Surface Decoration as Prospective Artificial Pinning Strategy in Superconducting YBa$_2$Cu$_3$O$_{7-x}$ films

**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$_2$Cu$_3$O$_{7-x}$ 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 superconductive 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.

**TWO TECHNIQUES**

**PAD:** POLYMER ASSISTED DEPOSITION

- Advantages:
  - Stable solutions
  - Concentration control
  - No collateral reactions
- Disadvantages:
  - Long process, many steps
  - Specific equipment required
  - High temperature treatment

**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

**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$_3$ - Perovskite, pseudo-cubic structure
YBCO-compatible - FERROMAGNETIC 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**

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

**CONCLUSIONS**
- Surface decoration appears to be a promising strategy for artificial pinning in superconducting materials.
- Both techniques (PAD and MOD) have shown promise, but further optimization is needed to achieve the desired results.
- The choice of the substrate (e.g., MgO vs. YSZ) and the solution concentration play crucial roles in the formation of discrete nanostructures.
- Future work should focus on refining the conditions for successful deposition and investigating the effects of different substrate and solution compositions on the pinning properties.

Acknowledgments
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom programme 2014-2018 under grant agreement N° 633053, AWP15-ENR-01/ENEA-08. The views and opinions expressed herein do not necessarily reflect those of the European Commission.