Using silicon quantum dots to prevent solar cells from overheating and improve photoelectric conversion efficiency

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The power conversion efficiency (PCE) of crystalline silicon solar cells decreases with rising temperature. Ultraviolet (UV) radiation is a primary heat source and contributes negligibly to overall efficiency because of extremely low external quantum efficiency. Silicon quantum dots (SiQDs) can downconvert UV light into red light (~ 650 nm), significantly enhancing PCE. This study examines how SiQD coatings affect solar cell performance and operating temperature. By spin-coating SiQD films at various concentrations, we found that an optimal coating loading lowers operating temperature by about 4.9 °C while increasing PCE by about 0.6 %. Using the calculated optical-optical conversion efficiency and thermal load, the spectral conversion benefit brought about by this passive thermal regulation was quantified. These results show that an optimized SiQD coating strategy can simultaneously provide excellent passive cooling and spectral conversion, effectively improving photovoltaic cell performance.

Keywords: silicon quantum dots, luminescent down-conversion, crystalline silicon solar cell, operating temperature.

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