Effect of Poly 3-Hexylthiophene Thin Film Coating on Functional Properties of Silicon Monoxide Solar Thin Film

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**Abstract:** Poly 3-hexylthiophene (P3HT) has potential for solar cell application due to its enhanced optoelectronic properties. The growth of electrical vehicles is progressively increased due to a green environment, improved performance, and economy than fossil fuel-operated vehicles. This research intends to enhance the thermal conductivity, photocurrent density and solar power conversion efficiency of P3HT-featured silicon monoxide thin film. The plasma chemical vapour deposition (PVCD) technique is used for thin film formation. Experimental measurements were conducted to evaluate the effects of silicon monoxide-coated photovoltaic solar cells on thermal conductivity, photocurrent density, and solar power conservation. The results showed a higher (0.45 W/mK) thermal conductivity, a high photocurrent density of 2 mA/cm², and approximately a 56% increase in solar power conservation compared to early daytime solar cells. This enhancement was achieved through the use of silicon monoxide produced by plasma chemical vapour deposition. These findings have potential applications in hybrid electric vehicles.

# Introduction

Due to energy demand, the utilization of renewable solar energy increased globally with modified photovoltaic film technology, and silicon-based photovoltaic cells (Si-PV) performed 25% higher power conversion compared to conventional photovoltaic cells. Solar irradiance was the main source for deciding the solar temperature coefficient of PV modules [1]. In the last five decades, solar renewable energy has developed from 2.6 GW (2014) to 28.18 GW (2019). The trend for silicon-based solar panels was significant in electric vehicle applications [2-3]. The solar-operated electric vehicle was made with a battery balancing system for driving/parking the electric vehicle. The battery was balanced via solar-assisted power generation with four 12-volt power module packs. A 48-volt power pack was simulated and experimentally studied, and a 2.1 to 3.33% power boost was reported every 13.2 km. The development of solar techniques in the automobile industry was recorded at 4.3 times in 2022 and pollution-free compared to conventional internal combustion systems [4-5]. Moreover, solar energy has gained potential for various applications [6].

PV cells adopted by electric vehicles were investigated experimentally and found to have a high efficiency compared to conventional driving. Thermo-electric chip-based solar green energy is utilized for air conditioners in an electrical application. It offered maximum solar behaviour. Solar light's effect on EV's performance was related to various day timings [7]. Silicon-based PV solar cell performance has to be evaluated by electric vehicles and found to have maximum efficiency with low cost. It was applied for heat storage applications [8] and multipurpose heat systems [9]. CFD analysis performed better results of thermal flow [10]. The thin film-coated surface of Mg with ZnO performs well on solar radiation [11-15]. Solar light's effect on EV's performance was related to various day timings [17-19]. Silicon-based PV solar cell performance has to be evaluated by electric vehicles and found maximum efficiency with low cost [20-24].

Above literature studies, the present investigation prepared the PV cell with silicon monoxide coating performance on thermal conductivity, photocurrent density, and conservation of solar power efficiency, which was experimentally measured and applied for electric vehicles.

# Materials and Methods

## Materials

Fig. 1 represents the PVD setup for silicon monoxide layer formation on the P3HT polymer surface. The P3HT and silicon monoxide acted as donors and acceptors for this setup; its detailed schematic diagram is mentioned in Fig. 2. The 50nm silicon monoxide particles were kept in the cathode terminal. The SiNx was utilized as a separator agent for silicon monoxide laying on P3HT during the coating process. It was made with 15MHz voltage, sputtering done by 5x10-6 Mbar for 15mins [25-29]. It leads to removing the unwanted dust particles against the silicon monoxide layer. After the thin silicon monoxide layer formed, plasma was executed, and structure was formed with the P3HT layer.

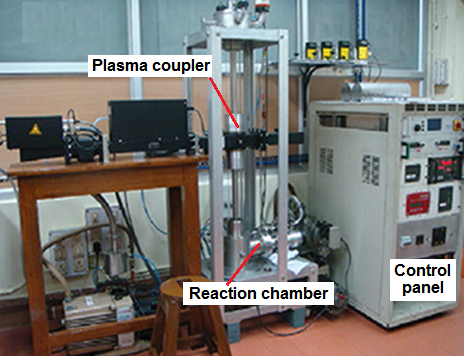


Fig. 1 Actual setup of plasma chemical vapour deposition equipment

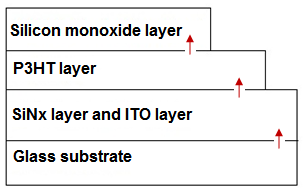


Fig. 2 Schematic diagram for silicon monoxide (SiO)/P3HT thin PV cell

## Composite Formulations

The schematic setup of the silicon monoxide deposited P3HT solar PV integrated electric vehicle represented by Fig. 3 contained a solar PV panel, DC to DC converter, battery, and electrical motor.

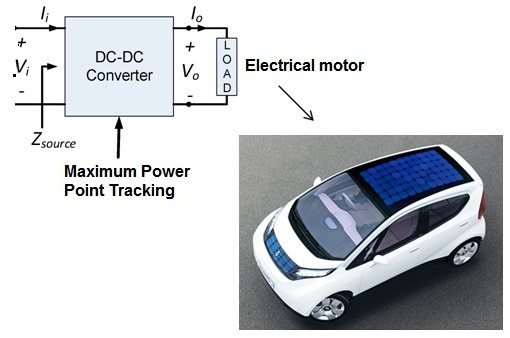


Fig. 3 Schematic diagram for silicon monoxide deposited P3HT PV cell operated electrical vehicle setup

The vehicle rooftop placed silicon monoxide deposited solar PV cells gathered the solar race into solar power through a DC-to-DC converter. It operated as on/ off-grid solar energy was stored in the battery [27-28]. Solar PV cells' efficiency varied due to weather conditions [30-34].

# Results and Discussion

## Microstructure of silicon monoxide deposition in P3HT solar film

Fig. 4 illustrates the microstructure of silicon monoxide (SiO) deposited P3HT surface with spherical shaped grains. It showed the homogenous particle distribution without voids. Moreover, the SiO particle space was less and coated uniformly in the P3HT surface. So, the thermal performance of the coated surface was high and discussed in below section B.

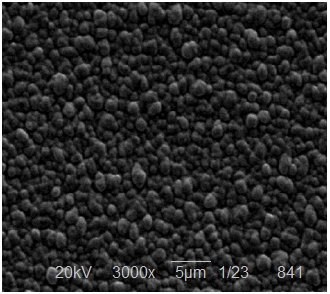


Fig. 4 SEM microstructure of SiO deposited P3HT solar film

## Effect of silicon monoxide deposition in P3HT solar film on thermal conductivity

Fig. 5 represents the thermal conductivity of SiO-deposited P3HT solar cells evaluated for 7 days from morning (6.00 am) to evening (6.00 pm). The mean thermal conductivity was represented on the secondary Y-axis as light green.

From Fig. 5, the thermal conductivity of SiO-deposited P3HT showed variations and gradually improved from 6:00 am to 3:00 pm. Because its radiation receives sunlight. Based on solar radiation, the conductivity of thermal energy was improved by the results of good solar power [35-38]. The mean thermal conductivity value showed 0.35W/mK at 6.00 am. Solar cells' thermal conductivity (k) variations were recorded every 60 minutes and showed progressive improvement at 10:00 am. During the solar peak hours, it was recorded for significant k and the highest k of 2.1W/mK was noted by 2.00 pm. The impact of higher solar radiation results in improved temperature of PV cells [39-42]. Further, the extended period to evening 6.00 pm found considerable decreases in thermal conductivity. SiO generally has good thermal conductivity (2.5W/mK) [43 and 52]. The solar cell performance was varied according to the k for SiO-deposited P3HT [53-55].

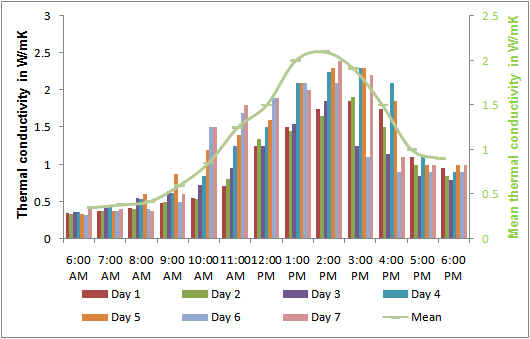


Fig. 5 Thermal conductivity of SiO-deposited P3HT solar film

## Effect of silicon monoxide deposition in P3HT solar cell on photocurrent density

Fig. 6 indicates the J-V performance curve for SiO-deposited P3HT solar film evaluated with the mean thermal conductivity properties of the current setup.

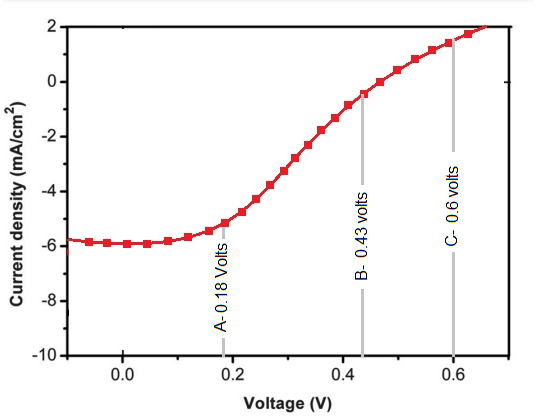


Fig. 6 J-V curve for silicon monoxide deposition in P3HT solar cell

Fig.6 results showed the active layer behaviour on the inclusions of 0.5nm thin film coating of SiO on the P3HT layer. It found significant improvement in photocurrent density with improved voltage. In step A, the photocurrent density initiated a trend in an upward direction on 5.3mA/cm2 of photocurrent density. Then, it progressively moved uptrend, and 2nd stage significance was recorded in stage B at 0.43 volts. It was due to high solar performance resulting in increased photocurrent density [44-48]. Moreover, based on solar irradiance, the vehicle battery power was balanced [49]. According to two-layer surfaces, the SiO and P3HT in the nanoscale found good photocurrent density compared to initial stage A. So, it could act as an efficient layer and perform at maximum level [50-51].

## Effect of silicon monoxide deposition in P3HT solar cell on photocurrent density

Fig. 7 shows the bar chart of time vs. solar power conversion efficiency of SiO-deposited P3HT solar cells with mean thermal conductivity. From Fig. 7, the efficiency for conservation of solar power was hiked slowly with increased mean thermal conductivity. Due to the time to solar radiation, its conservation of solar power has to be raised. The initial stage of efficiency was recorded by 32% at 6 am, and correspondingly it was increased to 36.8%, 38.4%, 42.8%, 44.9, 46.8%, 54.2%, and 56.3% at 7 am to 2 pm with 1 h interval.

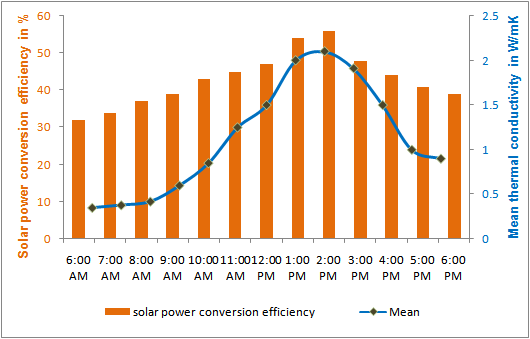


Fig. 7 Time Vs Solar power conversion efficiency/Mean thermal conductivity

In the meantime, it was related to the mean thermal conductivity of SiO-deposited P3HT was proved. The enhancement of PV cells with a coating of silicon-based materials (nano planer) was performed with prominent efficiency for conserving maximum solar power compared to conventional [22 and 24].

# Conclusion

The silicon monoxide deposition was effectively made with P3HT via the plasma chemical vapour deposition (PVCD) technique, and its effect on thermal conductivity, photocurrent density, and solar power conversion was studied. The scanning electron microscope - SEM revealed homogenous dispersed particle identified with reduced particle span. The evaluation results made with the mean value of thermal conductivity of SiO deposited P3HT film facilitated higher peaks (1.25-2.1 W/mK) from 12:00 pm to 2:00 pm. The photocurrent density was hiked (2mA/cm2) on stage C, found to be 0.6 volts, and related to an initial stage. It was improved by 1.6 times higher. A similar trend should be adopted in electric vehicles, and it found that efficiency for conservation of solar power was observed by 56% at 2:00 pm. It is based on energy conservation, balanced in an electric vehicle battery, and operated during driving.

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