1. Introduction

- Solar cells have wide applications ranging from electronic gadgets to remote area power generation. Thin film solar cell, because of the lower consumption of materials and higher performance, is the future trend of technology.
- The objective of this study is to investigate the effectiveness of a new material, cuprous oxide (Cu$_2$O), in the production of solar cells in terms of efficiency and cost.
- Cu$_2$O has the advantages of non-toxicity, low cost and availability, making it an attractive candidate.

![Figure 1. Advantages of Cu$_2$O: non-toxicity, low cost and availability](image)

2. Challenges and Methodology

- Challenge #1: to deposit high quality Cu$_2$O by sputtering
  - Focus on oxygen flow rate and temperature
- Challenge #2: to explore an n-type material that forms a pn junction (solar cell structure) with Cu$_2$O
  - Fabrication of ZnO/Cu$_2$O solar cell
  - Simulation of n-Cu$_2$O/p-Cu$_2$O and CdS/Cu$_2$O cells
- Challenge #3: n-type doping of Cu$_2$O
  - Review of past works and explore the symmetry between p-type doing ZnO and n-type doping Cu$_2$O

![Figure 2. Illustration of the working principle of sputtering, a common method for thin film deposition](image)

3. Results and Discussion

- By tuning the experiment conditions, Cu$_2$O thin film with good quality was produced. Some key characteristics include: mobility: 17.8 cm$^2$/V·s and electrical resistivity: 192 Ω·cm.
- We have achieved a conversion efficiency of 0.24% at a cost of material that is substantially lower than silicon.
- The band structure of CdS/Cu$_2$O heterojunction solar cell is calculated by the effective dipole theory. (specific values are not included)

![Figure 3. Typical structure (left) and real picture (right) of the fabricated cell](image)

![Figure 4. I-V characteristics of Cu$_2$O/ZnO solar cells. The open circuit voltage (Voc) and short circuit current (Isc) are indicated on the graph and in the shematic above](image)

![Figure 5. The energy band diagram of the proposed Cu$_2$O/CdS thin film structure. The physics of the energy band structure can help understand the performance](image)

4. Conclusion

- The simulation results indicate that n-Cu$_2$O can improve the fill factor and conversion efficiency of the traditional Cu$_2$O/ZnO cell thanks to better junction quality. Yet this needs to be verified by further experiments.
- The performance of different Cu$_2$O-based solar cells is listed in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Voc (V)</th>
<th>Jsc (mA/cm$^2$)</th>
<th>Fill Factor</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu$_2$O/ZnO</td>
<td>0.33</td>
<td>1.97</td>
<td>0.505</td>
<td>0.245</td>
</tr>
<tr>
<td>n-Cu$_2$O/p-Cu$_2$O</td>
<td>0.51</td>
<td>1.35</td>
<td>0.770</td>
<td>0.5279</td>
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<tr>
<td>Cu$_2$O/CdS</td>
<td>0.68</td>
<td>1.07</td>
<td>0.631</td>
<td>0.4582</td>
</tr>
</tbody>
</table>

Table 1. Performance of Cu$_2$O-based thin film solar cells. Note that results for n-Cu$_2$O/p-Cu$_2$O and Cu$_2$O/CdS were obtained by simulation on MEDICI.

5. References