

# РОЗДІЛ 1

## ПЕРЕДУМОВИ ТА ОСОБЛИВОСТІ ВИКОРИСТАННЯ АКТИВНОГО УЛЬТРАЗВУКА

1.1. Ефекти впливу ультразвуку на мікроелектронні структури та матеріали

[1–27]:

In the literature, there are several models that describe the current–voltage ( $I - V$ ) characteristics of the solar cells (SCs). These models contain some parameters, which reflect the processes within the structures and are related to the main characteristics of the photovoltaic conversion. So single diode model with three parameters has been used to represent the SC static characteristic because of simplicity:

$$I = I_0 \left[ \exp \left( -\frac{qV}{nkT} \right) - 1 \right] - I_{ph} , \quad (1.1)$$

were

## СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

1. Olikh, O.Ya. Relationship between the ideality factor and the iron concentration in silicon solar cells / O.Ya. Olikh // Superlattices Microstruct. — 2019. — Dec. — Vol. 136. — P. 106309.
2. Explanation of High Solar Cell Diode Factors by Nonuniform Contact Resistance / A. S. H. van der Heide, A. Schonecker, J. H. Bultman, W. C. Sinke // Progress in Photovoltaics: Research and Applications. — 2005. — Jan. — Vol. 13, no. 1. — Pp. 3–16.
3. Relationship Between the Diode Ideality Factor and the Carrier Recombination Resistance in Organic Solar Cells / L. Duan, H. Yi, C. Xu et al. // IEEE Journal of Photovoltaics. — 2018. — Nov. — Vol. 8, no. 6. — Pp. 1701–1709.
4. Electrical characterization of GaN Schottky barrier diode at cryogenic temperatures / Jiaxiang Chen, Min Zhu, Xing Lu, Xinbo Zou // Appl. Phys. Lett. — 2020. — Feb. — Vol. 116, no. 6. — P. 062102.
5. Dalapati, P. Analysis of the Temperature Dependence of Diode Ideality Factor in InGaN-Based UV-A Light-Emitting Diode / P. Dalapati, N.B. Manik, A.N. Basu // Semiconductors. — 2020. — Oct. — Vol. 54, no. 10. — Pp. 1284–1289.
6. Identifying Dominant Recombination Mechanisms in Perovskite Solar Cells by Measuring the Transient Ideality Factor / Phil Calado, Dan Burkitt, Jizhong Yao et al. // Phys. Rev. Applied. — 2019. — Apr. — Vol. 11. — P. 044005.
7. Machine learning and the physical sciences / Giuseppe Carleo, Ignacio Cirac, Kyle Cranmer et al. // Rev. Mod. Phys. — 2019. — Dec. — Vol. 91. — P. 045002.
8. Ju, Shenghong. Designing thermal functional materials by coupling thermal transport calculations and machine learning / Shenghong Ju, Shuntaro Shimizu, Junichiro Shiomi // J. Appl. Phys. — 2020. — Oct. — Vol. 128, no. 16. — P. 161102.
9. Rodrigues, Sandy. Machine learning PV system performance analyser / Sandy Rodrigues, Helena Geirinhas Ramos, Fernando Morgado-Dias // Prog. Photovoltaics Res. Appl. — 2018. — Aug. — Vol. 26, no. 8. — Pp. 675–687.

10. Pathways for solar photovoltaics / Joel Jean, Patrick R. Brown, Robert L. Jaffe et al. // *Energy Environ Sci.* — 2015. — Jul. — Vol. 8, no. 4. — Pp. 1200–1219.
11. A review of photovoltaic performance of organic/inorganic solar cells for future renewable and sustainable energy technologies / J. Ajayan, D. Nirmal, P. Mohankumar et al. // *Superlattices Microstruct.* — 2020. — Jul. — Vol. 143. — P. 106549.
12. Schmidt, Jan. Effect of Dissociation of Iron–Boron Pairs in Crystalline Silicon on Solar Cell Properties / Jan Schmidt // *Progress in Photovoltaics: Research and Applications.* — 2005. — Jun. — Vol. 13, no. 4. — Pp. 325–331.
13. Iron related solar cell instability: Imaging analysis and impact on cell performance / M.C. Schubert, M. Padilla, B. Michl et al. // *Sol. Energy Mater. Sol. Cells.* — 2015. — Jul. — Vol. 138. — Pp. 96–101.
14. Geerligs, L. J. Dynamics of light-induced FeB pair dissociation in crystalline silicon / L. J. Geerligs, Daniel Macdonald // *Appl. Phys. Lett.* — 2004. — Nov. — Vol. 85, no. 22. — Pp. 5227–5229.
15. Zoth, G. A fast, preperetion-free method to detect iron in silicon / G. Zoth, W. Bergholz // *J. Appl. Phys.* — 1990. — Jun. — Vol. 67, no. 11. — Pp. 6764–6771.
16. The effect of oxide precipitates on minority carrier lifetime in p-type silicon / J. D. Murphy, K. Bothe, M. Olmo et al. // *J. Appl. Phys.* — 2011. — Sep. — Vol. 110, no. 5. — P. 053713.
17. Wijaranakula, W. The Reaction Kinetics of Iron–Boron Pair Formation and Dissociation in P-Type Silicon / W. Wijaranakula // *J. Electrochem. Soc.* — 1993. — Jan. — Vol. 140, no. 1. — Pp. 275–281.
18. Iron-boron pairing kinetics in illuminated p-type and in boron/phosphorus co-doped n-type silicon / Christian Möller, Til Bartel, Fabien Gibaja, Kevin Lauer // *J. Appl. Phys.* — 2014. — Jul. — Vol. 116, no. 2. — P. 024503.
19. Dissociation and Formation Kinetics of Iron–Boron Pairs in Silicon after Phosphorus Implantation Gettering / Nabil Khelifati, Hannu S. Laine, Ville Vähänissi et al. // *Phys Status Solidi A.* — 2019. — Sep. — Vol. 216, no. 17. — P. 1900253.

20. Ostapenko, Sergei S. Ultrasound Stimulated Defect Reactions in Semiconductors / Sergei S. Ostapenko, Nadejda E. Korsunskaya, Moissei K. Sheinkman // Defect Interaction and Clustering in Semiconductors. — Vol. 85 of Solid State Phenomena. — Trans Tech Publications Ltd, 2001. — 12. — Pp. 317–336.
21. Savkina, Rada K. Recent Progress in Semiconductor Properties Engineering by Ultrasonication / Rada K. Savkina // Recent Patents on Electrical & Electronic Engineering. — 2013. — Vol. 6, no. 3. — Pp. 157–172.
22. Acousto-defect interaction in irradiated and non-irradiated silicon  $n^+p$  structure / O. Ya. Olikh, A. M. Gorb, R. G. Chupryna, O. V. Pristay-Fenenkov // J. Appl. Phys. — 2018. — Apr. — Vol. 123, no. 16. — P. 161573.
23. Davletova, A. Open-circuit voltage decay transient in dislocation-engineered Si p-n junction / A. Davletova, S. Zh. Karazhanov // Journal of Physics D: Applied Physics. — 2008. — Aug. — Vol. 41, no. 16. — P. 165107.
24. Olikh, Y. Mechanisms of Two-Stage Conductivity Relaxation in CdTe:Cl with Ultrasound / Y. Olikh, M. Tymochko, O. Olikh // J. Electron. Mater. — 2020. — Aug. — Vol. 49, no. 8. — P. 4524–453.
25. Olikh, Oleg. Reversible influence of ultrasound on  $\gamma$ -irradiated Mo/n-Si Schottky barrier structure / Oleg Olikh // Ultrasonics. — 2015. — Feb. — Vol. 56. — Pp. 545–550.
26. Olikh, O. Ya. Ultrasound influence on I–V–T characteristics of silicon Schottky barrier structure / O. Ya. Olikh, K. V. Voytenko, R. M. Burbelo // J. Appl. Phys. — 2015. — Jan. — Vol. 117, no. 4. — P. 044505.
27. Sukach, A.V. Ultrasonic treatment-induced modification of the electrical properties of InAs p-n junctions / A.V. Sukach, V.V. Teterkin // Tech. Phys. Lett. — 2009. — June. — Vol. 35, no. 6. — Pp. 514–517.