Surface Decoration as Prospective Artificial Pinning Strategy in Superconducting $YBa_2Cu_3O_{7-x}$ films

4MP5-04

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INTRODUCTION

In the wide field of artificial pinning strategies, chemically decorated surfaces have attracted attention as new, powerful tools for the improvement of transport properties in $YBa_2Cu_3O_{7-x}$ films. This approach, still to be thoroughly investigated, makes use of low-cost, easily-tunable chemical methods to obtain self-assembled oxide nanostructures on a substrate that will serve, in a second step, for the deposition of the superconducting film itself. The structures are supposed to produce, in the superconducting matrix, a specific amount of strain which is generally held responsible for the increased transport capacity of variously doped samples. In this work we analyze a variety of structure/oxide combinations and two different synthetic routes to give a general overview of the potential of the surface decoration technique.

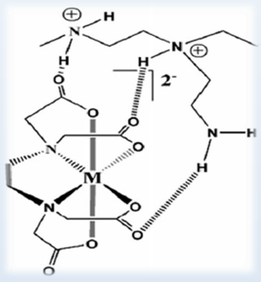
PAD: POLYMER ASSISTED DEPOSITION

Advantages:
- Stable solutions
- Concentration control
- No collateral reactions

Disadvantages:
- Long process, many steps
- Specific equipment required
- High temperature treatment

Precursor Solutions → Amicon Filtration → ICP: Concentration → Mixing → Spin Coating → Thermal treatment

Inorganic salts + water + EDTA+ polyethilenimine



5000 rpm, 60''

1000 °C, 4', air

VS.

MOD: METAL ORGANIC DECOMPOSITION

Advantages:
- Quick and easy process
- Standard equipment required
- Low temperature treatment

Disadvantages:
- Less stable solutions compared to PAD
- Less control over homogeneity of the solutions compared to PAD

Precursor Solution → Mixing → Spin Coating → Thermal Treatment

Water sensitive Organic salts + Propionic Acid

3000 rpm, 30''

700 °C, 1h, air or 1000 °C, 4', air

NECESSARY CONDITION FOR THE FORMATION OF DISCRETE NANOSTRUCTURES IS A HIGH VALUE OF LATTICE MISMATCH δ FOR THE OXIDE/SUBSTRATE COMBINATION

$La_{0,67}Sr_{0,33}MnO_3$

- Perovskyte, pseudo-cubic structure
- YBCO-compatible
- FERROMAGNETIC → **MAGNETIC PINNING**

SUBSTRATE CHOICE

OUR GOAL: homogeneous nanostructures

OUR RESULT: success on MgO and YSZ

SOLUTION OPTIMIZATION

OUR GOAL: identify the best solution concentration

OUR RESULT: best result obtained with a 0.01M LSMO solution

STABILITY CHECK

OUR GOAL: assess the thermal stability of the structures

OUR RESULT: the islands remain present: decreased density, increased height

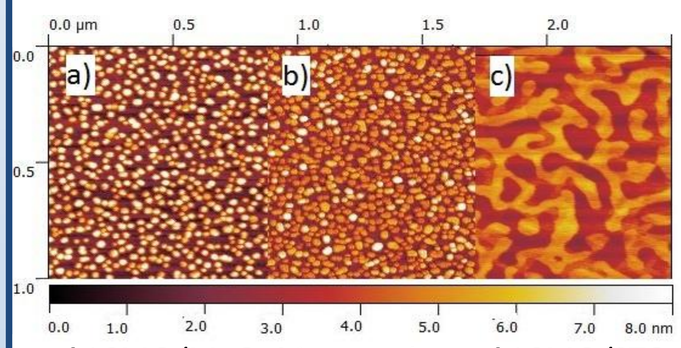
WHAT HAPPENED?

GROWTH MECHANISM HYPOTHESYS

OUR METHOD: change growth parameters (T, duration) and morphological analysis.

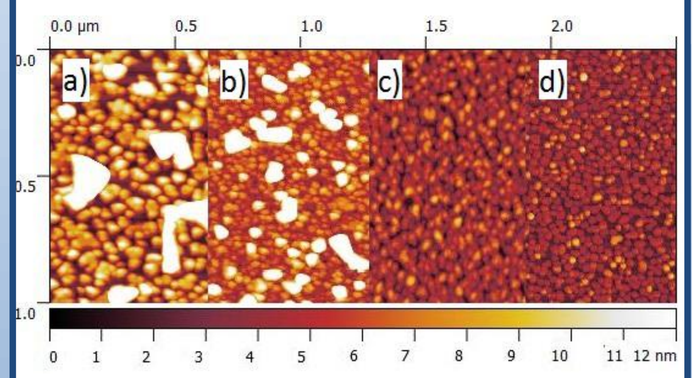
OUR HYPOTHESYS: i) polymer decomposition and nucleation of nanoislands; ii) spontaneous rearrangement of the structures so as to minimize contact with the substrate . The driving force of this step is given by the balance between the high interfacial energy with the substrate.

LSMO 0.01M: Different Substrates



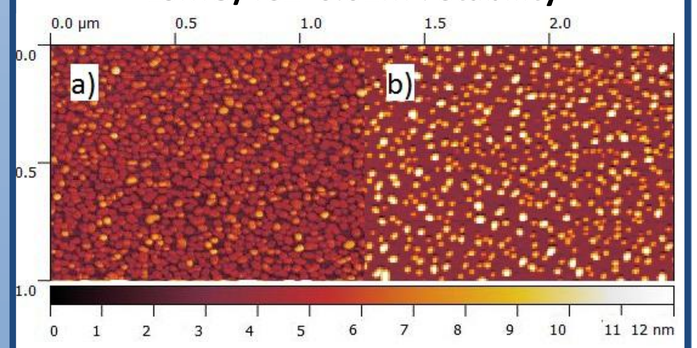
a) LSMO/MgO δ= 8.6% **b)** LSMO/YSZ δ= 6.7% **c)** LSMO/STO δ= 0.5%

LSMO/YSZ : Different Concentrations



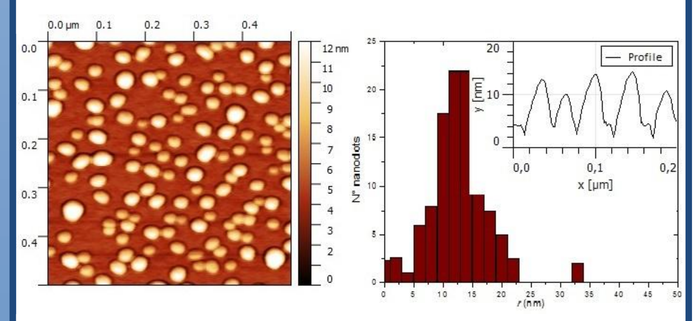
a) 0.05M **b)** 0.025M **c)** 0.015M **d)** 0.01M

LSMO/YSZ 0.01M : Stability



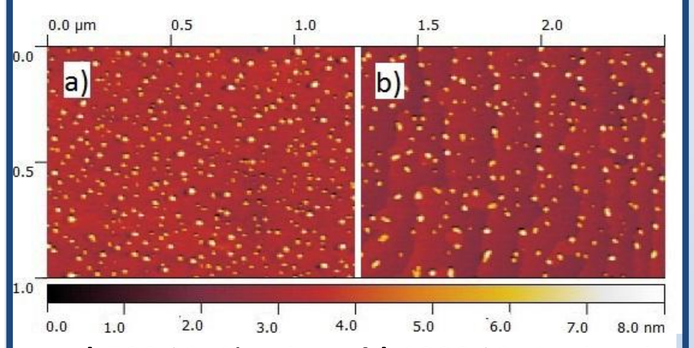
a) BEFORE TREATMENT **b)** AFTER TREATMENT

Size Distribution Analysis



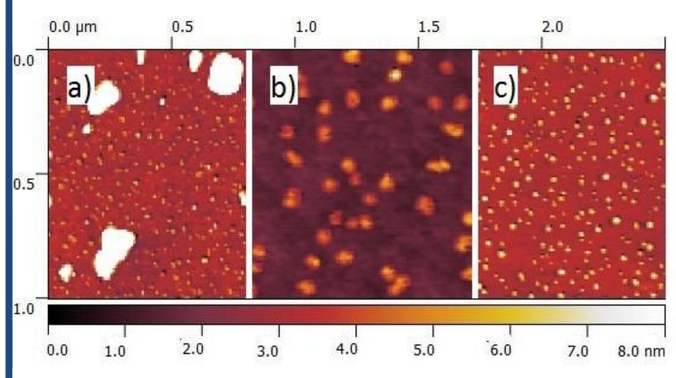
Average Ø: 30 nm Average height: 7 nm
Density: 700 $1/\mu^2$ Coverage: 58%

BYNO/STO: Different Treatments

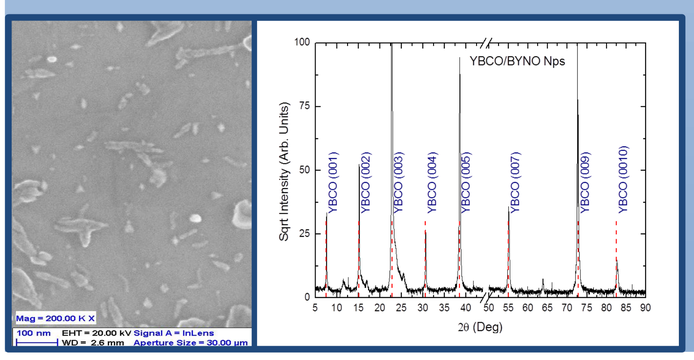


a) 700 °C, 1h, air **b)** 1000 °C, 4 min, air δ=7.4%

BYNO/STO : Different Concentrations



a) 0.002M **b)** 0.001M **c)** 0.0005M



Ba_2YNbO_6

Perovskyte, pseudo-cubic structure

STRUCTURAL PINNING ← **YBCO-compatible STO-compatible**

SUBSTRATE CHOICE

OUR GOAL: Discrete nanostructures on MOD-YBCO friendly substrate.

OUR RESULT: success on STO

SOLUTION OPTIMIZATION

OUR GOAL: identify the best solution

OUR RESULT: best result obtained with a 0.0005M BYNO solution

YBCO FILM DEPOSITION

OUR GOAL: deposition of YBCO film on nanostructures via MOD

OUR RESULT: YBCO film with good structural, morphologiacal and superconducting properties (T_c 90,7 K, J_c (0) (77K) = 1,18 MA\cm^2 (see poster **3MP1-11**)

CONCLUSIONS: SURFACE DECORATION

TWO TECHNIQUES **BOTH SUCCESSFUL!!**

PAD
- LSMO nanoislands on MgO and YSZ
- Homogeneous distribution and dimensions
- Verified thermal stability
- Growth mechanism hypothesys proposed
- YBCO film deposition still to be performed

MOD
- BYTO nanoislands on STO
- Homogeneous distribution and dimensions
- Verified compatibility with YBCO film → Good structural and superconducting properties (T_c).
- Positive preliminary J_c measurements, see poster **3MP1-11**

Acknowledgments

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