

ABSTRACT

CdS and CdSe quantum dots (QDs) which have excellent optical properties were used as sensitizer for the application in solar cells. CdS and CdSe quantum dot-sensitized solar cells (QDSSCs) were fabricated and studied for determining the optimum preparation parameters that produce the best cell performance. CdS and CdSe QD-sensitized TiO₂ electrodes were prepared by successive ionic layer adsorption and reaction (SILAR) method. Three preparation parameters were optimized for QD fabrication: concentration of precursor solutions, number of dipping cycles and dipping time per cycle in each solution. CdS QDSSC achieved optimum performance when the QDs were prepared with preparation parameter of 0.10 M precursor solution concentration and 4 dipping cycles with 5 minutes dipping time in each solution. For CdSe QDSSC, optimum performance was achieved when QDs were prepared from 0.03 M precursor solution concentration and 7 dipping cycles with each dipping lasted for 30 seconds. The performance of CdSe QDSSC was further improved with an improved polysulfide electrolyte. A suitable polysulfide electrolyte for CdSe QDSSC composed of 0.5 M Na₂S, 0.1 M S and 0.05 M GuSCN. The effect of counter electrode materials were also explored. It was found that both CdS and CdSe QDSSCs performed best when carbon and commercial platinum catalyst were used as their counter electrodes respectively. When a passivation layer of ZnS was applied on the working electrode, a better performance was observed. However, other Zn chalcogenides (ZnSe and ZnTe) did not produce the same effect due to high electron recombination at the photoanode/electrolyte interface. The best CdSe QDSSC performance was obtained when a 24 μm thick TiO₂ was applied with ZnS passivation layer. Its efficiency was 3.05%. For CdS QDSSC, doping with Mn²⁺ and applied with ZnS passivation layer produced the best efficiency of 1.89%.

ABSTRAK

Titik-titik kuantum CdS dan CdSe yang memiliki sifat-sifat optikal yang baik telah digunakan sebagai sensitizer untuk aplikasi sel solar. Sel-sel solar titik kuantum tersensitisasi (SSTKT) CdS dan CdSe telah direka dan dikaji untuk menentukan parameter penyediaan optimum bagi menghasilkan sel berprestasi tinggi. Titik kuantum CdS dan CdSe tersensitisasi elektrod TiO_2 telah disediakan melalui kaedah penjerapan dan tindak balas lapisan ionik berturutan. Tiga parameter penyediaan telah dioptimumkan untuk pembuatan titik kuantum: kepekatan larutan-larutan pendahulu, bilangan kitar celupan dan masa celupan dalam setiap larutan. SSTKT CdS mencapai prestasi optimum apabila titik-titik kuantumnya disediakan dengan 0.10 M kepekatan larutan pendahulu dan 4 kitar celupan dengan 5 minit masa celupan setiap larutan. Untuk SSTKT CdSe, prestasi optimum dicapai apabila titik-titik kuantumnya disediakan daripada larutan pendahulu berkepekatan 0.03 M dan 7 kitar celupan dengan 30 saat setiap celupan. Prestasi bagi SSTKT CdSe seterusnya dipertingkatkan dengan menggunakan elektrolit polisulfida yang telah ditambah-baikkkan di mana komposisinya terdiri daripada 0.5 M Na_2S , 0.1 M S dan 0.05 M GuSCN . Kesan bahan-bahan elektrod kaunter yang berlainan juga diterokai. Didapati bahawa kedua-dua SSTKT CdS dan CdSe menunjukkan prestasi terbaik apabila karbon dan pemangkin platinum komersial digunakan sebagai elektrod kaunter masing-masing. Apabila lapisan pasivasi ZnS diterapkan ke atas elektrod kerja, prestasi sel solar yang lebih baik telah diperhatikan. Walau bagaimanapun, chalcogenide Zn yang lain (ZnSe dan ZnTe) tidak menunjukkan kesan yang sama disebabkan penggabungan semula elektron yang tinggi di antara muka fotoanod/elektrolit. SSTKT CdSe berprestasi tinggi telah diperolehi apabila TiO_2 berketebalan 24 μm digunakan dengan lapisan pasivasi ZnS. Kecekapan sel yang diperolehi ialah 3.05%. Untuk SSTKT CdS, Mn^{2+} “doping” dengan lapisan pasivasi ZnS telah menghasilkan kecekapan yang terbaik iaitu 1.89%.

LIST OF PUBLICATIONS

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ABBREVIATIONS

| | |
|----------------------------|--|
| CB | Conduction band |
| CBD | Chemical bath deposition |
| $\text{Cd}(\text{NO}_3)_2$ | Cadmium nitrate |
| CdS | Cadmium sulfide |
| CdSe | Cadmium selenide |
| CE | Counter electrode |
| Cu_2S | Copper sulfide |
| DSSC | Dye-sensitized solar cell |
| EDX | Energy dispersive x-ray |
| EIS | Electrochemical impedance spectroscopy |
| FESEM | Field emission scanning electron microscopy |
| FF | Fill factor |
| GuSCN | Guanidine thiocyanate |
| IPCE | Incident photon to current efficiency |
| <i>J-V</i> | Current density-voltage |
| J_{sc} | Short-circuit current density |
| KCl | Potassium chloride |
| MEG | Multiple exciton generation |
| Na_2S | Sodium sulfide |
| QD | Quantum dot |
| QDSSC | Quantum dot-sensitized solar cell |
| RGO | Reduced graphene oxide |
| RMS | Root mean square |
| SILAR | Successive ionic layer adsorption and reaction |

| | |
|------------------|----------------------------------|
| TCO | Transparent conducting oxide |
| TEM | Transmission electron microscopy |
| TiO ₂ | Titanium dioxide |
| VB | Valence band |
| V_{OC} | Open-circuit voltage |
| ZnS | Zinc sulfide |
| ZnSe | Zinc selenide |
| ZnTe | Zinc telluride |
| η | Efficiency |