

# Solar Cell Defect Analysis



## Overview

Fast and non-destructive analysis of material defect is a crucial demand for semiconductor devices. Herein, we are devoted to exploring a solar-cell defect analysis method based on machine learning of the mo. Electronic defect is one of the most fundamental and important physical properties of a. 2.1. Charge-carrier mechanism of perturbation TPVIn a complete cell, charge-carrier processes are determined by a series of time-dependent charg. In this work, based on a comprehensive understanding of the generation and decay mechanism of the perturbation photovoltage, we have explored to develop a defect analysis. Y. S. Li, J. Shi and Q. Meng conceived the idea. Y. S. Li conducted device simulation, machine learning programming, data analysis and paper writing. Y. M. Li contributed to th. The authors are very grateful to Prof. Yuan Lin (Institute of Chemistry, Chinese Academy of Science), Dr. Nicola Courtier (University of Oxford, UK), and Dr. Haili Wang (COMSO).



## Article Content

Solar cell surface defect inspection based on ...

The Multispectral solar cell CNN is based on the solar cell CNN model and analyzes the characteristics of different solar cell surface features defects under different spectra and improved the obtained network structure.

Quantum efficiency as a tool for defect analysis in solar ...

The standard hence seems to miss the optical aspect of defects analysis, where the efficiency of the solar cell itself and the optical and thermal properties of its layers is not considered separately. ... Generalized quantum efficiency analysis for non-ideal solar cells: case of Cu<sub>2</sub>ZnSnSe<sub>4</sub>. J. Appl. Phys., 119 (1) (2016), p. 014505. View in ...

Identifying defects on solar cells using magnetic field ...

Identifying defects on solar cells using magnetic field measurements and artificial intelligence trained by a finite-element-model Kjell Buehler<sup>1,\*</sup>, ... magnetostatic analysis was set up using the FE software ANSYS Mechanical. A four-busbar solar cell (156 mm<sup>2</sup>) was modelled in consideration of the real layer stack consisting

Device deficiency and degradation diagnosis model of Perovskite solar ...

In situ TEM analysis of organic-inorganic metal-halide perovskite solar cells under electrical bias. Nano Lett. 16, 7013–7018 (2016). Article ADS CAS PubMed Google Scholar

Advanced spectroscopic techniques for characterizing defects in ...

There is great interest in commercializing perovskite solar cells, however, the presence of defects and trap states hinder their performance. Here, recent developments in characterization ...

Defect analysis of crystalline Si solar cells by learning radiation ...

This paper presents analytical results for improving crystalline Si solar cells, analyzed using our knowledge in radiation-induced defects in Si. This study suggests that key issues for realizing higher performance Si solar cells are decrease in carbon concentration of less than  $1 \times 10^{14} \text{ cm}^{-3}$ . Defect introduction rates of Bi-O<sub>2</sub>i center induced by light illumination are ...

Nature of defects and their passivation engineering for ...

The Mott-Schottky analysis is a technique that is frequently used to investigate defect states in solar cells. Plotting the inverse of capacitance ( $1/C$ ) against the applied voltage ...

Nature of defects and their passivation engineering for ...

The Mott-Schottky analysis is a technique that is frequently used to investigate defect states in solar cells. Plotting the inverse of capacitance ( $1/C$ ) against the applied voltage (V) reveals deviations from the ideal behavior and implies the presence of defect states.

Research on multi-defects classification detection method for solar ...

2 Solar cells defect detection system, datasets construction and defects feature analysis. Based on the field application requirements, The defect detection system for solar cells is built and shown in Fig 1. The solar cells will pass through four detection working stations (from WS1 to WS4) in sequence, in each station, a grayscale industrial camera with a resolution of ...

An improved hybrid solar cell defect detection approach using ...

Traditionally, defect detection in EL images of PV cells has relied on labor-intensive manual inspection, which are not only time-consuming but also prone to human errors and subjectivity (Bartler et al., 2018). Due to the rise of advanced imaging techniques and considerable progress in machine vision and artificial intelligence, innovative solutions have ...

A review of automated solar photovoltaic defect detection systems ...

This paper reviews all analysis methods of imaging-based and electrical testing techniques for solar cell defect detection in PV systems. This section introduces a comparative ...

Solar Cell Defects Detection Based on Photoluminescence ...

1. Introduction. The benefits and prospects of clean and renewable solar energy are obvious. One of the primary ways solar energy is converted into electricity is through photovoltaic (PV) power systems []. Although solar cells (SCs) are the smallest unit in this system, their quality greatly influences the system []. The presence of internal and external defects in ...

High-Precision Defect Detection in Solar Cells Using YOLOv10 ...

This study presents an advanced defect detection approach for solar cells using the YOLOv10 deep learning model. Leveraging a comprehensive dataset of 10,500 solar cell images annotated with 12 distinct defect types, our model integrates Compact Inverted Blocks (CIBs) and Partial Self-Attention (PSA) modules to enhance feature extraction and ...

Solar Cell Defects Detection Based on Photoluminescence ...

Solar cells (SCs) are prone to various defects, which affect energy conversion efficiency and even cause fatal damage to photovoltaic modules. In this paper, ...

Defects and Defect Passivation in Perovskite Solar ...

Perovskite solar cells have made significant strides in recent years. However, there are still challenges in terms of photoelectric conversion efficiency and long-term stability associated with perovskite solar cells. The ...

High-Precision Defect Detection in Solar Cells Using ...

This section provides a comparative analysis of recent deep learning models applied to defect detection in solar cells using EL imaging, summarized in Table 3. The analysis highlights the key models, datasets, ...

Defect Analysis in Solar Cell Silicon by Photoluminescence ...

We review the characterization of electrically active intra-grain defects in multicrystalline silicon for solar cells. Origin of the defects was identified to be dislocation clusters forming subgrain boundaries by photoluminescence (PL) spectroscopy and topography combined with electron backscatter diffraction pattern measurement and etching/optical microscopy.

Decreased interface defects in  $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$  solar cells via ...

Kesterite  $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$  (CZTSSe) thin film solar cells are considered a promising new type of film cell, due to their rich elemental reservation and excellent photovoltaic performance. However, the deleterious defects at the heterojunction interface severely hinder charge transport, separation, and extraction, significantly limiting the photovoltaic performance ...

Accelerating defect analysis of solar cells via machine learning of ...

Herein, we are devoted to exploring a solar-cell defect analysis method based on machine learning of the modulated transient photovoltage (m-TPV) measurement. The perturbation photovoltage generation and decay mechanism of the solar cell is firstly clarified for this study. High-throughput electrical transient simulations are further carried ...

Machine Learning-Assisted Defect Analysis and Optimization for ...

A solar cell capacitance simulator (SCAPS-1D) was used to prepare 3611 cell data with different defect densities in the bulk and interface of p-i-n-structured perovskite solar cells. The training was conducted using four machine learning algorithm models.

Defect Analysis of Electroluminescence Images of PV CELL

Defect analysis in a cell is one amongst them. Defective cell reduces the efficiency of photovoltaic cell, which reduction in efficiency alleviates in large numbers just in case of huge projects of solar energy plants collectively. ... Yang, B., Reuter, M., Stoicescu, L.: Automated detection of solar cell defects with deep learning. In: 2018 ...

Grain boundary cracks patching and defect dual passivation with ...

Triple-cation perovskite solar cells exhibit better long-term stability as compared to FAPbI<sub>3</sub> devices but also have more ions and vacancies defects in film. Herein, ammonium formate (NH<sub>4</sub>HCO<sub>2</sub>) is ...

#### A Lightweight Multiscale Feature Fusion Network for Solar Cell Defect ...

Deep learning has been introduced into solar cell defect detection to address these issues. Zhang et al. proposed a multi-feature region proposal fusion network MF-RPN to improve the adaptability of scale variations of surface defects in solar cells. However, this network needs to extract candidate regions from different feature layers of the ...

#### Solar photovoltaic panel cells defects classification using deep ...

This study thoroughly examined solar PV cell defect classification by incorporating eight leading deep learning architectures and two ensemble techniques—voting and bagging—utilizing drone-acquired EL images. The experimental analysis demonstrated that both ensemble methods provide strong performance for four-class classification, achieving ...

#### Solar Cell Surface Defect Detection Based on Improved YOLO v5

A solar cell defect detection method with an improved YOLO v5 algorithm is proposed for the characteristics of the complex solar cell image background, variable defect morphology, and large-scale differences. First, the deformable convolution is incorporated into the CSP module to achieve an adaptive learning scale and perceptual field size; then, the feature ...

#### Shunt Analysis in Solar Cells

By applying a voltage to a solar cell defects, inhomogeneity or even cell cracks are visible. Usually, solar cells have defects originating from the bulk material or by non-perfect production conditions. In this contribution a mc-Si solar cell was used to demonstrate the procedure of defect classification, preparation and target preparation.

#### 24% Efficient, Simple ZnSe/Sb<sub>2</sub>Se<sub>3</sub> Heterojunction Solar Cell: An ...

**Abstract.** In this work, a new wide-band-gap n-type buffer layer, ZnSe, has been proposed and investigated for an antimony selenide (Sb<sub>2</sub>Se<sub>3</sub>)-based thin-film solar cell. The study aims to boost the Sb<sub>2</sub>Se<sub>3</sub>-based solar cell's performance by incorporating a cheap, widely accessible ZnSe buffer layer into the solar cell structure as a replacement for the CdS layer.

#### Defect analysis of 1-MeV electron irradiated flexible InGaAs solar ...

However, few investigations have been conducted on the irradiation effects of flexible IMM 3J solar cells. Since the InGaAs subcell plays an important role in the performance of triple-junction cells before and after irradiation, studying the radiation effects of flexible InGaAs solar cells and its degradation mechanism by radiation induced defects provides a theoretical ...

A proposed hybrid model of ANN and KNN for solar cell defects ...

The second part of the analysis involves defect detection, where FCM and MM are employed to enhance the accuracy of identifying defects caused by temperature variations. By establishing this link, the study aims to contribute a comprehensive approach to solar cell quality improvement, integrating temperature prediction and defect detection for ...

(PDF) Solar Cell Busbars Surface Defect Detection Based on ...

Defect detection of the solar cell surface with texture and complicated background is a challenge for solar cell manufacturing. The classic manufacturing process relies on human eye detection ...

Defect detection in III-V multijunction solar cells using reverse ...

SEM cross-section imaging and EDX compositional analysis of these defects reveal their complex structures, which in essence consist of material abnormally grown on and around particles present on the wafer surface before growth. ... Part of the equipment used in this research for solar cell manufacturing was acquired through project LABCELL30 ...

Below the Urbach Edge: Solar Cell Loss Analysis Based on Full ...

We suggest a new solar cell loss analysis using the external quantum efficiency (EQE) measured with sufficiently high sensitivity to also account for defects. Unlike common radiative-limit methods, where the impact of deep defects is ignored by exponential extrapolation of the Urbach absorption edge, our loss analysis considers the full EQE including states below ...

Accelerating defect analysis of solar cells via machine ...

Fast and non-destructive analysis of material defect is a crucial demand for semiconductor devices. Herein, we are devoted to exploring a solar-cell defect analysis method based on machine learning of the modulated transient photovoltage (m-TPV) measurement. The perturbation photovoltage generation ...

Defect analysis in polycrystalline silicon solar cells

Localized bulk defects like diffusion length variations and structural defects like grain boundaries are analyzed in polycrystalline silicon solar cells using laser scanning and deep level transient spectroscopy techniques. The effect of hydrogen passivation on ...

Adaptive automatic solar cell defect detection and classification ...

Solar cell defect characterization: Generally, the local defects are shown up as dark spots in solar cell EL images, ... Subsequently, we perform statistical analysis for all the detected defects to assess the reliability of the defect classification module. Finally, we further compare the proposed method with some existing approaches.

## Broad-scale Electroluminescence analysis of 5 million

Additionally, the chi-squared contributions for Normal Cells (Defect-Free Cells), though smaller, highlight a positive trend in newer installations, where the presence of defect-free cells has increased from 23.64 % to 28.30 %. This improvement, while beneficial, still plays a role in the overall change in defect distributions.

## Research on multi-defects classification detection method for ...

The YOLOv5s model with Decoupled Head is used to real-time detect the cell-crack, glass-crack and bubble defects of solar cells. Furthermore, the lightweight target ...

## Solar Cell Surface Defect Detection Based on Improved YOLO v5

Abstract: A solar cell defect detection method with an improved YOLO v5 algorithm is proposed for the characteristics of the complex solar cell image background, ...

## 1 MeV electron irradiation effect and damage ...

In addition to improving the solar cell efficiency, the effects of space radiation damage must be considered when cells are in orbit for an extended period. 19,20 Radiation, particularly from charged particles, can ...

## Local Performance Analysis of Perovskite Solar Cells: ...

Perovskite solar cells (PSCs) have emerged as a leading photovoltaic technology due to their high efficiency and cost-effectiveness, yet long-term stability and consistent performance remain challenges. This perspective discusses how local structural properties, such as grain boundaries and intragrain defects, and optoelectronic properties, ...

## Solar cell surface defect inspection based on multispectral ...

Multispectral defect feature analysis. Solar cells appear a complex texture background including irregular lattice features, and grid line features. The shape and location of lattice are random, whose color is similar to background color of solar cell. The grid line is the energized current-conducting part of the cell, which is silver white.

## SOLAR CELL DEFECT DETECTION AND ANALYSIS ...

The author in presents an innovative solar cell defect detection system emphasizing portability and low computational power. The research utilizes K-means, MobileNetV2, and linear ...

## (PDF) Defect Analysis in Solar Cell Silicon by Photoluminescence ...

Image capturing, processing, and analysis have numerous uses in solar cell research, device and process development and characterization, process control, and quality assurance and inspection.

## 1 MeV electron irradiation effect and damage mechanism analysis ...

In addition to improving the solar cell efficiency, the effects of space radiation damage must be considered when cells are in orbit for an extended period. 19,20 Radiation, particularly from charged particles, can introduce a significant number of crystal defects in the solar cell active areas. 21,22 These defects create non-radiative recombination centers, which ...

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