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H2 Solar: Thin films multilayers of semiconductors oxides for photoelectrochemical water splitting

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The global energy consumption has been sharply raising over the years. To sustain the energetic needs and simultaneously combat the harmful use of pollutants, it is necessary to resort on efficient green energy sources with the possibility of storing their products. Photoelectrochemical (PEC) cells relies on semiconductors to convert the absorbed solar light into green hydrogen through a process of photogeneration of electron-hole pairs which chemically splits the water molecule [1], producing hydrogen that can be stored, transported, and used as fuel. Several semiconductors (SC) have been extensively studied for PEC cells applications, including SC oxides such hematite, TiO2, WO3, etc. [2]
Following the need for the development of a low-cost, stable, and non-toxic photoanodes [3], the present work resorts on the combination of both, hematite (α-Fe2O3) and titanium dioxide (TiO2) semiconductors. Different photoanodes consisting of Fe and Ti thin films multi-layers were prepared by ion-beam deposition with different thicknesses and arrangement to study these features impact in the final photoresponse. Additionally, thermal annealing optimization was performed where the addition of a high temperature annealing step of 800 ºC for 20 minutes to the first step at 550/600 ºC for 2 hours revealed to be crucial in the photocurrent output. Photoelectrochemical performances were evaluated by photocurrent density-voltage (J-V) characteristic curves in the dark and under 1 sun AM 1.5G illumination. The morphological and structural characterization of the obtained multilayers photoanodes was carried out by scanning electron microscopy (SEM) and X-ray diffractometry (XRD), respectively.
Enhanced J ≈ 0.7 mA/cm2 at 1.45 VRHE was obtained for the thin film photoanodes consisting of an FTO/α-Fe2O3/TiO2 multi-layer, i.e. TiO2 layer in the top of the α-Fe2O3. Additionally, through an analysis of the XRD data, this photoanode presented an increase on the grain size when compared with FTO/α-Fe2O3 or FTO/TiO2 /α-Fe2O3.
Thus, the combination of optimized annealing, semiconductor order and thickness are key parameters to take into account for a highly improved photocurrent, being an indispensable approach to obtain highly efficient PEC cells.

References
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[2] Arlete Apolinário et al. ACS Applied Energy Materials, 2 (2), 1040-1050, 2019,
[3] Paula Quitério et al. J. Phys. Chem. C, 2020, https://doi.org/10.1021/acs.jpcc.0c01259

Scientific Area

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