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# Electrochemical Properties of $Cu_2S$-SiNWs Based Photocathodes Used for the $CO_2$ Conversion

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## ABSTRACT

Novel photocatalyst structure was successfully synthesized by a simple chemical method, it involves copper sulfide deposited on silicon nanowires by CBD. The $Cu_2S$@Si-NW structure was used as a cathode material for the photoelectrochemical reduction of CO2. the morphology and optical properties of the developed cathodes were characterized by SEM and UV-visible spectroscopy. For photoelectrochemical characterizations we use a potentiostat station. We carried out linear voltammetry (LSV) in the dark and under white light irradiation and chronoamperometry is carried out to study the stability of our photocathodes.

**Keywords:** $CO_2$ conversion, photocathode, $Cu_2S$, SiNWs.

## 1. Introduction

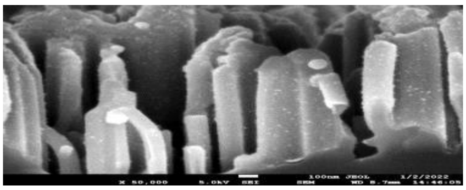
To counter global warming, caused mainly by increasing levels of carbon dioxide in the atmosphere, the conversion of carbon dioxide into chemical fuels and other energy-dense products constitutes an attractive strategy for producing renewable energy in the form of chemical energy [1,2]. This could be accomplished by a system combining an electrochemical (EC) cell with a photovoltaic (PV) cell to reduce carbon dioxide. Photoelectrochemical $CO_2$ reduction ($CO_2$RR) is a current renewable energy process that is a promising way to combat climate change by converting $CO_2$ into useful products like methanol, methane, and formic acid [4]. Which can be used as fuels. Raw chemicals or raw materials. Various catalysts and photocatalysts used for the electrochemical reduction of $CO_2$ citing metals, oxides and sulfides. The important characteristics of $Cu_2S$ are non-toxicity, affordable price and excellent bandgap. Additionally, it is crucial for many applications, such as $CO_2$ reduction, ionic batteries, solar energy absorbers, electroconductive coatings, and superconductors [4]. In this present work, we used thin films of $Cu_2S$ obtained by chemical bath deposition deposited on silicon nanowire substrates. The electrodes based on $Cu_2S$@SiNW as developed are used as photocathode for $CO_2$ reduction.

## 2. Experimental

In the present study we develop $Cu_2S$-based photoelectrodes used as $CO_2$ photoelectrocatalyst. Thin layers of $Cu_2S$ were synthesized by a chemical bath deposition (CBD) method and deposited on silicon these nanowires are fabricated by metal-assisted chemical etching using silver as a catalyst. This step requires very good cleaning. The silicon substrates used are P-type monocrystalline silicon wafers, with a crystallographic orientation (100).

## 3. Results and Discussion

Morphology and optical properties were characterized by SEM and UV-visible spectroscopy



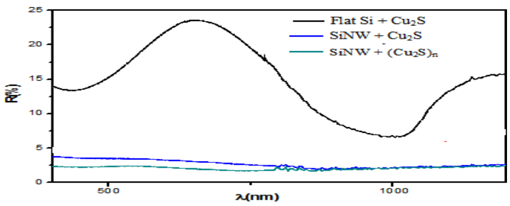



**Figure 1: a:** SEM image of $Cu_2S$_SiNW Photoelectrode, **b:** Reflectance of different samples.



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The SEM images revealed the quality of the nanowires, whereas after the deposit of $Cu_2S$ we notice the distribution of this deposit on the nanowires. UV-visible spectroscopy shows that the addition of the $Cu_2S$ layer applied on textured substrates significantly reduces the reflectance (R %) (Figure 1).

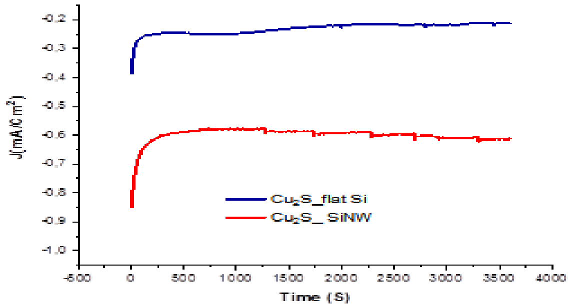


**Figure 2:** LSV curve of $Cu_2S$ pellet in aqueous $KHCO_3$ solution (0.1 M)

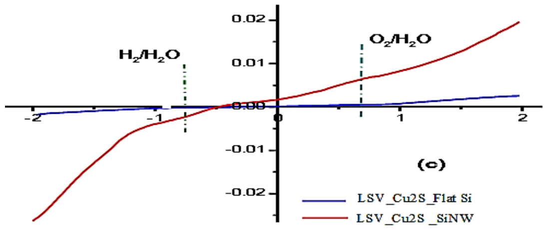


**Figure 3:** I-t curve of SiNWs_Cu2S-based electrode for fixed voltage of -0.9V for 60 min.

For the photoelectrochemical characterizations we use a potentiostat station. We performed linear voltammetry (LSV) in the dark and under white light irradiation, and a chronoamperometry is performed to study the stability of our photocathodes. The results of the photoelectrochemical study shows that the growth of nanowires on the silicon surface improves the photoelectrochemical properties compared to flat silicon (Figure 2).

## 4. Conclusions

Texturizing the surface of the substrates provides more efficient electrodes, it improves the photocurrent and the stability of the electrodes.

## 5. Acknowledgements

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