# ANALYSIS OF ELECTROCHEMICALLY DEPOSITED METAL OXIDE AS COUNTER ELECTRODE FOR SOLAR CELLS

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# ANALYSIS OF ELECTROCHEMICALLY DEPOSITED METAL OXIDE AS COUNTER ELECTRODE FOR SOLAR CELLS

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**This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours**

**Faculty of Electronic and Computer Engineering**
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Supervisor Name : DR. ZUL ATFYI FAUZAN BIN MOHAMMED NAPIAH

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# DEDICATION

I dedicate the thesis to my parents for their endless love, support, and encouragement throughout my pursuit for education. I hope this achievement will fulfill the dream they envisioned for me.

# ABSTRACT

Electrochemical deposition is one of the low-cost techniques to deposit copper oxide thin films onto ITO glass. The method involves using three electrodes system with ITO glass as a working electrode, a silver chloride electrode (Ag/AgCl) as a reference electrode, and a platinum (Pt) plate as a counter electrode for electrochemical deposition. The copper oxide has been electrochemically deposited on the ITO glass in two electrolytes: 0.2M CuSO4.5H2O with 3M lactic acid and 0.2M CuSO4.5H2O with 0.1M of sulfuric acid. The copper oxide was electrochemical deposition by varying deposition potentials and deposition times. The copper oxide deposited was characterized by Scanning Electron Microscopy (SEM), Ultraviolet-Visible Spectroscopy (UV-Vis) and a four-point probe. From visual inspection, it was found that copper oxide was dark brown on ITO glass. The SEM study reveals that the deposited layer becomes uniform when the deposition potential and time increase. It was found that the deposited layer becomes thicker with the increase of deposition time. UV-Vis shows that the deposited layer with increased deposition time has high absorbance. Finally, the copper oxide deposited was applied to solar cells where the Dye-Sensitized Solar Cells and Perovskite Solar Cell were fabricated.

# ABSTRAK

*Pemendapan elektrokimia adalah salah satu teknik kos rendah untuk menyalutkan oksida kuprum pada konduktif kaca. Kaedah ini melibatkan penggunaan tiga elektrod dengan konduktif kaca sebagai elektrod berfungsi, elektrod perak klorida sebagai elektrod rujukan dan platinum sebagai elektrod tambahan digunakan untuk pemendapan elektrokimia. Oksida kuprum dimendapkan secara elektrokimia pada konduktif kaca dalam dua elektrolit: 0.2M CuSO4.5H2O dengan 3M asid laktik dan 0.2M CuSO4.5H2O dengan 0.1M asid sulfurik. Oksida kuprum adalah pemendapan elektrokimia dengan pemendapan voltan dan masa pemendapan yang berbeza-beza. Oksida kuprum yang dimendapkan dicirikan oleh Scanning Electron Microscopy (SEM), Ultraviolet-Visible Spectroscopy (UV-Vis) dan four-point probe. Daripada pemeriksaan, didapati kuprum oksida berwarna perang gelap pada konduktif kaca. Kajian SEM mendedahkan bahawa lapisan termendap menjadi lebih sekata apabila pemendapan voltan dan masa meningkat. Didapati lapisan termendap menjadi lebih tebal dengan peningkatan masa mendapan. UV-Vis menunjukkan bahawa lapisan termendap dengan peningkatan masa pemendapan mempunyai penyerapan yang tinggi. Akhirnya, oksida kuprum yang didepositkan telah digunakan pada sel suria iaitu "Dye-Sensitized Solar Cells" dan "Perovskite Solar Cell" telah dibuat.*

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# LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| PV | : | Photovoltaic |
| DSSC | : | Dye Sensitized Solar Cell |
| TCO | : | Transparent Conducting Oxide |
| Pt | : | Platinum |
| CuO | : | Copper Oxide |
| SEM | : | Scanning Electron Microscopes |
| UV-Vis | : | Ultraviolet-Visible Spectroscopy |
| PSC | : | Perovskite Solar Cell |
| ITO | : | Indium Tin Oxide |
| Ag/AgCl | : | Silver/Silver Chloride |
| IEA | : | International Energy Agency |
| DC | : | Direct Current |
| AC | : | Alternating Current |
| GaAs | : | Gallium Arsenide |
| CdTe | : | Cadmium Telluride |
| CIS | : | Copper Indium Diselenide |
| CIGS | : | Copper Indium Gallium Selenide |
| c-Si | : | Crystalline Silicon |
| a-Si | : | Amorphous Silicon |

| | | |
|---|---|---|
| OPV | : | Organic/Semi-organic PV panels |
| QD | : | Quantum Dot |
| TiO2 | : | Titanium Dioxide |
| FTO | : | Fluorine-Doped Tin Oxide |
| HOMO | : | Highest Occupied Molecular Orbital |
| LUMO | : | Lowest Unoccupied Molecular Orbital |
| ZnO | : | Zinc Oxide |
| NiO | : | Nickel Oxide |
| MoS2 | : | Molybdenum Disulfide |
| PET | : | Flexible Polyethene Terephthalate |
| CV | : | Cyclic Voltammetry |
| XRD | : | X-Ray Diffraction |
| PCE | : | Power Conversion Efficiency |
| FF | : | Fill Factor |
| VoC | : | Open-Circuit Voltage |
| Isc | : | Short-Current Photocurrent |
| NoOH | : | Sodium hydroxide |
| I-V | : | Current-Voltage |
| HTL | : | Hole Transport Layer |
| ETL | : | Electron Transport Layer |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Project introduction

Solar energy is a common renewable energy source used worldwide because it can benefit humans and the environment. The sun emits energy in the form of solar radiation, and technology like solar cells, also called photovoltaic or PV cells, convert the sunlight into usable energy. Solar cells use the PV effect to convert sunlight into electrical energy. Therefore, the third-generation solar cells rapidly developed because of good efficiency and a cheaper production cost. Example of third-generation solar cell is quantum dot solar cells, organic solar cell, copper zinc tin sulphide (CZTS), dye-sensitized solar cells (DSSC) and perovskite solar cells (PSC).

Among them, DSSC has attracted significant interest because it has good efficiency photon to electricity conversion, low production cost and easy fabrication process.

DSSC is an assembly of a working electrode soaked with a sensitizer or a dye and sealed to the counter electrode soaked with a thin layer of electrolyte, as shown in Figure 1.1.

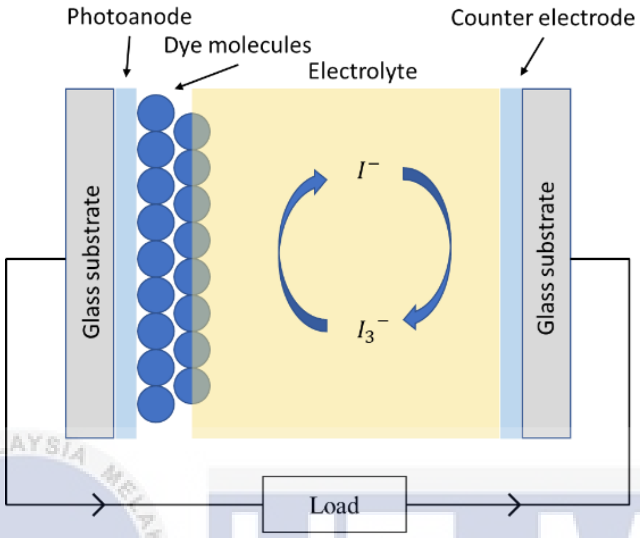


Figure 1.1: The working principle of dye-sensitized solar cells

In the structure of DSSC, the counter electrode is one of the significant components. The purpose of the counter electrode is to carry back the electrons from the circuit into holes in the dye molecules by the catalyzing reduction. The ideal counter electrode materials are high conductivity and have excellent electrocatalytic activity to maximize the charge transport between an external circuit and an electrode while minimizing the redox couple.

The counter electrode can be deposited using spin coating, doctor blade, sputtering and electrochemical deposition. Between these methods, the electrochemical deposition is suitable for depositing the counter electrode layers of DSSC because it can control the structures and size of layers on conducting materials. Electrochemical deposition, also known as electrodeposition, is the process of depositing a thin layer of metal to a conductive surface by passing an electrical current through the solution