

The Effect of Structural Modifications on the Efficiency of Thin-Film Tandem Solar Cells



Introduction

Photovoltaics

- » Solar irradiation to electricity
- » Edmond Becquerel
- » Charles Fritts
- » Renewable energy



Figure 1. Image of solar cells making up a solar panel

How Solar Cells Work

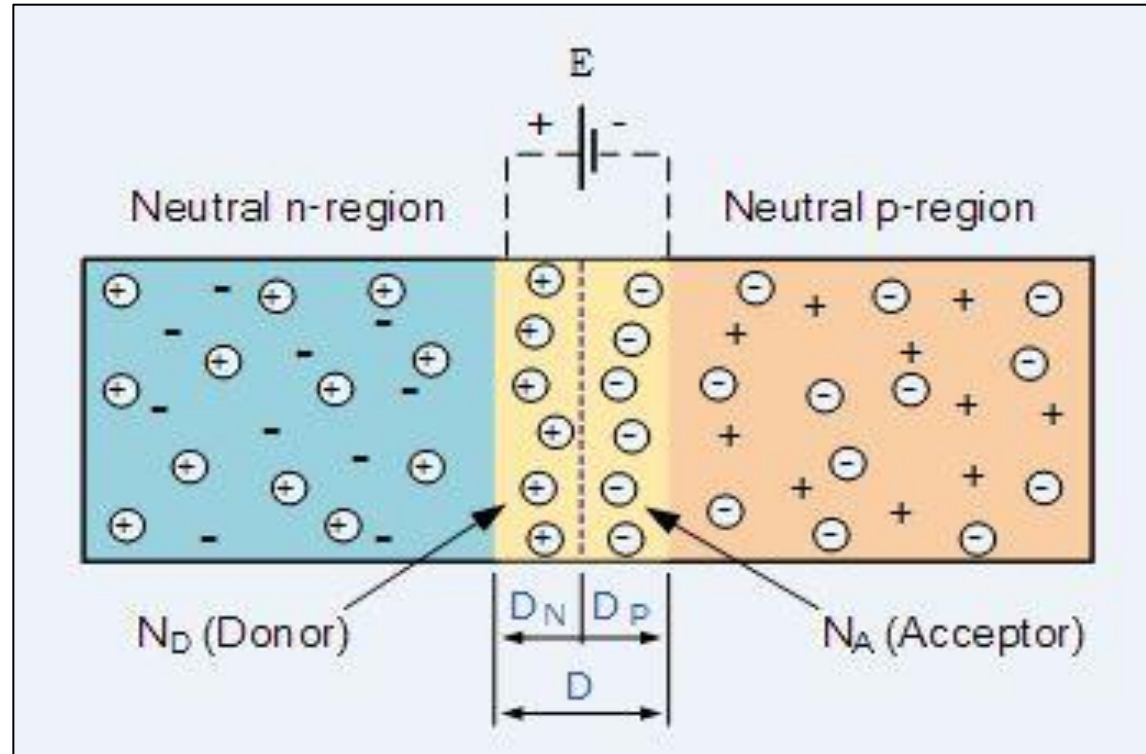


Figure 2. Diagram of electron-hole pair and electricity generation

Factors Affecting Solar Cells

- » Band gap
- » Open circuit voltage
- » Short circuit current
- » Fill factor - Power
- » Efficiency - Energy

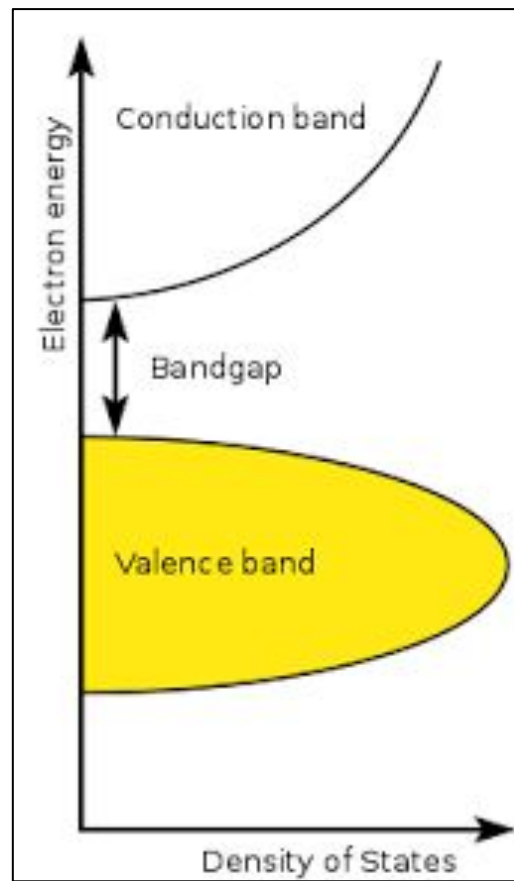


Figure 3. Graph of band gap energy for electrons

Types of Solar Cells

Thin Film

- » CdTe
- » CIGS
- » Perovskite
- » Amorphous Silicon

Silicon

- » Monocrystalline
- » Multicrystalline or Polycrystalline

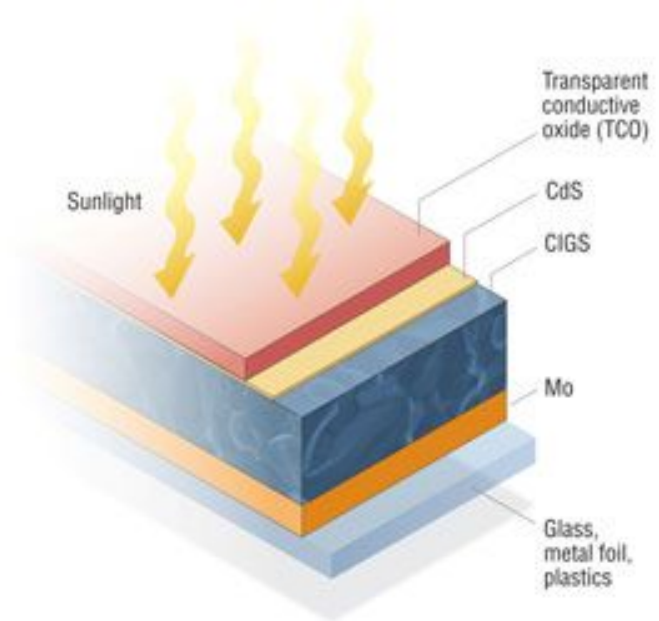


Figure 4. Breakdown of a CIGS cell

New Research

- » Tandem solar cells
- » Different layers for different wavelengths
- » Difficulties- degrade, stability, cost

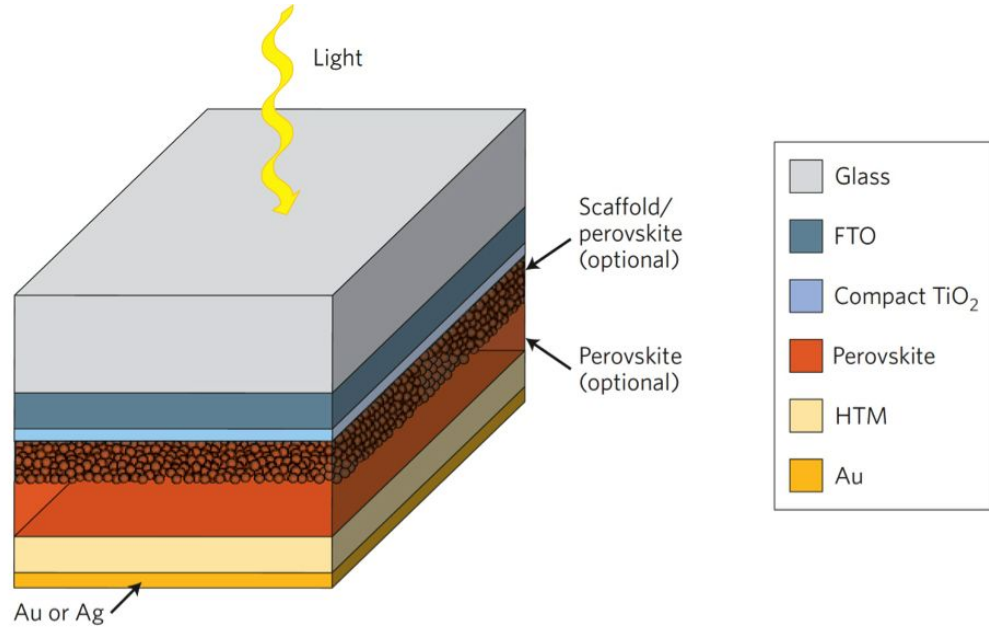


Figure 5. Dissection of a tandem solar cell



Purpose, Research Question, and Hypotheses

Purpose

- » Dependability on renewable energy
- » Increase efficiency of solar cells
- » Average price of electricity- 12 cents per kWh

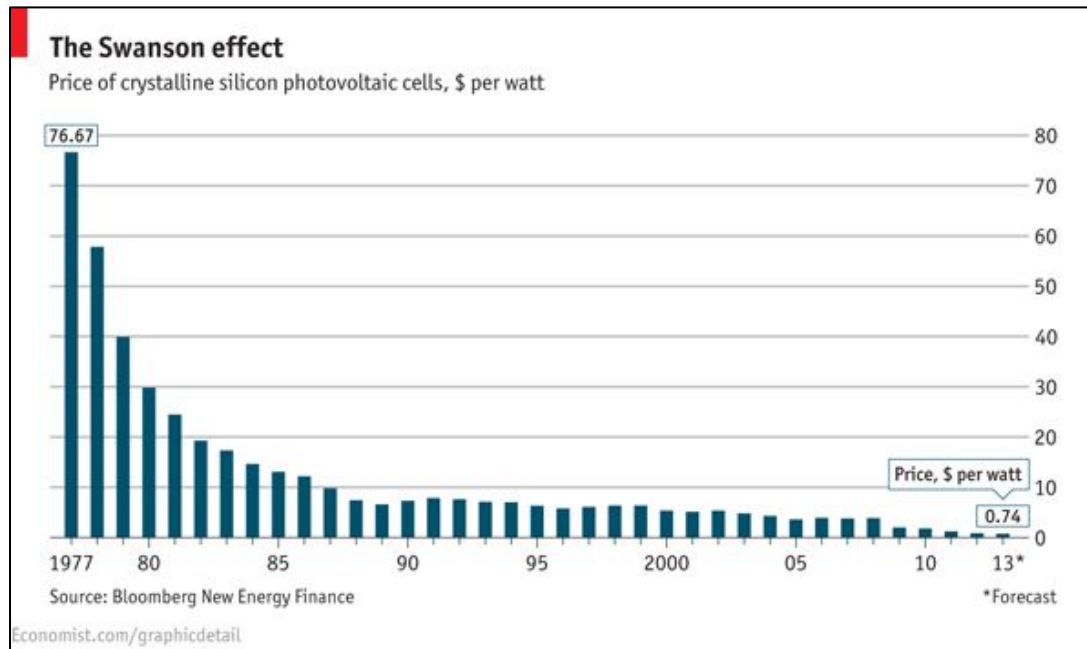
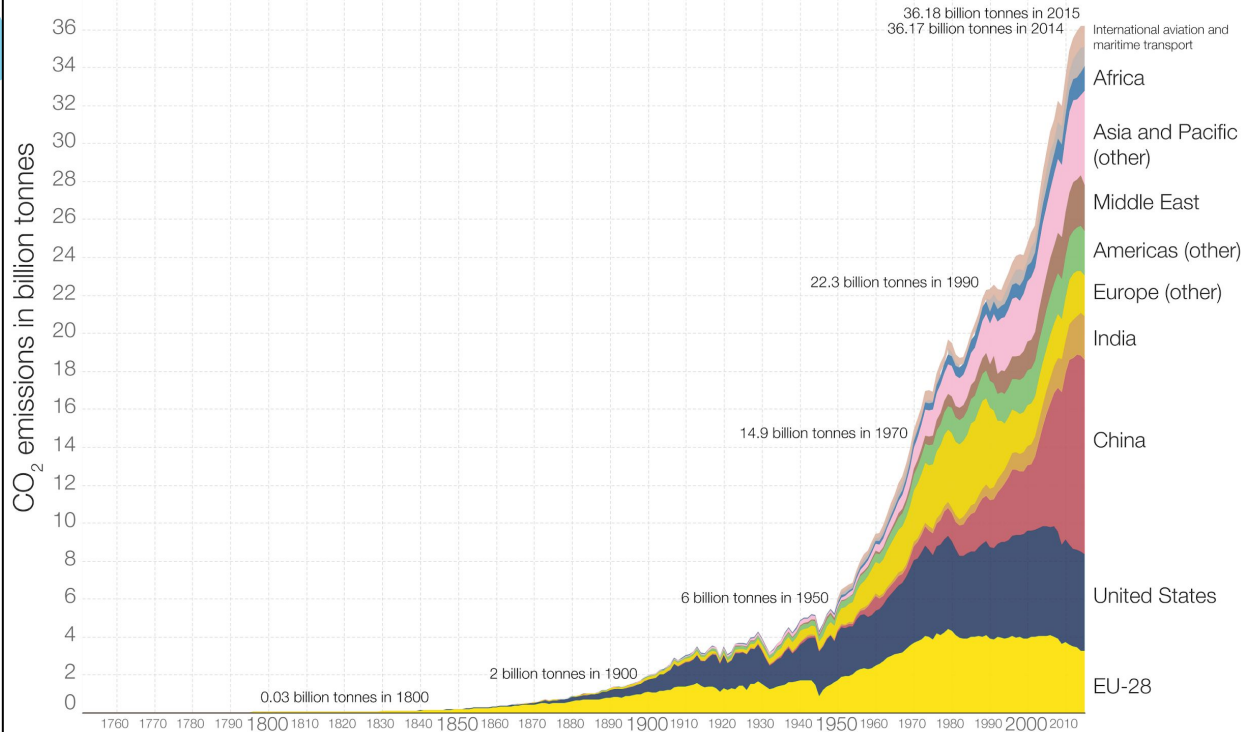


Figure 7. Graph of average cost per kWh of crystalline solar cells

Global CO₂ emissions by world region, 1751 to 2015

Annual carbon dioxide emissions in billion tonnes (Gt).

Our World
in Data



Data source: Carbon Dioxide Information Analysis Center (CDIAC); aggregation by world region by Our World In Data.
The interactive data visualization is available at OurWorldinData.org. There you find the raw data and more visualizations on this topic.

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Figure 8. Graph of increase in carbon dioxide emissions by country over time

Research Question

Can thin film tandem solar cells' structure be manipulated to produce more efficient solar cells compared to silicon solar cells?



Null Hypothesis

Thin Film Tandem
Efficiency

= or <

Silicon Cell
Efficiency

Alternative Hypothesis

Thin Film Tandem
Efficiency

>

Silicon Cell
Efficiency



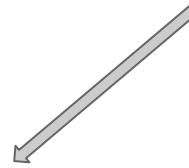
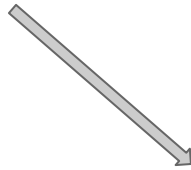


Methods

Types of Cells Investigated

Polycrystalline

Monocrystalline



- » CIGS-Perovskite 4T
- » Perovskite-Perovskite
- » CdTe-Si

Data
Search

Article
Selection

Systematic
Literature
Review

- ScienceDirect
- JSTOR
- PubMed
- Google Scholar
- ResearchGate
- Explore references
- Constant variables
- Find averages
- Conduct t-tests

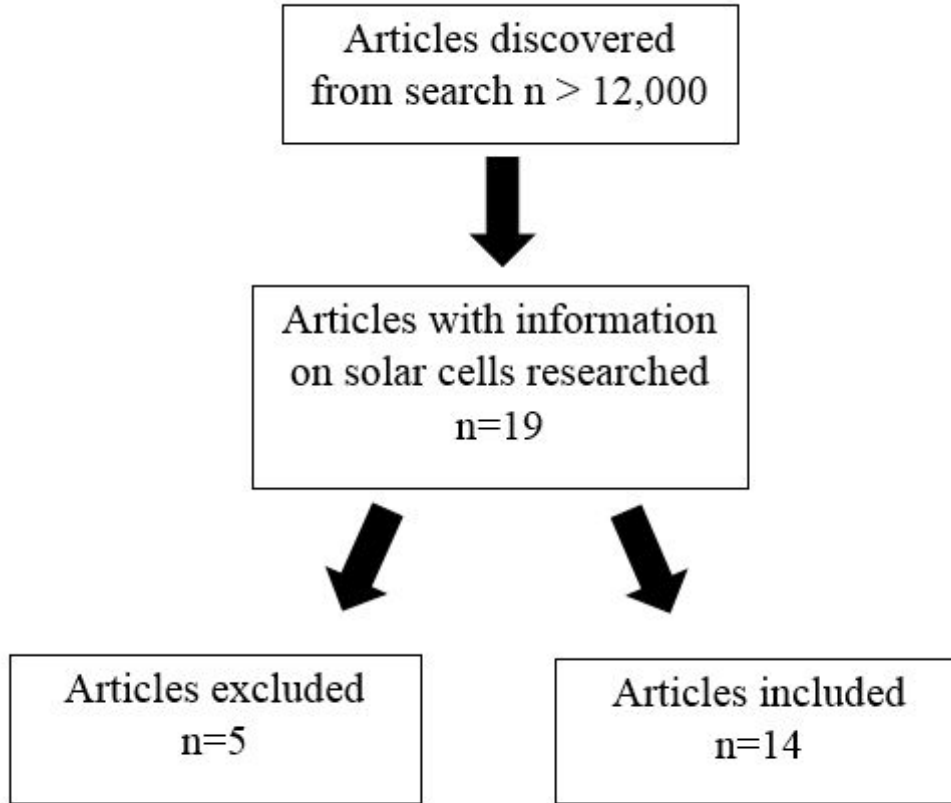


Figure 9. Article selection process



Results

Silicon

- 1) Polycrystalline
- 2) Monocrystalline

Thin Film Tandem

- 3) CIGS/Perovskite 4T
- 4) CdTe/Silicon
- 5) Perovskite/Perovskite

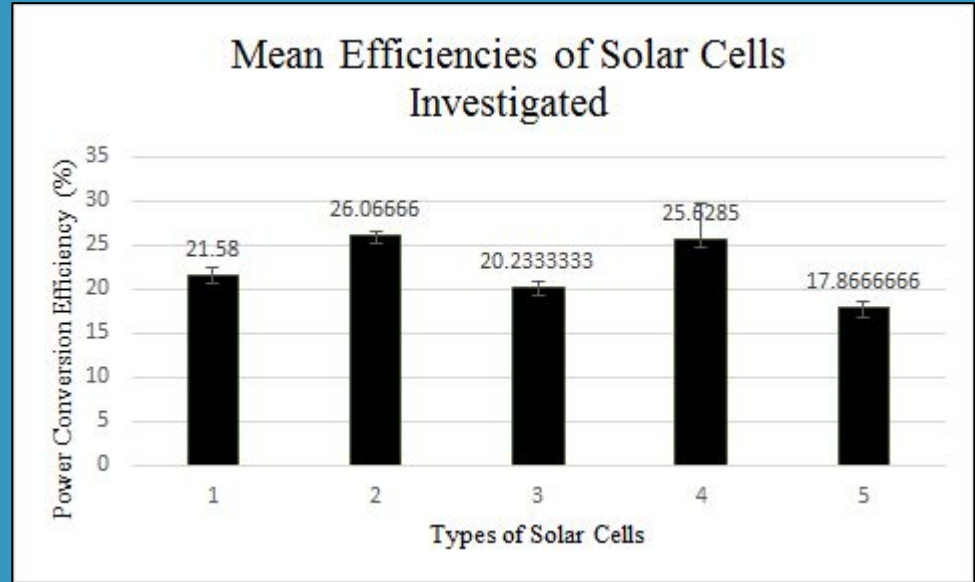


Figure 10. Bar graph of the mean efficiencies of solar cells analyzed

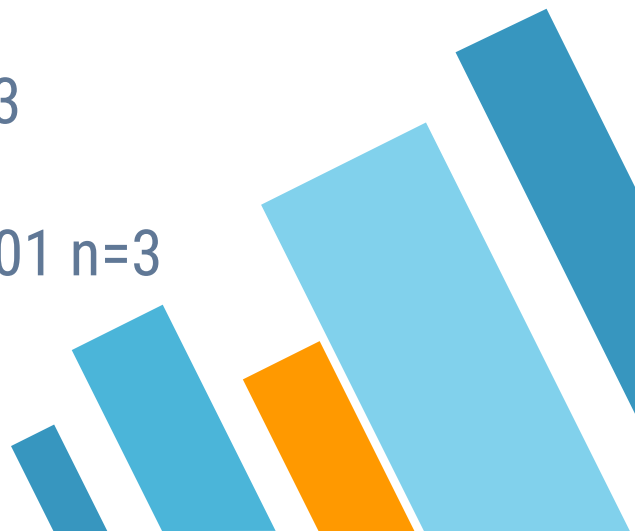


P-values

Multicrystalline n=5

- » CIGS/Perovskite .04 n=3
- » CdTe/Silicon .19 n=2
- » Perovskite/Perovskite .003 n=3

Monocrystalline n=3


- » CIGS/Perovskite .0003 n=3
 - » CdTe/Silicon .9 n=2
 - » Perovskite/Perovskite .0001 n=3
- 



Discussion



Discussion


- » Accept null
 - » No conclusive evidence
 - » Thin film and tandem cells still in the research phase
- 



Conclusion



Conclusion

- » More material = higher cost
 - » Limited resources for types of thin film
 - » Fabrication techniques
 - » Environment
- 



Limitations

- » Available research
 - » Limited distributions
- 

Further Work

- Cost
- Investigating different types of solar cells
 - Organic
 - CZTS
 - DSSC
 - Carbon quantum dots

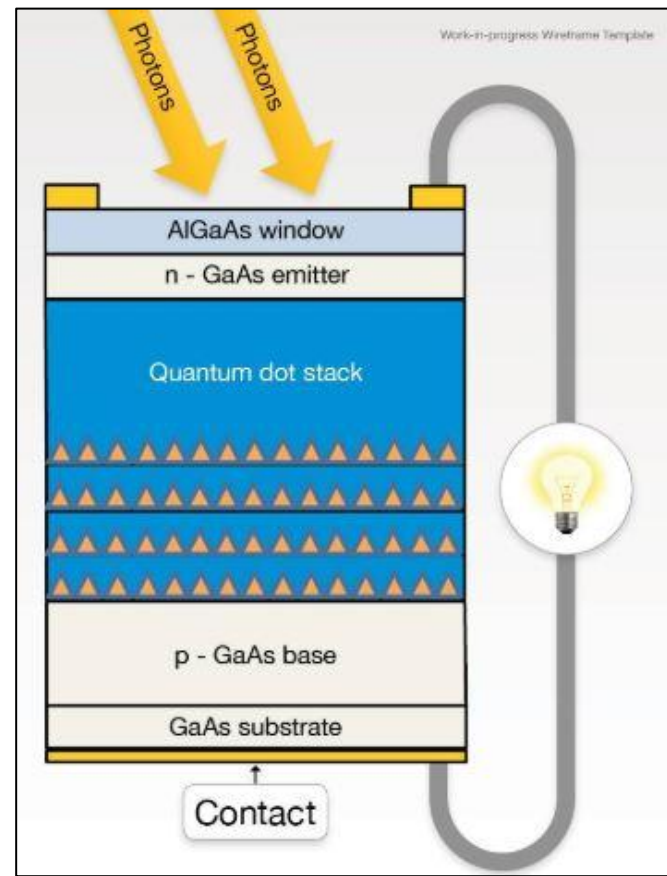


Figure 11. Breakdown of carbon quantum dot cell



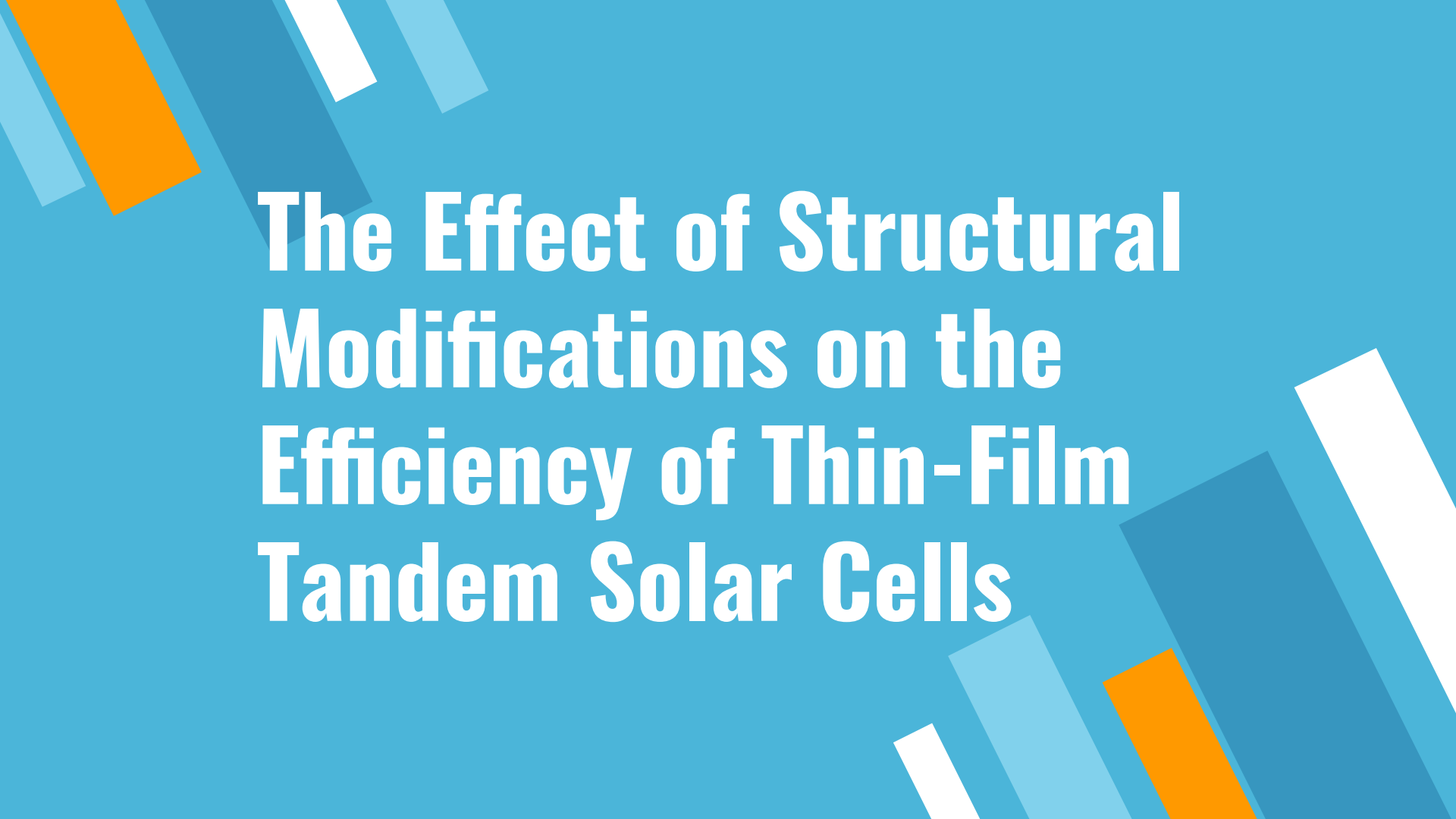
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