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Oxide nanostructures for solar energy conversion devices

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The research interest in methods and materials for clean energy generation and storage in a sustainable manner is driven by the rapidly growing global demand on energy and the negative effect of greenhouse gasses on the environment. The present study addresses these research topics by designing new nanostructured systems that are based on oxide ferroelectric materials, for which recently reported experimental results and theoretical studies showed promising characteristics [1-3]. The main focus in this step was the growth of high quality (low structural defects, high crystallinity and low band gap values) thin films of Bi_2FeCrO_6 and TiO_2. Pulsed laser deposition (PLD) is a versatile physical vapor deposition method, which presents a distinct set of advantages that increases its appeal in high quality nanostructured devices, such as: (a) congruent target-to-substrate transfer of substances with intricate stoichiometry; (b) control over the growing films morphology by adapting the deposition variables and (c) high hardness and adherence of the growing film to the substrate. In this paper, the influence of various deposition parameters is considered: substrate temperature, pressure, laser repetition rate, substrate type and target synthesis conditions. The structural and chemical properties of oxide bulk materials used as targets in the deposition process and of the thin films were investigated by profilometry, XRD, Raman spectroscopy and SEM-EDX. These results showed that, when no in-situ heating is applied, the films are amorphous and additional thermal treatments are required. Also, in different pressure and substrate temperature conditions, secondary phases are formed. UV-VIS spectroscopy measurements were used for band gap estimation from Tauc plots. These results are important in determining the optimal growth conditions of high-quality nanostructured systems that present elevated solar power conversion efficiency and are a good starting point in designing new deposition configurations (e.g.: magnetic field assisted PLD) that can eliminate existing issues in structural properties.

[1] R. Nechache et al. Nat. Photonics 9 (2014) 61
[2] R. Nechache et al. Nanoscale 8 (2016) 3237
[3] D. Benetti et al. Sci. Rep. 7 (2017) 2