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Multi-layered Hierarchical Nanostructures for Transparent Monolithic Dye-Sensitized Solar Cells Architectures

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Monolithic dye sensitized solar cells (DSC) architectures holds great potential for building integrated photovoltaics applications. They benefit from lower weight and costs as they avoid the use of a transparent conductive oxide coated glass counter electrode. In this work a transparent monolithic DSC comprising hierarchical 1D nanostructures stack is fabricated by physical vapour deposition techniques. The proof of concept device comprises hyperbranched TiO_2 nanostructures, sensitized by N719 dye, as photoanode, a hierarchical nanoporous Al_2O_3 spacer and a microporous ITO top electrode. The photoanode morphology is optmized for improving photovoltaic performances. On one side, light harvesting depends on chemisorbing high quantity of dye and enhancing optical thickness. On the other, electron transport is influenced by the crystalline domain size and shape. We report on how the morphology of self-assembled hyperbranched quasi 1D nanostructures can be engineered in order to maximize light harvesting and electron transport. Quasi 1D nanostructures allow for high light harvesting efficiency, broadband and intense scattering while sustain significant decrease in electron transport time. The introduction of a porous transparent conductive oxide layer allows an efficient trade-off between transparency and power conversion. The porous ITO exhibits submicrometer voids and supports high annealing temperatures without compromising its optoelectronical properties. After thermal annealing at 500°C the porous ITO layer showed a series resistance of only 45Ω. An overall 3.12% power conversion efficiency with 60% transmittance outside the dye absorption spectral window is demonstrated. Electrochemical and intensity modulated spectroscopy give insight of charge dynamic within the hierarchical monolithic DSC paving the way to potential ways of device architecture improvements.

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