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## Invited Talk

# LOW-TEMPERATURE SOL-GEL METHODS FOR THE INTEGRATION OF CRYSTALLINE METAL OXIDE THIN FILMS IN FLEXIBLE ELECTRONICS

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**ABSTRACT:**

The development of low-temperature sol-gel (solution) processes for the fabrication of crystalline metal oxide thin films has become a key objective in the emerging Flexible Electronics. Amorphous metal oxide semiconductors have been recently grown at temperatures below 350ºC on plastics, by solution methods.[1] However, the preparation of crystalline oxide films at these temperatures is a challenge, because they crystallize at temperatures over 600 ºC. This is a handicap for their preparation on the flexible substrates (e.g., plastics, rubber or paper) used in Flexible Electronics. Nevertheless, the incorporation of crystalline oxides in Flexible Electronics would improve the performance of the device, making applications feasible which are now restrained (e.g. smart-skin, flexible-displays or solar-cells) and which performances are associated to the functional properties of the crystalline oxide (ferroelectricity, pyroelectricity, piezoelectricity or photovoltaic-effect).

This presentation shows an overview to the solution strategies reported in the literature for the low-temperature fabrication of metal oxide thin films, emphasizing those developed in our group.[2] We use UV-light as an alternative energy source to the thermal energy conventionally applied to achieve the oxide crystallization. Photosensitive sol-gel precursors are synthesized and, after being deposited on the substrate, the layers are irradiated with UV-excimer lamps. A precise control of the photoreactions occurring in the irradiated layer, is carried out to induce hydrolysis and condensation reactions in the film, and to advance its crystallization, without the need of applying a high-temperature annealing.[3] Examples of flexible films ($Bi_2O_3$, $Fe_2O_3$, $BiFeO_3$ or $Pb(Zr,Ti)O_3$) crystallized at low temperatures will illustrate the recent achievements of our group.[4]

**References**

1- Sun et al., (2007) Adv.Mater.. 19(15): 1897-1916.
2- Bretos et al., (2018), Chem.Soc.Rev., 47, 291-308.
3- Bretos et al., (2020), Chem.Eur.J. 26, 9277 –9291.
4- Bretos et al., (2020), IEEE T-UFFC, 67(10), 1967-1979.

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