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Efficient High Surface Area Vertically Aligned Metal Oxide Nanostructures for Dye-Sensitized Photoanodes by Pulsed Laser Deposition[1]

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Dye Sensitized Solar Cells (DSSCs) differ from conventional semiconductor devices in that they separate the function of light absorption from charge carrier transport. At the heart of a DSSC is a metal oxide nanoparticle film, which provides a large effective surface area for adsorption of light harvesting molecules. The films need to be thick enough to absorb a significant fraction of the incident light but increased thickness results in diminished efficiencies due to augmented recombination. Losses in efficiency are due to the slow trap-limited diffusion process responsible for electron transport. This process limits the effective electron diffusion length to about $\sim 10\ \mu$m and results in an efficiency-limiting trade-off between light absorption and carrier extraction. Here we introduce a new structural motif for the photoanode in which the traditional random nanoparticle oxide network is replaced by vertically aligned bundles of oxide nanocrystals. This structure improves absorbed photon to current efficiencies (APCE) to values above 90% over most of the dye absorption range. The bundled anode is fabricated by a simple laser deposition process and features a surface area ~ 2 times larger than that of traditional anodes. The direct pathways provided by the vertical structures also appear to provide for an enhanced collection efficiency for carriers generated throughout the device.

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