Organic Photovoltaics: A brief Review

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Abstract

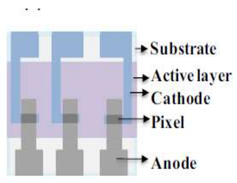
Organic photovoltaics (OPVs) have emerged as a promising alternative to conventional silicon-based solar cells due to their lightweight nature, flexibility, and cost-effectiveness. This review provides an overview of OPV technology, its working principles, key advancements, and challenges. The focus is on device architecture, material design, performance.

▪Organic photovoltaic technology enabled direct conversion of sunlight to electricity.
▪ Organic polymer based solar cells are advantageous due to their thin film architectures, light weight , low cost large area processability, high mechanical flexibility and transparency.
▪ For fair comparison of efficiencies of solar cells we need an accurate and step by step protocol for PCE measurement.
▪ In 1980's US department of energy at NREL developed a simple method to determine accurate efficiency of Silicon solar cells.
▪ Lack of accuracy has been found in organic solar cell devices data from lab to lab due to their instability and compatibility issues.
▪ There is urgent need to develop a method for accurate measurement of power conversion efficiency of organic solar cells with metrological traceability similar to silicon solar cells.
▪ In the current work inverted device has been fabricated and tested for different parameters under standard testing conditions (STC:1000W/m^2, AM 1.5G & 25˚C).
▪Inverted device structure has been fabricated as it avoids the need for hygroscopic PEDOT:PSS and also its acidic nature corrodes ITO.
▪ In the inverted structure active layer is encapsulated due to air stable top electrodes.

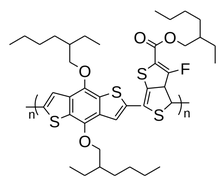
Introduction

The growing energy demand and environmental concerns have fueled the search for renewable energy sources.
Organic photovoltaics (OPVs) utilize organic semiconductors for light absorption and charge transport.
Unlike silicon solar cells, OPVs can be fabricated using solution-processing techniques, making them ideal for flexible and lightweight applications.

HOT PLATE



DEVICE STRUCTURE

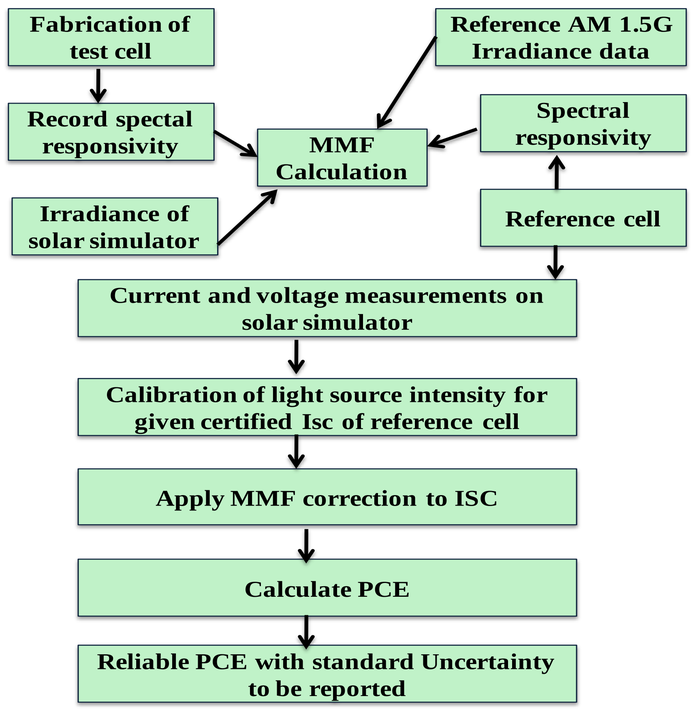


ACTIVE LAYER MATERIAL

However, challenges such as low efficiency and stability limit their widespread adoption.

Design/Other information

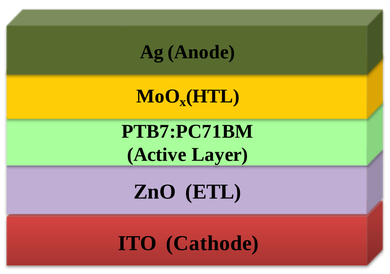
•Material Selection: Donor-acceptor pairs must exhibit optimal energy level alignment.
•Morphology Control: Phase separation in active layers affects charge transport.
•Stability & Degradation: OPVs degrade due to moisture, oxygen exposure, and UV-induced damage.
•Scalability: Roll-to-roll processing and inkjet printing are promising for mass production.
•Guidelines of various international electrotechnical commissions have been described and should be completely followed for the accurate measurement of PCE.



STEP BY STEP PROTOCOL FOR PCE MEASUREMENT OF ORGANIC SOLAR CELLS

Set up

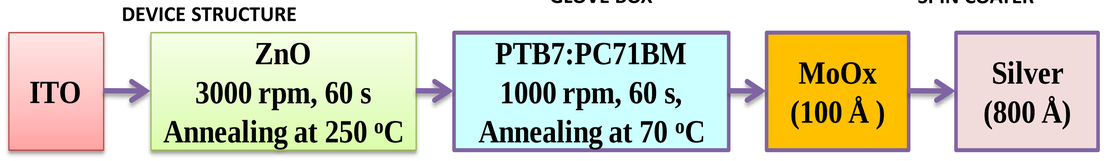
Device fabrication



DEVICE STRUCTURE

GLOVE BOX

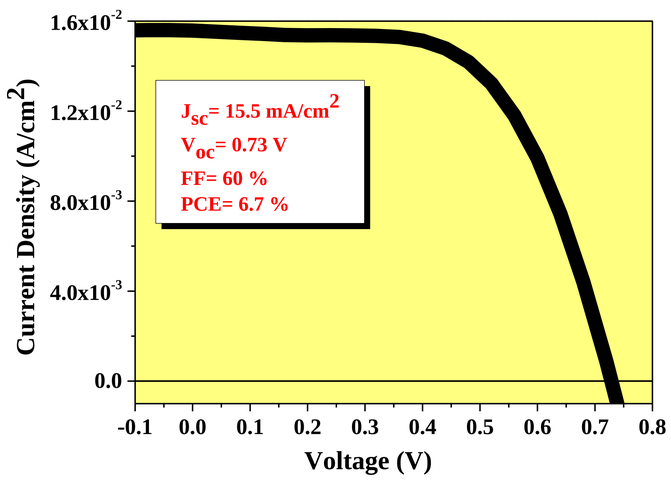
SPIN COATER



STEPS OF DEVICE FABRICATION

Results

Key performance indicators of OPVs:
•Power Conversion Efficiency (PCE): Recent advancements have pushed OPV efficiency above 18%.
•Open Circuit Voltage (Voc): Ranges between 0.6V-1.2V.
•Short Circuit Current Density (Jsc): Optimized active layers yield improved charge transport.
•Fill Factor (FF): Typically, between 60-80%, indicating effective charge extraction.



➢A step by step protocol has been established for the accurate measurement of PCE of organic solar cells.
➢ Inverted organic solar cell devices have been fabricated and tested for their photovoltaic characteristics.
➢ Traceability of each parameter has been ascertained.
➢ This protocol has to be followed in each and every lab where device fabrication is to be done.

Conclusions

➢ Organic photovoltaics hold great promise for next-generation solar technology due to their tunable properties, cost-effectiveness, and flexible applications.
➢ Ongoing research focuses on improving efficiency, stability, and scalability to make OPVs a viable competitor in the renewable energy sector.
➢ Future advancements in material engineering and device architecture will be crucial in overcoming existing limitations.

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