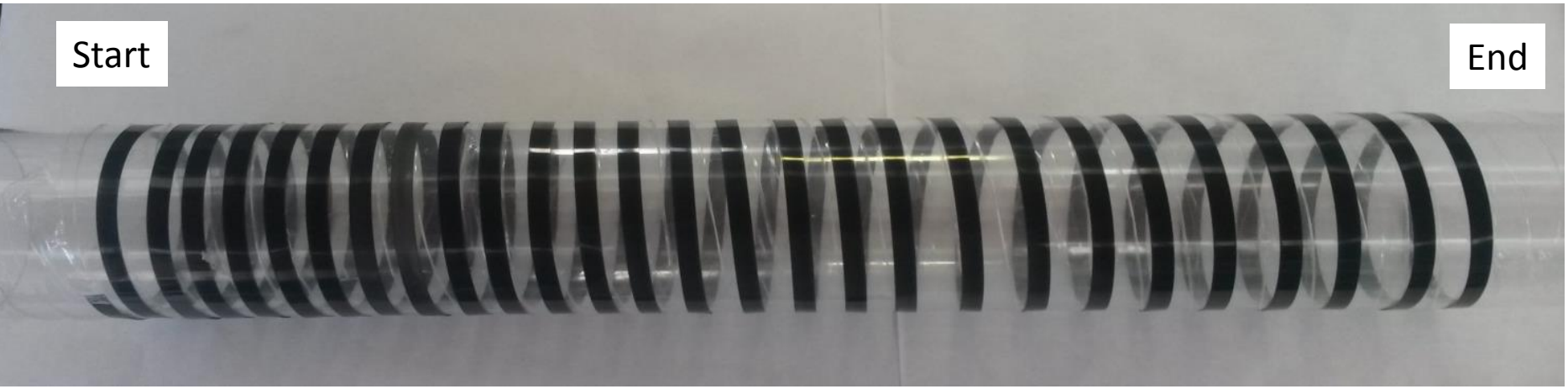
REEL-TO-REEL YBCO^{TFA} CONVERSION

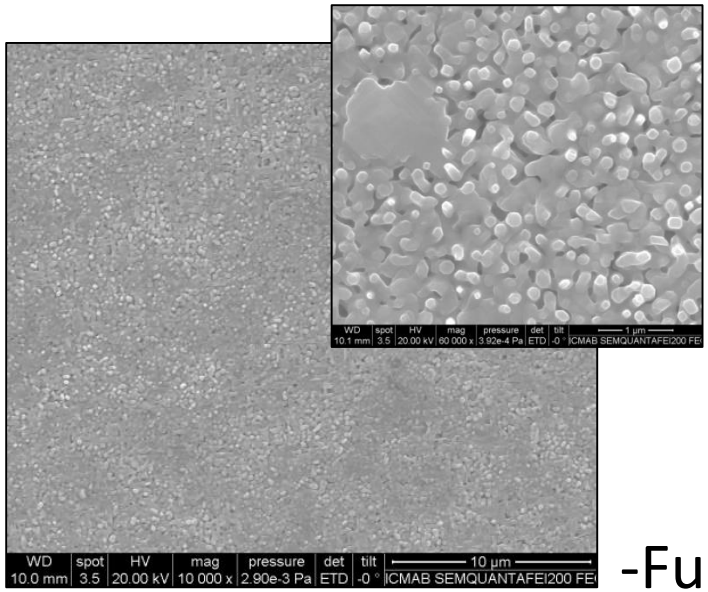


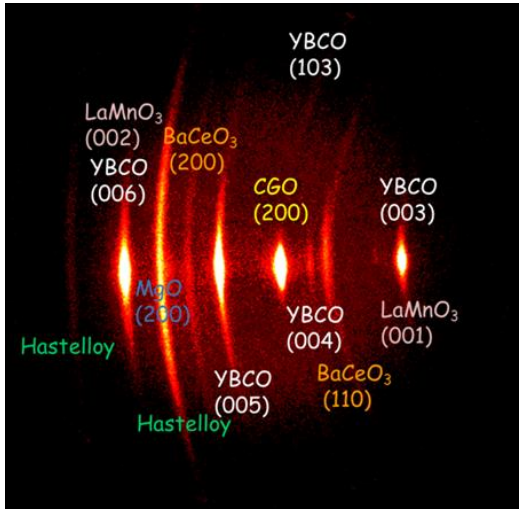
System for long length YBCO conversion

- Speeds up to 100 m/h, 12 mm width, 50 mbar- 1 bar of total pressure
- Initial testing of **10 meters**
- **Capable of 100 meters** when special insert will be built and installed

10 METERS OF GROWN R2R IJP YBCO^{LF} ON SUPEROX SUBSTRATE





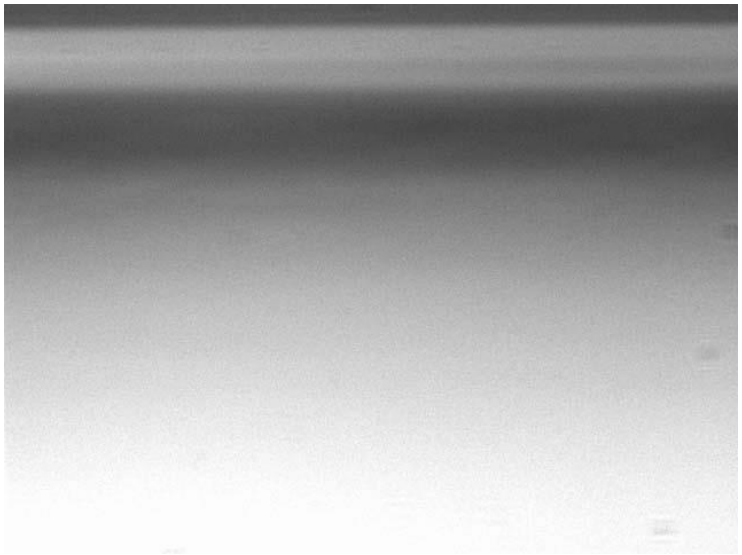


-Full conversion

-c-axis orientation predominates

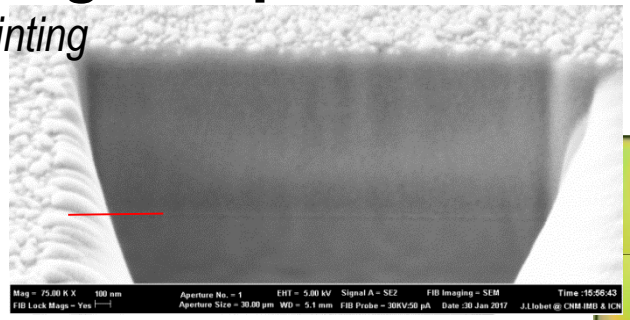
-Silver deposition and oxigenation in progress

Transfer to OXOLUTIA: deposition of thick CSD nanocomposites

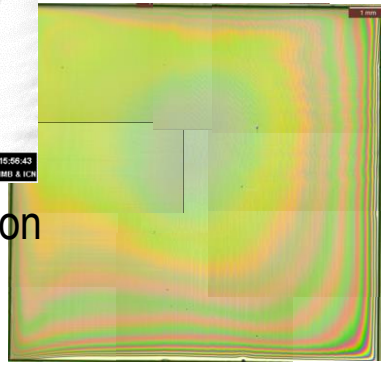


Ink jet printing colloidal solution +UV curing

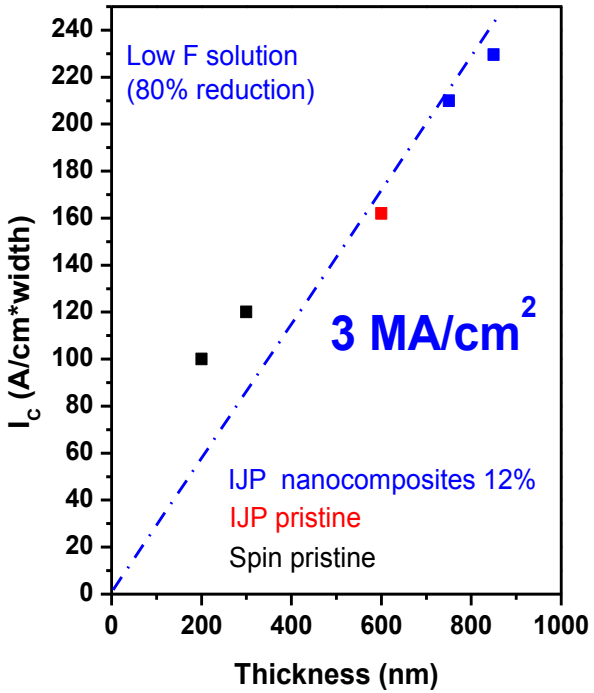
Single deposition *by ink jet printing*



1 μm grown film with 1 deposition



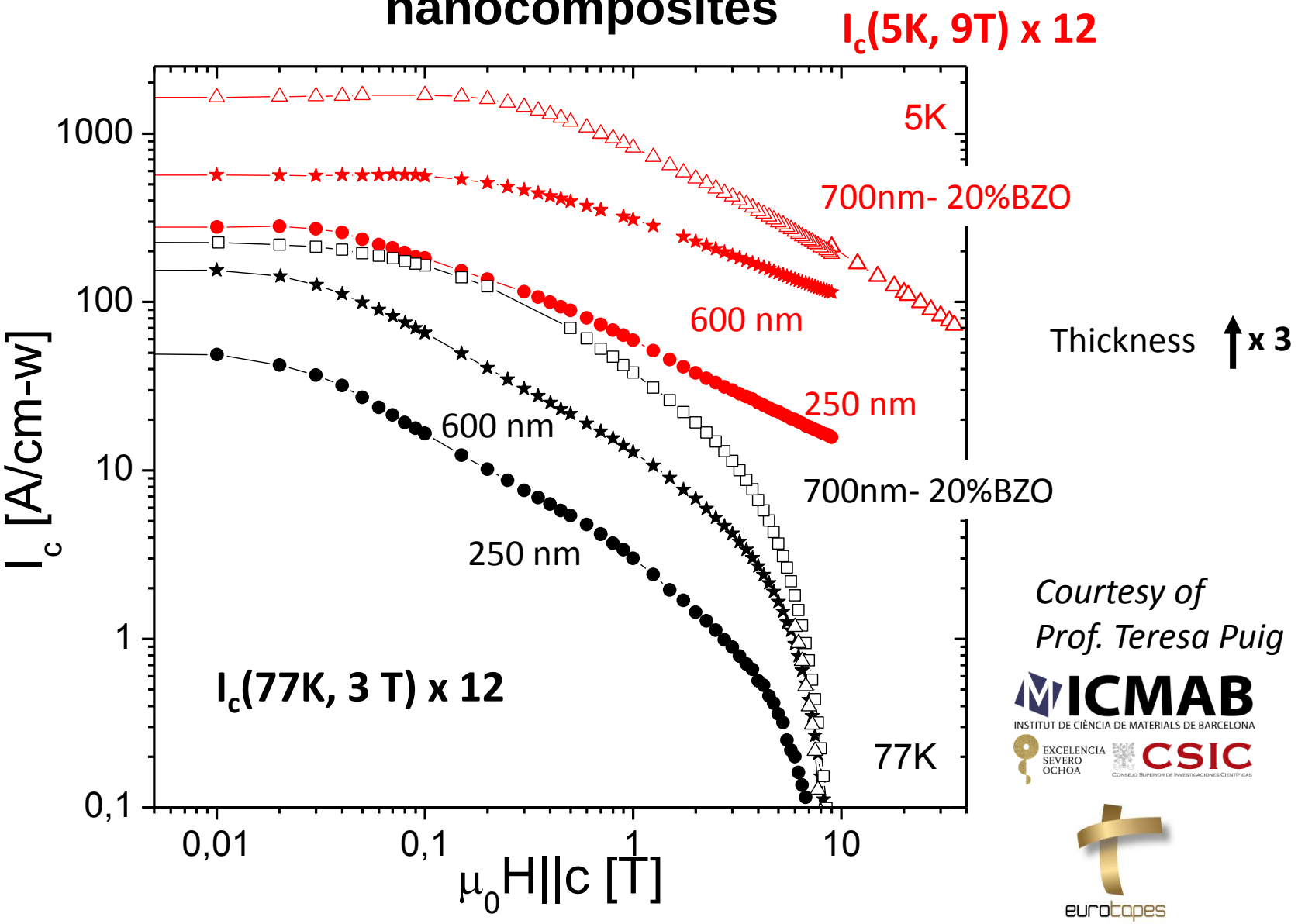
10x10 mm² substrate



1.6 μm grown film with 2 depositions

Courtesy of Prof. Teresa Puig

Transfer to OXOLUTIA: Increase of I_c with thickness by IJP deposition of nanocomposites



Courtesy of Prof. Teresa Puig

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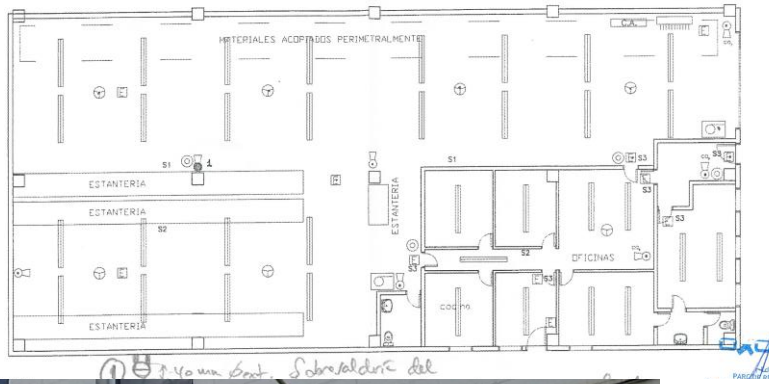
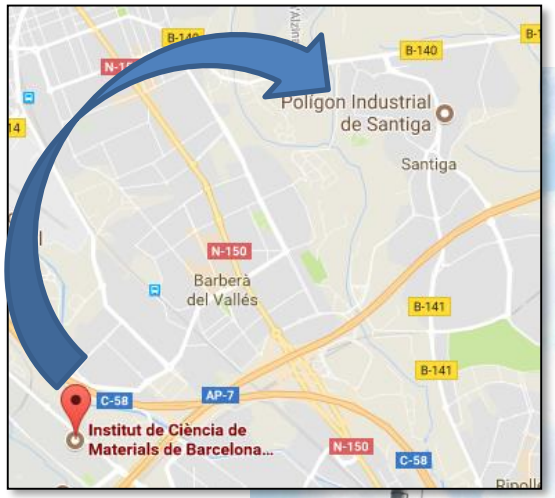
New production site

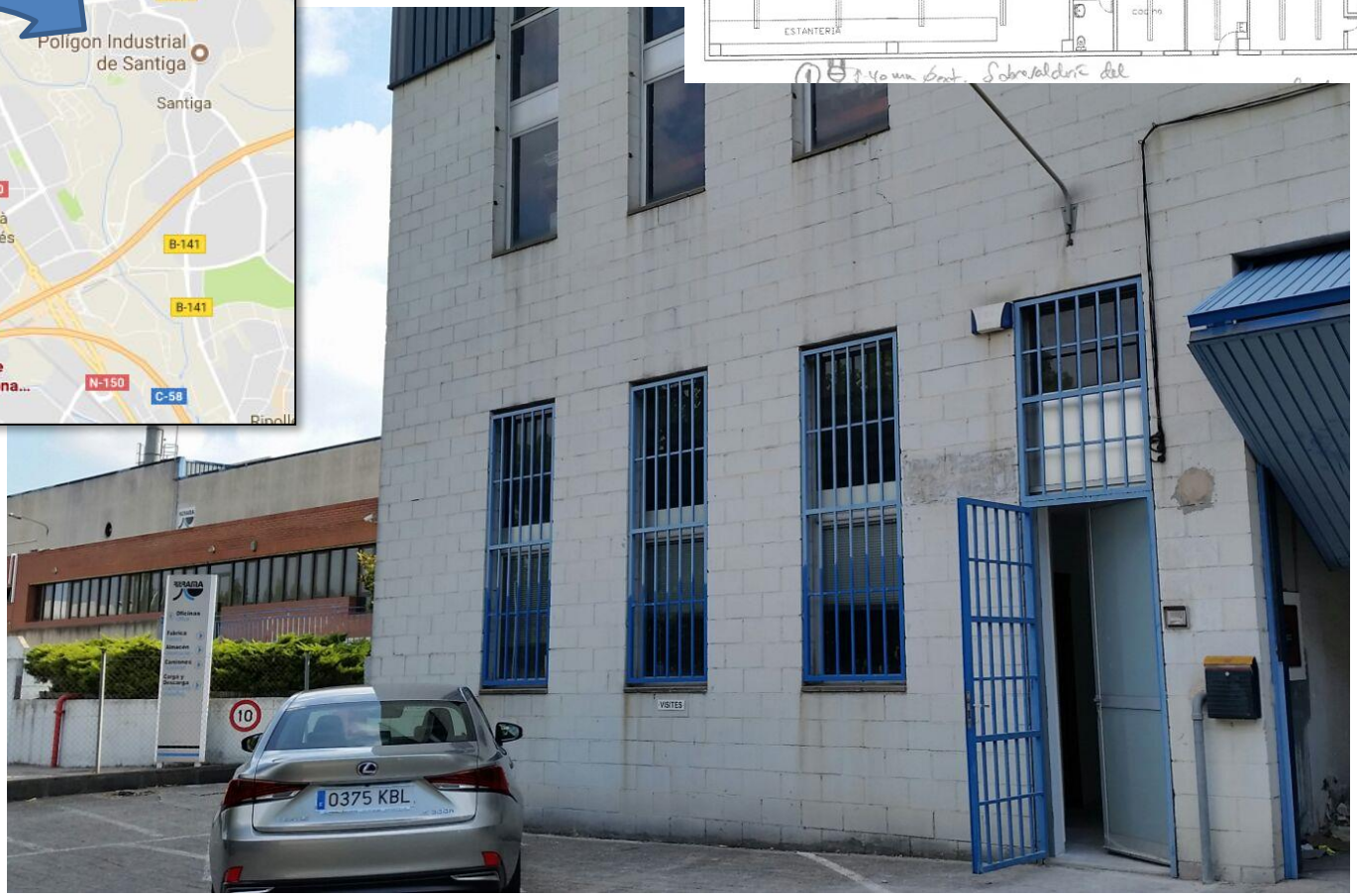
-5 km away from Scientific Park of UAB

-500 m²

-Inauguration: 25th September 2017







Acknowledgements

Partners and collaborators:

ICMAB
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CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

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Kao Chimigraf

UAB
Universitat Autònoma de Barcelona

SuperOx

BRUKER

VICTORIA VENTURE CAPITAL

Projects:

FastGrid

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SUPERINKS

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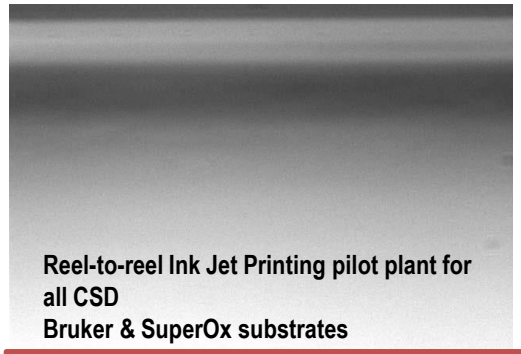
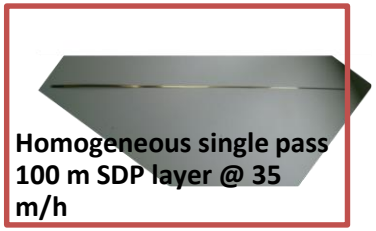
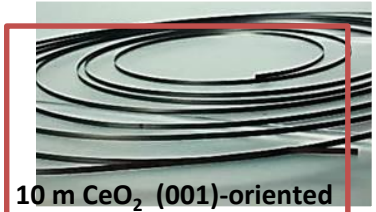
Chemical Solution Deposition scalability processes at Oxolutia



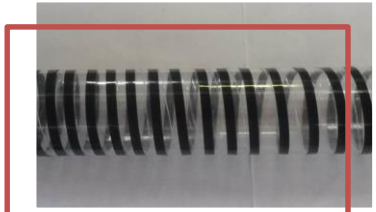
Reel-to-reel Ink Jet Printing pilot plant for all CSD
Bruker & SuperOx substrates



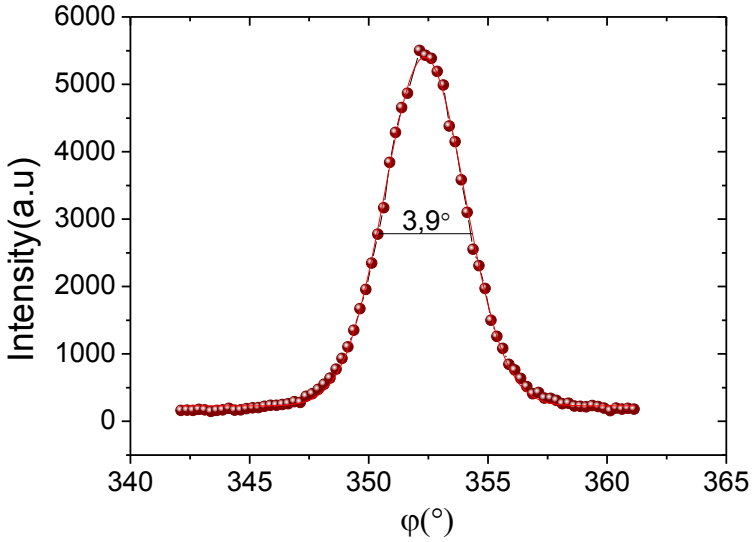
Homogeneous single pass 100 m SDP layer @ 35 m/h

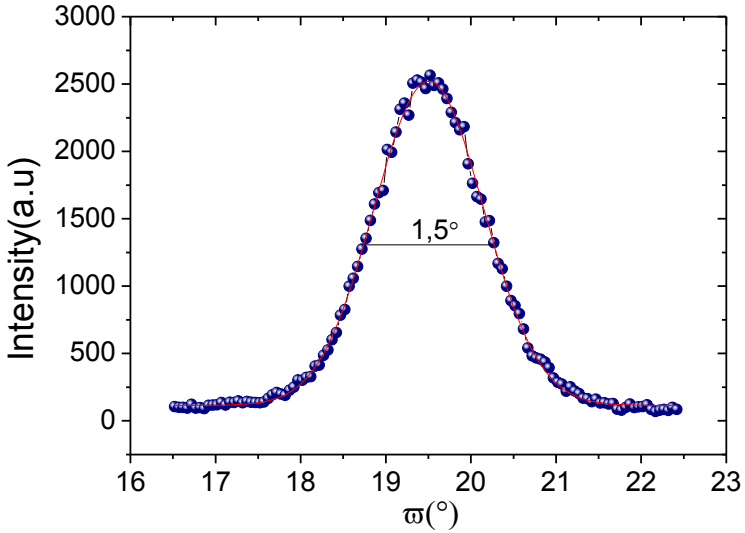


10 m CeO_2 (001)-oriented buffer @ 28 m/h



10 m of YBCO


6000
5000
4000
3000
2000
1000
0
Intensity(a.u)
3,9°
340
345
350
355
360
365
φ(°)


3000
2500
2000
1500
1000
500
0
Intensity(a.u)
1,5°
16
17
18
19
20
21
22
23
ϖ(°)

COATED CONDUCTORS BY R2R INKJET PRINTING ON IBAD/ABAD TEMPLATES

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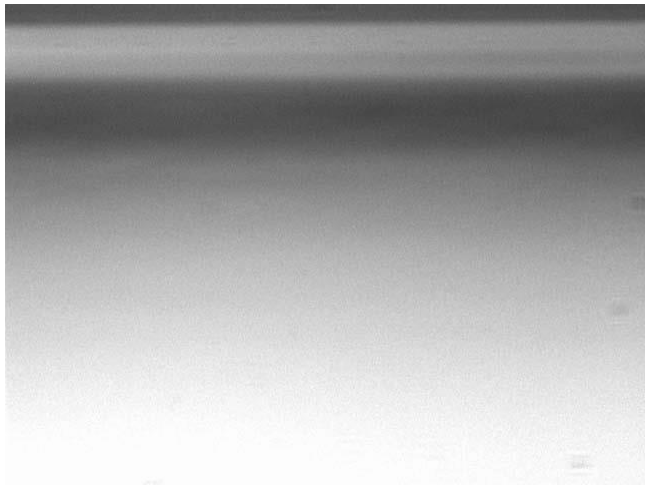
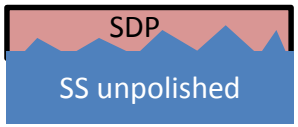
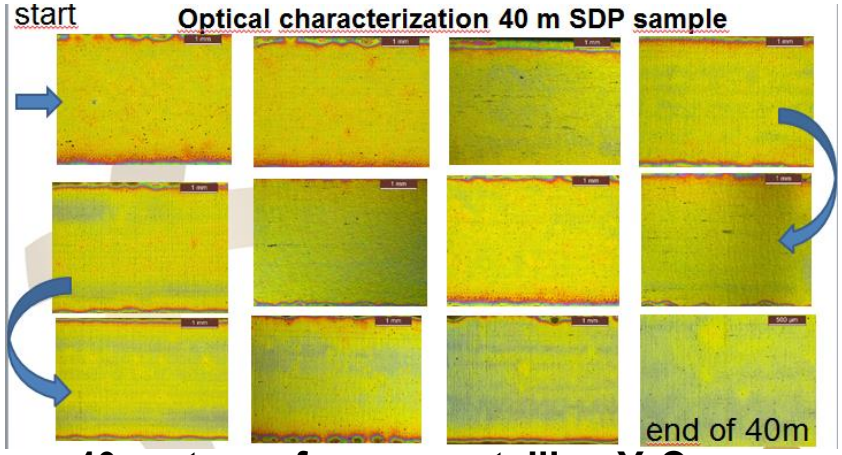


PLANARIZING CHEMICAL LAYERS FOR ^{ABAD}YSZ

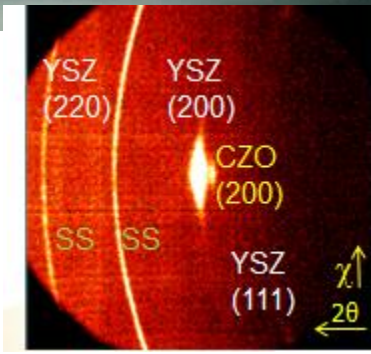


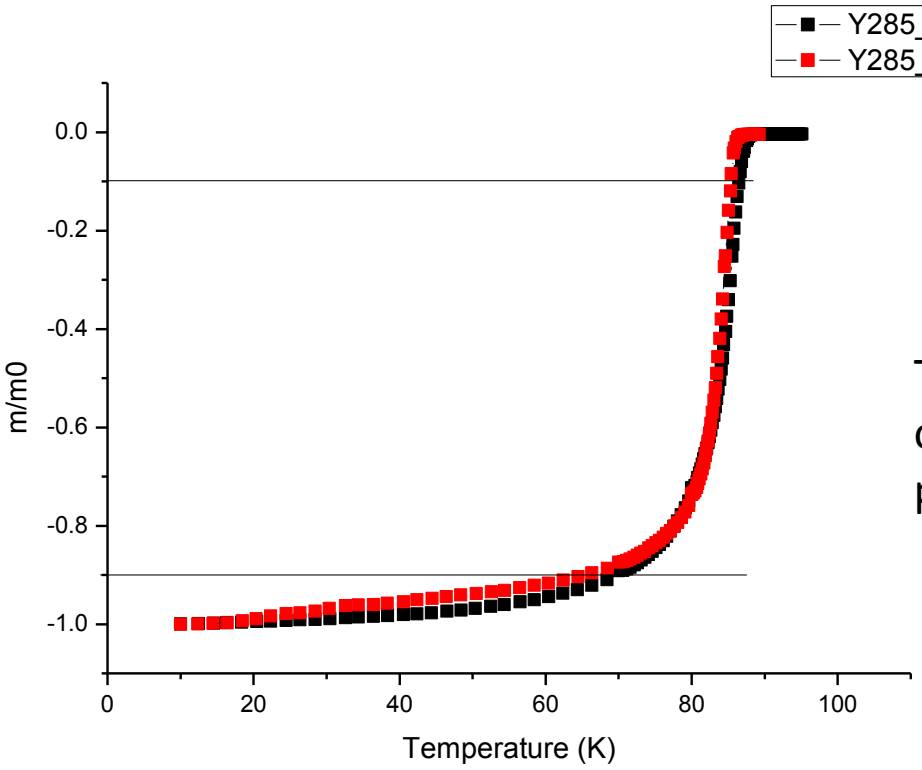


40 meters of nanocrystalline Y_2O_3 buffer printed at 30 m/h on unpolished stainless steel

$Ce_{0.90}Zr_{0.10}O_x$ CAP LAYERS

10 meters of (001)-oriented $(Ce,Zr)O_2$ buffer printed at 28 m/h





The superconducting properties of the sample from the end of the pyrolysed 10 m decreases.

Sample's name	Ic(A/cm-w)	Tc onset(K)	ΔTc(K)
Y285_1K_P	21	88.1	17.2
Y285_1K_F	12.3	86.8	19.3