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 TiO$_2$ 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 Na$_2$S, 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 TiO$_2$ was applied with ZnS passivation layer. Its efficiency was 3.05%. For CdS QDSSC, doping with Mn$^{2+}$ 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 elekad TiO₂ 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 SSSTKT CdSe seterusnya diperbaiki dengan menggunakan elektrolit polisulfida yang telah ditambah-baikkan di mana komposisinya terdiri daripada 0.5 M Na₂S, 0.1 M S dan 0.05 M GuSCN. Kesannya 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 TiO₂ berketebalan 24 μm digunakan dengan lapisan pasivasi ZnS. Kecekapan sel yang diperolehi ialah 3.05%. Untuk SSTKT CdS, Mn²⁺ “doping” dengan lapisan pasivasi ZnS telah menghasilkan kecekapan yang terbaik iaitu 1.89%.
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## TABLE OF CONTENTS

Original literary work declaration ii
Abstract iii
Abstrak iv
List of publications v
Acknowledgements vii
Table of Contents viii
List of Figures xii
List of Tables xvii
Abbreviations xx

### 1. INTRODUCTION

1.1 Motivation 1
1.2 Objectives 4
1.3 Overview 5
1.4 References 6

### 2. QUANTUM DOT-SENSITIZED SOLAR CELLS (QDSSCs)

2.1 Introduction 8
2.2 Basic principles of QDSSCs 11
   2.2.1 Structure of a QDSSC 11
   2.2.2 Performance parameters 12
   2.2.3 Working mechanism 15
2.3 Transport processes and properties of QDSSC 17
   2.3.1 Charge separation and transport 17
   2.3.2 Advantages of quantum dots (QDs) as sensitizers 19
     2.3.2.1 Tunable energy gaps 19
     2.3.2.2 Multiple exciton generation 21
2.4 Preparation of QD sensitizers 21
   2.4.1 Chemical bath deposition (CBD) 22
   2.4.2 Successive ionic layer adsorption and reaction (SILAR) 23
   2.4.3 Surface attachment thought molecular linkers for *ex situ* fabrication of QDs 24
2.4.4 Other methods
2.5 Characterization of QDSSC
2.6 Summary
2.7 References

3. METHODOLOGY

3.1 Materials and preparation
   3.1.1 Transparent conducting glass
   3.1.2 Compact layer
   3.1.3 Mesoporous TiO$_2$ layer

3.2 Fabrication of QD sensitizers via successive ionic layer adsorption and reaction (SILAR)
   3.2.1 CdS QD
   3.2.2 CdSe QD
   3.2.3 ZnS, ZnSe and ZnTe QDs
   3.2.4 Safety and precaution

3.3 Assembly of solar cell
   3.3.1 Cell assembly
   3.3.2 Preparation of different counter electrode materials

3.4 Characterization
   3.4.1 UV-Vis spectroscopy
   3.4.2 Surface morphology
   3.4.3 Photoelectrochemical measurement
   3.4.4 Electrochemical impedance spectroscopy (EIS)

3.5 References

4. OPTIMIZATION OF CdS and CdSe QDSSCs WITH QDs PREPARED BY SILAR

4.1 Introduction
4.2 Results and discussion
   4.2.1 SILAR method for preparing QDs
   4.2.2 Optimum concentration for precursor solutions
      4.2.2.1 CdS QDs
      4.2.2.2 CdSe QDs
   4.2.3 Dipping cycles
## 4.2.3.1 CdS QDs

### 4.2.4 Dipping time

- **4.2.4.1 CdS QDs**
- **4.2.4.2 CdSe QDs**

### 4.2.5 Surface morphology of the optimized QD-sensitized electrode

## 4.3 Summary

## 4.4 References

## 5. A SUITABLE POLYSULFIDE ELECTROLYTE FOR CdSe QDSSC

### 5.1 Introduction

### 5.2 Results and discussion

- **5.2.1 Optimum solvent for the electrolyte**
- **5.2.2 Optimum \( Na_2S \) salt concentration for the electrolyte**
- **5.2.3 Sulfur content needed for the best performance of the cells**
- **5.2.4 Additives needed for optimum performance of the cells**
- **5.2.5 Stability of the electrolyte**

### 5.3 Summary

### 5.4 References

## 6. SOME LOW-COST COUNTER ELECTRODE MATERIALS FOR CdS AND CdSe QDSSCs

### 6.1 Introduction

### 6.2 Results and discussion

### 6.3 Summary

### 6.4 References

## 7. MULTILAYERED QDSSCs WITH PASSIVATION OF Zn CHALCOGENIDE LAYER

### 7.1 Introduction

### 7.2 Results and discussion

- **7.2.1 Surface morphology**
- **7.2.2 \( J-V \) curves**
- **7.2.3 EIS measurements**
8. EFFICIENCY IMPROVEMENT OF CdS AND CdSe QDSSCs BY TiO$_2$ SURFACE TREATMENT

8.1 Introduction 141
8.2 Results and discussion 142
  8.2.1 Surface treatment effect in QDSSC 142
  8.2.2 Effect of doping in QDSSC 150
8.3 Summary 152
8.4 References 153

9. CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK 157

9.1 Conclusions 157
9.2 Suggestions for future work 161
## LIST OF FIGURES

| Figure 1.1 | Best research-cell efficiencies. | 3 |
| Figure 2.1 | Efficiency-cost trade-off for the three generations of solar cell technology: wafers, thin-films and advanced thin-films (year 2003 dollars). | 10 |
| Figure 2.2 | Structure and operating principle of a typical DSSC. | 12 |
| Figure 2.3 | Current-voltage curves of a photovoltaic solar cell under dark and illuminated conditions. The intersection value with the abscissa and ordinate are the open-circuit voltage ($V_{oc}$) and the short-circuit current ($I_{sc}$) respectively. Maximum power output, $P_{max}$ is determined by the maximized product of $I_m$ and $V_m$. By dividing the $P_{max}$ with the product of $I_{sc}$ and $V_{oc}$, it results the fill factor (FF). | 13 |
| Figure 2.4 | Structure and operating principle of a typical QDSSC. | 15 |
| Figure 2.5 | Schematic of an energy diagram of a QDSSC stack under flat band conditions. Key processes leading to the generation of photocurrent are shown in (a) – (e). | 17 |
| Figure 2.6 | Schematic diagram illustrating the energy levels of different-sized CdSe QDs and TiO$_2$. (The injection of electrons from CdSe QDs into TiO$_2$ is influenced by the energy difference between the two conduction bands. Note that band positions are for reference only and not to scale). | 20 |
| Figure 2.7 | Illustration of SILAR process where QD is grown on the substrate by successive dipping and drying. | 24 |
| Figure 2.8 | Linking QDs to TiO$_2$ surface with a bifunctional molecular linker. | 25 |
| Figure 2.9 | Device characterization technique for QDSSC. | 28 |
| Figure 3.1 | Architecture of the solar cell assembly | 46 |
| Figure 4.1 | Photos of electrodes after each SILAR cycle (a) of 1-3, 5,7 and 10 cycles for CdS growth and (b) of 1-5, 7-10 cycles for CdSe growth. | 54 |
| Figure 4.2 | (a) UV-vis spectra, (b) Tauc plot, and (c) J-V curves of QDSSCs for CdS QDs prepared using different precursor concentrations. | 55 |
| Figure 4.3 | (a) UV-vis spectra, (b) Tauc plot, and (c) J-V curves of QDSSCs for CdSe QDs prepared using different precursor concentrations. | 59 |
concentrations

Figure 4.4 (a) UV-vis spectra, (b) Tauc plot, and (c) $J-V$ curves of QDSSC for CdS QDs prepared using different number of SILAR cycles.

Figure 4.5 (a) UV-vis spectra, (b) Tauc plot, and (c) $J-V$ curves of QDSSC for CdSe QDs prepared using different number of dipping cycles.

Figure 4.6 (a) UV-vis spectra, (b) Tauc plot, and (c) $J-V$ curves of QDSSC for CdS QDs prepared using different dipping times.

Figure 4.7 (a) UV-vis spectra, (b) Tauc plot, and (c) $J-V$ curves of QDSSCs for CdSe QDs prepared using different dipping times.

Figure 4.8 FESEM images of (a) bare TiO$_2$ film surface, (c) CdS(4)-sensitized TiO$_2$ film and (e) CdSe-sensitized TiO$_2$ film. TEM images of (b) bare TiO$_2$ film surface, (d) CdS(4)-sensitized TiO$_2$ film and (f) CdSe-sensitized TiO$_2$ film. EDX result of (g) CdS(4)-sensitized TiO$_2$ film and (h) CdSe-sensitized TiO$_2$ film.

Figure 5.1 (a) $J-V$ curves of CdSe QDSSCs with 0.1 M Na$_2$S electrolyte having various solvent ratios. (b) Variation of efficiency and fill factor of the cells with different solvent ratios in the electrolyte.

Figure 5.2 (a) $J-V$ curves of CdSe QDSSCs with electrolytes having various amounts of Na$_2$S. (b) Variation of efficiency and fill factor of the cells with the amount of Na$_2$S in the electrolyte.

Figure 5.3 (a) $J-V$ curves of CdSe QDSSCs with electrolytes having various amount of S. (b) Variation of efficiency and fill factor of the cells with the amount of S in the electrolyte. The electrolyte used: 0.5 M Na$_2$S in ethanol/water (8:2 by volume).

Figure 5.4 (a) $J-V$ curves of CdSe QDSSCs with electrolytes having various amounts of KCl additive. (b) Variation of efficiency and fill factor of the cells with the amount of KCl in the electrolyte. Electrolyte used: 0.5 M Na$_2$S, 0.1 M S in ethanol/water (8:2 by volume).

Figure 5.5 (a) $J-V$ curves of CdSe QDSSCs with electrolytes having various amounts of GuSCN additive. (b) Variation of efficiency and fill factor of the cells with the amount of GuSCN in the electrolyte. Electrolyte used: 0.5 M Na$_2$S, 0.1 M S in ethanol/water (8:2 by volume).
Figure 5.6  Efficiency variation of CdSe QDSSCs with time under two-hour light soaking. The polysulfide electrolytes used in the cells were with and without added TiO$_2$ nanoparticles.

Figure 5.7  UV-vis spectra of CdSe-sensitized TiO$_2$ electrodes before and after dipping in polysulfide electrolytes (Inset: Photograph of CdSe-sensitized electrodes before dipping and after dipping in polysulfide electrolyte).

Figure 6.1  $J$-$V$ curves of CdS QDSSCs with various CEs.

Figure 6.2  $J$-$V$ curves of CdSe QDSSCs with various CEs.

Figure 6.3  (a) Nyquist plots of CdS QDSSCs under dark; the equivalent circuit of the QDSSC with the representation of impedance at CE/electrolyte interface (subscript CE), QD-sensitized TiO$_2$/electrolyte (subscript r) and series resistance (subscript s). The symbol R and CPE denote the resistance and constant phase element, respectively. (b) Details of plots (a) at high frequency. (c) Nyquist plots of the same cells under 1000 W/m$^2$ illumination. (d) Details of plots (c) at high frequency. The solid lines are the fitted curves.

Figure 6.4  (a) Nyquist plots of CdSe QDSSCs under dark; the equivalent circuit of the QDSSC with the representation of impedance at CE/electrolyte interface (subscript CE), QD-sensitized TiO$_2$/electrolyte (subscript r) and series resistance (subscript s). The symbol R and CPE denote the resistance and constant phase element, respectively. (b) Details of plots (a) at high frequency. (c) Nyquist plots of the same cells under 1000 W/m$^2$ illumination. (d) Details of plots (c) at high frequency. The solid lines are the fitted curves.

Figure 7.1  The effect of the number of SILAR cycles on the colour change of the QD-sensitized TiO$_2$ layer. $n$ is the number of SILAR cycles which increases sequentially from the most left sample to the right sample.

Figure 7.2  FESEM images of (a) bare TiO$_2$; (b) CdS(4)/CdSe(6) - sensitized TiO$_2$; (c) CdS(4)/CdSe(6)/ZnSe(6) - sensitized TiO$_2$; (d) CdS(4)/CdSe(6)/ZnTe(6) - sensitized TiO$_2$. All images are under 100,000x magnification.

Figure 7.3  TEM images of (a) CdS(4)/CdSe(6)/ZnSe(6) - sensitized TiO$_2$; (b) CdS(4)/CdSe(6)/ZnTe(6) - sensitized TiO$_2$.

Figure 7.4  EDS mapping analysis of CdS(4)/CdSe(6)/ZnTe(6) - sensitized TiO$_2$ sample.
Figure 7.5 UV-vis spectra for CdS(n)/CdSe(7) - sensitized TiO$_2$ where $n$ is from 1-4.

Figure 7.6 $J$-$V$ curves of CdS(n)/CdSe(7) QDSSCs.

Figure 7.7 UV-vis spectra for CdS(4)/CdSe(n) - sensitized TiO$_2$ where $n$ is from 1-7.

Figure 7.8 $J$-$V$ curves of CdS(4)/CdSe(n) QDSSCs.

Figure 7.9 $J$-$V$ curves of CdS(4)/CdSe(6) QDSSCs with and without ZnS layer.

Figure 7.10 $J$-$V$ curves of CdS(4)/CdSe(6)/ZnSe(n) QDSSCs.

Figure 7.11 UV-vis spectra for CdS(4)/CdSe(6)/ZnSe(n)-sensitized TiO$_2$, where $n$ changes from 1-6.

Figure 7.12 $J$-$V$ curves of CdS(4)/CdSe(6)/ZnTe(n) QDSSCs.

Figure 7.13 Nyquist plots of CdS(n)/CdSe(7) QDSSCs under dark with 0.45 V bias. The equivalent circuit of the QDSSC with the representation of series resistance (subscript s), impedance at QD-sensitized TiO$_2$/electrolyte (subscript r) and counter electrode/electrolyte interface (subscript CE). The symbol R and CPE denote the resistance and constant phase element, respectively. Details of the plots at high-frequencies are showed in the inset. The solid lines are the fitted curves.

Figure 7.14 Nyquist plots of CdS(4)/CdSe(n) QDSSCs under dark with 0.45 V bias. Details of the plots at high-frequencies are shown in the inset. The solid lines are the fitted curves.

Figure 7.15 Nyquist plots of CdS(4)/CdSe(6)/ZnSe(n) QDSSCs under dark with 0.40 V bias. Details of the plots at high-frequencies are shown in the inset. Solid lines are the fitted curves.

Figure 7.16 Nyquist plots of CdS(4)/CdSe(6)/ZnTe(n) QDSSCs under dark with 0.45 V bias. Details of the plots at high-frequencies are shown in the inset. Solid lines are the fitted curves.

Figure 8.1 $J$-$V$ curves for CdS QDSSC with various photoanode structures. (a) Nominal TiO$_2$ thickness, and (b) increased TiO$_2$ thickness. “SL” denotes the scattering layer, “24um” indicates a thicker TiO$_2$ layer applied and “TiCl4” indicates treatment with TiCl$_4$.

Figure 8.2 $J$-$V$ curves for CdSe QDSSC with various photoanode structures. (a) Nominal TiO$_2$ thickness, and (b) increased
TiO$_2$ thickness. “SL” denotes the scattering layer, “24um” indicates a thicker TiO$_2$ layer applied and “TiCl4” indicates treatment with TiCl$_4$.

Figure 8.3 Proposed energy band structure alignment of TiO$_2$/CdS/ZnS and TiO$_2$/CdSe/ZnS interface at conductive state. The energy levels are referenced to NHE scale. VB and CB are valence band and conduction band, respectively.

Figure 8.4 SEM images of TiO$_2$ layer thickness as prepared with doctor blade method on (a) one layer of Scotch tape, and (b) two layers of Scotch tape. The TiO$_2$ layer thickness is shown by the arrow with the value enclosed.

Figure 8.5 $J$-$V$ curves of CdS QDSSCs with and without Mn-doped.

Figure 8.6 $J$-$V$ curves of CdSe QDSSCs with and without Mn-doped.

Figure 8.7 Structure of an efficient QDSSC.
## LIST OF TABLES

| Table 3.1 | Properties of FTO conducting glass. | 40 |
| Table 3.2 | Temperature profile for sintering TiO$_2$ layer. | 42 |
| Table 4.1 | The energy gap and size of QDs and QDSSC performance parameters for CdS QDs prepared using different precursor concentrations. | 57 |
| Table 4.2 | The energy gap and size of QDs and QDSSC performance parameters for CdSe QDs prepared using different precursor concentrations | 60 |
| Table 4.3 | The energy gap and size of QDs and QDSSC performance parameters for CdS QDs prepared from various SILAR cycles. | 63 |
| Table 4.4 | The energy gap and size of QDs and QDSSC performance parameters for CdSe QDs prepared using different number of dipping cycles. | 66 |
| Table 4.5 | The energy gap and size of QDs and QDSSC performance parameters for CdS QDs prepared using various dipping times. | 69 |
| Table 4.6 | The energy gap and size of QDs and QDSSC performance parameters for CdSe QDs prepared using various dipping times. | 71 |
| Table 5.1 | Performance parameters of CdSe QDSSCs with 0.1 M Na$_2$S electrolytes having various solvent ratios. | 84 |
| Table 5.2 | Performance parameters of CdSe QDSSCs with electrolytes having various amounts of Na$_2$S in ethanol/water (8:2 by volume) solution. | 87 |
| Table 5.3 | Performance parameters of CdSe QDSSCs with electrolytes having various amounts of S. The electrolyte used: 0.5 M Na$_2$S in ethanol/water (8:2 by volume). | 90 |
| Table 5.4 | Performance parameters of CdSe QDSSCs with electrolytes having various amounts of KCl additive. Electrolyte used: 0.5 M Na$_2$S, 0.1 M S in ethanol/water (8:2 by volume). | 92 |
| Table 5.5 | Performance parameters of CdSe QDSSC with electrolytes having various amounts of GuSCN additive. Electrolyte used: 0.5 M Na$_2$S, 0.1 M S in ethanol/water (8:2 by volume). | 94 |
Table 5.6  | Performance parameters of CdSe QDSSCs with and without TiO$_2$ nanoparticles in the electrolyte. Electrolyte used: 0.5 M Na$_2$S, 0.1 M S, 0.05 M GuSCN in ethanol/water (8:2 by volume).

Table 6.1  | Performance parameters of CdS QDSSCs with various CEs

Table 6.2  | CdSe QDSSC performance parameters with various CEs

Table 6.3  | EIS results of CdS QDSSCs with different CEs under 1000 W/m$^2$ illumination and dark (showed in parenthesis): series resistance, charge-transfer resistance and impedance values of the CPE.

Table 6.4  | EIS results of CdSe QDSSCs with different CEs under 1000 W/m$^2$ illumination and dark (showed in parenthesis): series resistance, charge-transfer resistance and impedance.

Table 7.1  | Performance parameters of CdS($n$)/CdSe(7) QDSSCs.

Table 7.2  | Performance parameters of CdS(4)/CdSe($n$) QDSSCs.

Table 7.3  | Performance parameters of CdS(4)/CdSe(6) QDSSCs with and without ZnS layer.

Table 7.4  | Performance parameters of CdS(4)/CdSe(6)/ZnSe($n$) QDSSCs.

Table 7.5  | Performance parameters of CdS(4)/CdSe(6)/ZnTe($n$) QDSSCs.

Table 7.6  | EIS results of CdS($n$)/CdSe(7) QDSSCs under dark with 0.45 V bias: series resistance, charge-transfer resistance, impedance and electron lifetime.

Table 7.7  | EIS results of CdS(4)/CdSe($n$) QDSSCs under dark with 0.45 V bias: series resistance, charge-transfer resistance, impedance and electron lifetime.

Table 7.8  | EIS results of CdS(4)/CdSe(6)/ZnSe($n$) QDSSCs under dark with 0.40 V bias: series resistance, charge-transfer resistance, impedance and electron lifetime.

Table 7.9  | EIS results of CdS(4)/CdSe(6)/ZnTe($n$) QDSSCs under dark with 0.45 V bias: series resistance, charge-transfer resistance, impedance and electron lifetime.

Table 8.1  | Performance parameters of CdS QDSSCs with various photoanode structures.
<table>
<thead>
<tr>
<th>Table 8.2</th>
<th>Performance parameters of CdSe QDSSCs with various photoanode structures.</th>
<th>147</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 8.3</td>
<td>Performance parameters of CdS QDSSCs with and without Mn-doped.</td>
<td>151</td>
</tr>
<tr>
<td>Table 8.4</td>
<td>Performance parameters of CdSe QDSSC with and without Mn-doped.</td>
<td>152</td>
</tr>
<tr>
<td>Table 9.1</td>
<td>Optimized parameters of CdS and CdSe QDSSCs prepared via SILAR method.</td>
<td>160</td>
</tr>
</tbody>
</table>
ABBREVIATIONS

CB  Conduction band
CBD  Chemical bath deposition
Cd(NO$_3$)$_2$  Cadmium nitrate
CdS  Cadmium sulfide
CdSe  Cadmium selenide
CE  Counter electrode
Cu$_2$S  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
$J-V$  Current density-voltage
$J_{SC}$  Short-circuit current density
KCl  Potassium chloride
MEG  Multiple exciton generation
Na$_2$S  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
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>TCO</td>
<td>Transparent conducting oxide</td>
</tr>
<tr>
<td>TEM</td>
<td>Transmission electron microscopy</td>
</tr>
<tr>
<td>TiO₂</td>
<td>Titanium dioxide</td>
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<td>VB</td>
<td>Valence band</td>
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<tr>
<td>V&lt;sub&gt;oc&lt;/sub&gt;</td>
<td>Open-circuit voltage</td>
</tr>
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<td>Zinc sulfide</td>
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<td>Efficiency</td>
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</table>