Faculty of Engineering
School of Photovoltaic and Renewable Energy Engineering

Chemical processed AgBiS$_2$ deposition as an absorber layer for high performance solar cell application

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Background and literature review

Why developing AgBiS$_2$
- High potential of high efficiency
- Non-toxic and earth abundant elements
- Crystal phase stability
- Pure single phase compound
- Tunable band gap by adding dopants

Recent synthesizing method
- Sonochemical
- Solvothermal and hydrothermal
- Sol gel
- SILAR
- Low cooling method

Recent applications for AgBiS$_2$
- Thermoelectric applications
- As a sensitizer in semiconductor-sensitized solar cell
- As an absorber in thin film solar cell

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band gap</td>
<td>1.2-1.3 eV</td>
</tr>
<tr>
<td>Absorption coefficient</td>
<td>$10^5$ cm$^{-1}$</td>
</tr>
<tr>
<td>Carrier concentration</td>
<td>$2.6 \times 10^{18}$ cm$^{-3}$</td>
</tr>
<tr>
<td>Mobility</td>
<td>$1.1$ cm$^2$V$^{-1}$ s$^{-1}$</td>
</tr>
</tbody>
</table>

Background and literature review

What should be done to further improve the efficiency

- Step 1 (Optimizing absorber properties)
  - Optimizing structural properties (composition ratio, crystal sizes, phases and orientation)
  - Optimizing optical and electrical properties (optical band gap, absorption coefficient, mobility and lifetime)

- Step 2 (Optimizing device configuration)
  - Trying different device configuration
  - Optimizing electron and hole transport layers
Experiment

- Solution based deposition of $\text{AgBiS}_2$

- Deposition
- Spinning
- Drying

Heat treatment
1) AgBiS$_2$ polycrystalline formation by chemical process
Ternary compound with normal valence states of Ag\(^+\)Bi\(^{3+}\)S\(^{2-}\) has been formed after heat treatment process.
DMSO is the suitable solvent for spin coating compact layer of AgBiS$_2$ on top of FTO.
2) Solvent engineering for making AgBiS$_2$ solution

- **0.6M solution**
- **0.4M solution**
- **0.2M solution**

The best solution concentration for making uniform film on top of TiO$_2$ layer is 0.2M.
3) Optical characterization

<table>
<thead>
<tr>
<th>Atomic Ratio</th>
<th>Band gap</th>
<th>$\alpha$ (1/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag/Bi=1</td>
<td>1.30 eV</td>
<td>$&gt;3\times10^5$</td>
</tr>
<tr>
<td>Ag/Bi=0.8</td>
<td>1.25 eV</td>
<td></td>
</tr>
<tr>
<td>Ag/Bi=1.2</td>
<td>1.20 eV</td>
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</table>
Result and discussion

4) Solar device fabrication

<table>
<thead>
<tr>
<th></th>
<th>Jsc mA/cm²</th>
<th>Voc (mV)</th>
<th>FF%</th>
<th>Eta%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.49</td>
<td>208.40</td>
<td>41.50</td>
<td>0.47</td>
</tr>
<tr>
<td>2</td>
<td>5.98</td>
<td>213.10</td>
<td>41.20</td>
<td>0.52</td>
</tr>
<tr>
<td>3</td>
<td>5.11</td>
<td>205.29</td>
<td>41.18</td>
<td>0.43</td>
</tr>
</tbody>
</table>

The optimized thickness of absorber layer in TiO₂/AgBiS₂ configuration is 200nm.
Result and discussion

4) Solar device fabrication
Conclusion

- Poly crystalline-AgBiS$_2$ formation by chemical process.

- Stable compound in various composition ratio Ag/Bi and heat treatment temperature.

- Tuneable optical bandgap by composition ratio (Ag/Bi=1 band gap=1.3eV).

- High absorption coefficient (~ $3\times10^5$).

- Non-uniform Ag distribution at the interface reduced the efficiency.
Acknowledgement

Thank you for your attention!