# Photovoltaic behavior of $MoS_2$ based PEC Solar Cell

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*Abstract* – **Recent years have seen a spurt in the activities on layered transition metal dichalcogenides (TMDCs) because the electrical and other physical properties of these compounds exhibit a vast range of variation. $MoS_2$- a member of this group has been found to be a potential material with high stability against the electrolyte environment. In present paper, the authors report their investigations on based PEC solar cells. The photo conversion characteristics of MoS2 / I2 /I- / Pt PEC solar cells have been investigated under monochromatic illumination. This is quite obvious because the absorption of light quanta having nearly to the band gap of the semiconductor will be more. These results have been used to calculate the quantum efficiency.**

*Keywords:* **Molybdenum Sulfide, Growth and Characteristics, PEC Solar Cells.**

## I. INTRODUCTION

For possible PEC solar cell fabrication semiconductor materials which include the metal chalcogenides and dichalcogenides. This satisfies most of the requirements for efficient solar to electrical energy conversion. Among these metal chalcogenides layered material such as $MoX_2$ (X=S,Se) are known to be stable against corrosion [1,2].In presence of suitable electrolytes these are very efficient in PEC Solar cells [3].

Group VI-B (Mo and W) are semiconductor dichalcogenides have been the subject of many investigations since they were shown to be interesting for solar energy conversion [4-6].Their band gap width between 1 and 2eV [7],a major part of the solar spectrum can be used to excite "d → d" type transitions.

The forbidden energy gap of layer type, semiconducting molybdenum sulphides and diselenides is formed by a d-hybridization gap separating energy bands derived from transitions metals d-orbitals.Absorption of photons by these crystals produces d → d excitation of electrons, which does not involve the breakup of essential bonds, thereby not directly leading to photo electrochemical corrosion of these crystals. The applicability of the layer type compounds based on molybdenum and tungsten dichalcogenides as semiconductor electrodes grown by chemical vapor transport technique was described and investigated by Tributsch et all[8,9].However the performance of cells reported to date have been remained rather modest. We report here performance of $MoS_2$ single crystal electrode PEC cell in aqueous iodide medium.

Influence of crystal surface orientation on redox-reactions at semiconducting n-$MoS_2$ has also been examined by Ahmed and Gerischer [10] and better conversion efficiencies are found in iodine/iodide solution by Kline et al [11] for $MoS_2$ photo electrodes. These results have shown that PEC behavior of n-type natural $MoS_2$ is interesting. [12] From PEC studies on TMDCs the most efficient system based on the n-$MoS_2$ and n-/$I^-$/$I_2$ junctions, but the results are very sensitive to crystal selection and orientation.

## II. EXPERIMENTAL

### *Growth of Crystals*

The single crystals $MoS_2$ used for the fabrication of PEC cell were grown by the chemical vapor transport method. An investigation has been made of the optical properties. Molybdenum dichalcogenides have been extensively studied. The chemical composition of the grown crystal has been well confirmed by carrying out EDAX analysis as shown in Table 1.

| Wt(%) of elements | $MoS_2$ | |
|---|---|---|
| | Mo | S |
| Taken | 60.00 | 40.06 |
| From EDAX | 62.19 | 37.81 |

Table 1. EDAX analysis for $MoS_2$ single crystal

### *Fabrication of PEC cell*

The crystal surface (basal) was connected to a copper wire with silver paste and the crystal was mounted on a glass plate by applying clear epoxy resin along the boundary to insulate the back surface and the connecting wire from the electrolyte. The exposed surface area of the crystal was about 0.3 $cm^2$.For determining the suitable electrolyte, photo electrodes were prepared with $MoS_2$ as grown crystal having visibly smooth surface was ascertained by optical zoom microscope [MODEL CARL ZEISS 100(Germany)].

**Figure 1. Micrograph of $MoS_2$ Single crystals used as a photo electrode**

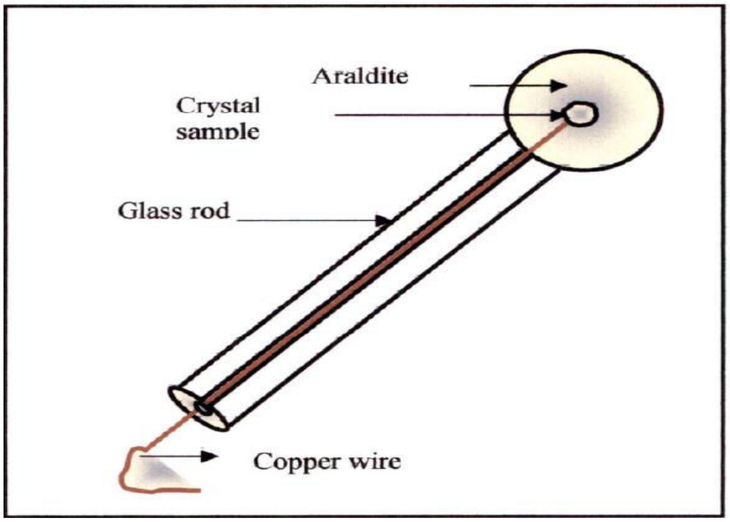


**Figure 2. Schematic diagram of photo electrode**

Figure 1 shows the micrograph showing a plane surface of one of the $MoS_2$ single crystal used for the photo electrode preparation. Schematic diagram of photo electrode is as shown in Figure 2.The mounted crystal was immersed in an aqueous iodide electrolyte prepared by addition of 0.5M KI + 0.005M $I_2$ in double distilled water. Platinum grid ($9cm^2$) was used as counter electrode. Figure 3 shows the schematic diagram of PEC solar cell.

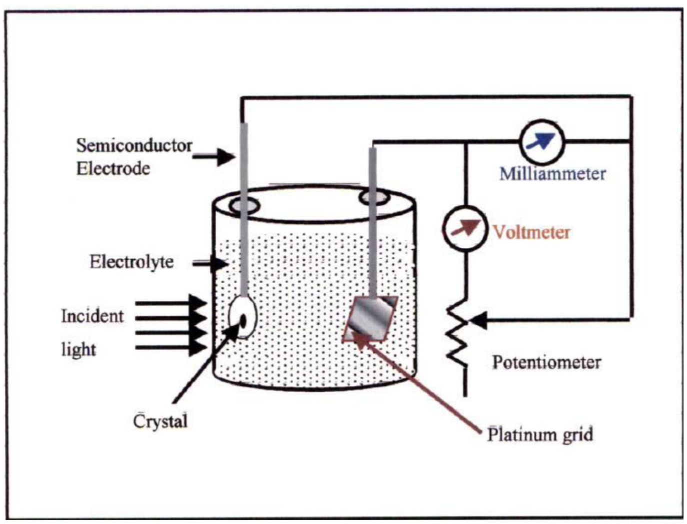


**Figure 3. Schematic diagram of PEC solar cell**

***Measurements***

The crystal surface was illuminated by an incandescent 6V-15V microscope lamp. The intensity of illumination at the crystal surface was measured incorporating the correction corresponding to absorption by the electrode by the electrolyte between crystal surface was measured incorporating the correction corresponding to absorption by the electrolyte between crystal surface and the glass wall. The I-V characteristics of $MoS_2$ single crystals are shown in figure 4 at 20mW/cm$^2$. The values of efficiencies and fill factors at different levels of illumination are shown in Table 2.

Table 2 Values of efficiencies and fill factors at different illumination level

| Crystals | Illumination level | Fill factor | Efficiency (%) |
|---|---|---|---|
| $MoS_2$ | 20mW/cm$^2$ | 0.214 | 0.014 |

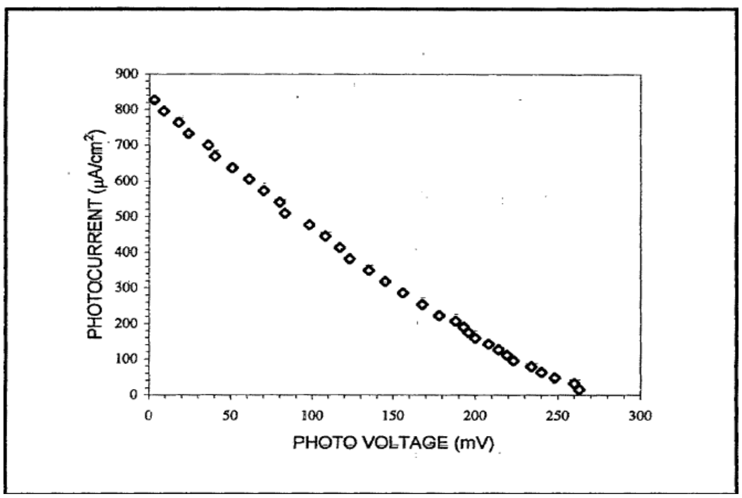


**Figure 4. I-V characteristics of $MoS_2$ single crystal**

## III. RESULT AND DISCUSSION

The PEC study of shows that the solar energy conversion efficiency of is very low. The semiconductor electrode is also unstable for the electrolyte used. Conclusively, author admits that normally grown surfaces of permit very low values of photo conversion efficiencies but concentrated efforts are to be made in selection of suitable material with the result that effective efficiency improvements can be achieved by:-

(i) Reducing the reflectivity of semiconductor electrode surface.

(ii) Decreasing the surface and bulk recombination rate.

(iii) Lowering the bulk resistivity of the material.

(iv) Minimizing the absorption losses in the electrolyte.

## CONFLICT OF INTEREST

THE AUTHORS DECLARE NO CONFLICT OF INTERESTS.

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