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REVIEWER'S REPORT

Manuscript No.: IJAR- 56662

Title: AC BACK SURFACE RECOMBINATION VELOCITY AND OPTIMUM BASE THICKNESS IN AN IRRADIATED N+–P–P+ SILICON SOLAR CELL UNDER TEMPERATURE AND FREQUENCY MODULATION

Recommendation:

Accept

Rating	Excel.	Good	Fair	Poor
Originality	Yes			
Techn. Quality	Yes			
Clarity		Yes		
Significance		Yes		

Reviewer's ID: JPR-142

Detailed Reviewer's Report

Detailed Reviewer Comments

1. Introduction

The manuscript addresses a significant problem in the domain of photovoltaic systems and semiconductor physics, focusing on optimizing base thickness in an irradiated n^+–p–p^+ silicon solar cell under AC polychromatic illumination and varying temperature conditions. The introduction effectively emphasizes the importance of reducing recombination losses and improving charge carrier transport to enhance overall device efficiency. Furthermore, the influence of irradiation, temperature variation, and frequency modulation on minority carrier dynamics in the base region is clearly articulated. The rationale for employing the AC back surface recombination velocity method as an optimization tool is well justified and logically presented.

2. Literature Review

The review of existing literature is relevant and provides a solid theoretical background on minority carrier transport, recombination processes, and analytical modeling of silicon solar

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cells. Prior studies examining irradiation effects and recombination velocity are appropriately cited, helping establish the context of the research. However, the section would benefit from the inclusion of more recent studies (particularly from the last decade) and a clearer identification of research gaps. Additionally, a more explicit comparison between the proposed model and existing analytical or numerical approaches would further strengthen the contribution of the study.

3. Methodology / Solution Approach

The methodological approach is well-structured and represents a key strength of the paper. The authors derive analytical expressions by solving the minority carrier continuity equation within the base region under modulated illumination, incorporating critical factors such as irradiation energy flux, damage coefficient, temperature variation, and frequency modulation. The introduction of two components of back surface recombination velocity (Sb_1 and Sb_2), and determining the optimum base thickness through their intersection, is both logical and effective. The assumptions adopted are physically sound and align with established semiconductor transport theory. Nevertheless, clarity could be enhanced by including a schematic diagram of the n^+–p–p^+ solar cell and by clearly defining all parameters used in the equations.

4. Results and Discussion

The results are well presented and demonstrate the impact of irradiation, damage coefficient, temperature, and frequency on the optimum base thickness. The graphical representation of Sb_1 and Sb_2 as functions of base thickness effectively illustrates the optimization process. The findings indicate that increased irradiation and damage coefficients lead to higher recombination rates, thereby reducing the optimum base thickness. Additionally, temperature and frequency are shown to significantly influence carrier diffusion and lifetime. The interpretations are physically meaningful and well connected to semiconductor principles. However, the discussion could be further improved by incorporating quantitative comparisons with previous studies and by expanding on the practical implications for solar cell design and performance optimization.

5. Conclusion

The conclusion clearly and concisely summarizes the main outcomes of the study. It successfully demonstrates that the AC back surface recombination velocity approach is a

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reliable method for determining optimum base thickness under varying environmental and irradiation conditions. The findings confirm the significant role of irradiation damage, temperature, and frequency in influencing recombination behavior and carrier transport. The conclusions are consistent with the analytical and graphical results presented.

The manuscript also outlines valuable directions for future research. These include experimental validation of the proposed model, extension of the analytical framework to advanced photovoltaic materials such as perovskite solar cells and compound semiconductors like gallium arsenide, and further investigation into additional recombination mechanisms, interface effects, and multilayer device structures. Integrating numerical simulations with experimental studies is also recommended to enhance the practical applicability of the model.