

Numerical simulation of the performances of the top cell in a micromorph silicon-based tandem photovoltaic solar cell using SCAPS-1D.

Daouda Oubda, Kouka Mahamoudou Sawadogo, Pingdewinde Sawadogo, Soumaïla Ouedraogo

L.A.M.E (Laboratory of Materials and Environment), Joseph KI-ZERBO University, Ouagadougou, Burkina Faso

Email: daoudaoubd@gmail.com / Tel: 00226 71294798; 00226 78253882

Abstract

In a global context marked by rising energy demand, regional conflicts over fossil fuel production and distribution, the depletion of these fossil resources, and environmental concerns, a transition to clean, renewable energy sources has become imperative. Significant questions remain regarding the consequences of fossil fuel exploitation, notably ozone layer depletion and environmental pollution. Consequently, promoting renewable energies including solar photovoltaics has become more than just a necessity; solar photovoltaics represent one of the most powerful alternatives for the future of large scale electricity generation. It is within this context that the present study explores the performances optimization of the top cell in a micromorph silicon (μ -Si) tandem photovoltaic structure using SCAPS-1D numerical simulation, with the aim of developing a stable, high-efficiency tandem PV model. To achieve this objective, we adopted a methodological approach involving the numerical evaluation of each sub cell performances, ultimately leading to the realization of a four-terminal tandem PV solar cell. Results obtained for the hydrogenated amorphous silicon-based top PV cell demonstrated that, as the top cell thickness increases, open-circuit voltage and fill factor values undergo a significant decrease; conversely, short-circuit current density values rise considerably, resulting in an increase in PV conversion efficiency. These results suggest that the absorption of incident photons increases with the thickness of the absorber layer, leading to significant photogeneration of electron-hole pairs. However, we note that a small fraction of these charge carriers recombine at the buffer/absorber layer interface. These findings have significant implications for optimizing the performance and stability of μ -Si-based PV solar devices. In conclusion, the study of the top cell reveals a fill factor of 80.24% and an efficiency of 13.58%. Future investigations will focus on the effects of operating temperature on the performance and stability of the top solar cell.

Keywords : SCAPS-1D, micromorph tandem solar cell, amorphous bottom solar cell, absorber layer, electrical parameters.