

Semiconductor-sensitized solar cells: The effect of absorber thickness and deposition method

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The fundamental purpose of the mesoporous solar cell architecture is to minimize *local* absorber thickness on the mesoporous charge collector while allowing sufficient optical thickness to absorb (nearly) all the light. A low local thickness should allow a greater probability of removal of both photogenerated charges by the electron and hole conductors which should be particularly noticeable for poor quality (low effective diffusion lengths) absorbers. We set out to test this expectation using mainly liquid junction but also some solid state (Extremely Thin Absorber – ETA) cells.

Three different types of CdS (SILAR and two different chemical bath deposited [CBD] solutions – from an alkaline citrate bath and a slightly acidic thioacetamide bath) and CBD CdSe were deposited on ZnO nanrod films and internal quantum efficiency (IQE) measurements made in polysulfide electrolyte. Some measurements were also made on solid state cells using CBD CdS with CuSCN in place of the electrolyte.

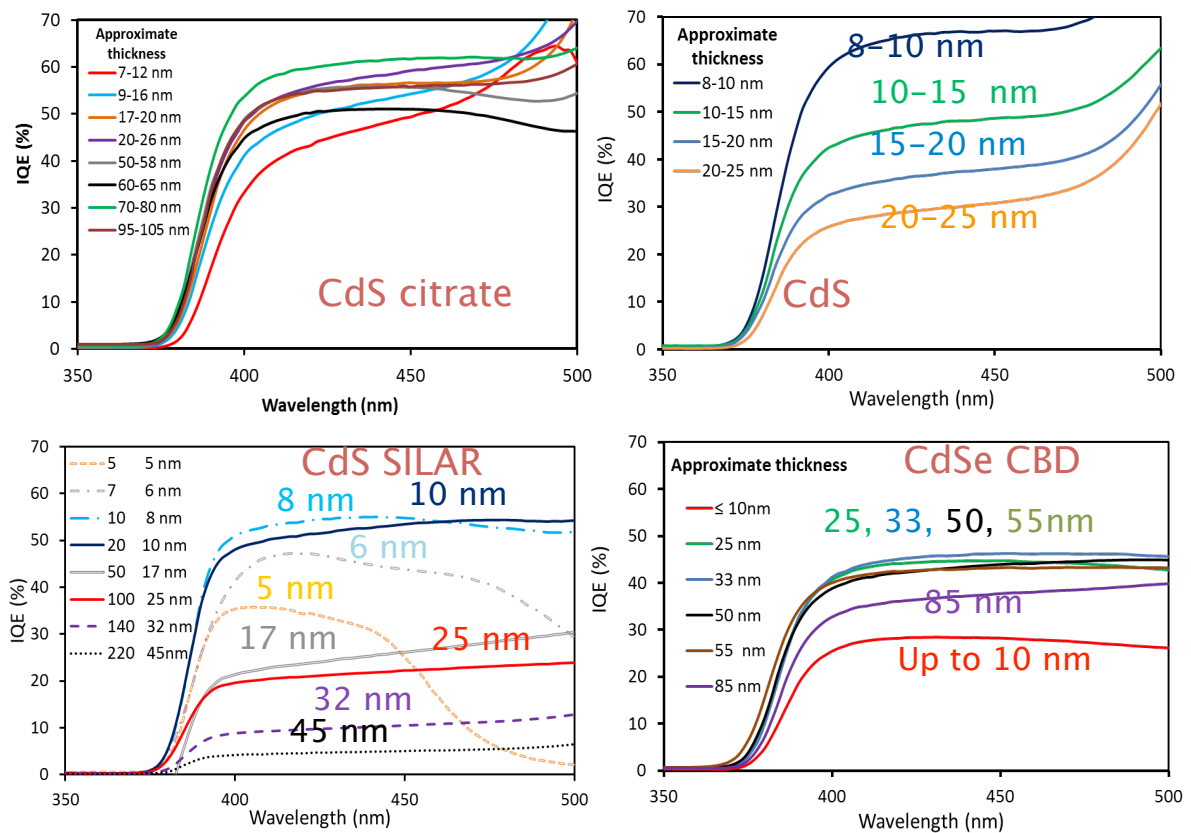


Fig. 1. Internal quantum efficiencies of four different cell types (ZnO/CdS(e)/S_x²⁻) as a function of absorber thickness.

Cells using the different CdS(e) deposition methods could be divided into two fundamentally-different types: Those where the IQE dropped continuously as the absorber thickness increased beyond about 10 nm, and those where the IQE remained constant with increasing thickness (at 10 nm thickness, the IQE of all samples were comparable).

A combination of transient absorption (which provides information on charge lifetimes in the CdS(e) and photovoltage decay (which quantifies the rate of loss of electrons in the ZnO by recombination back to either the absorber or to the electrolyte) showed that both these processes are important in determining the loss in IQE with increasing absorber thickness and in some cases correlates well with the variation of IQE as a function of absorber thickness, but not in others. We also present some evidence for the suggested important role of film porosity (even in these very thin films – maximum thickness about 50 nm) in the variation of IQE with thickness, where the more porous films allow better access of the electrolyte to the absorber resulting in better hole removal. This involves controlling the porosity, particularly of SILAR films which normally are dense. Some results will also be presented for solid state cells, where hole conductor percolation into the nanoporous substrate is less facile than that of a liquid electrolyte, showing the dependence of IQE on absorber thickness.

Apart from the results described above, this study emphasizes the very different nature and performance of the absorber when deposited, even by the same general method, from different baths.