Software for modeling semiconductor solar cells

PVcell

Overview

2013

Advanced physical model

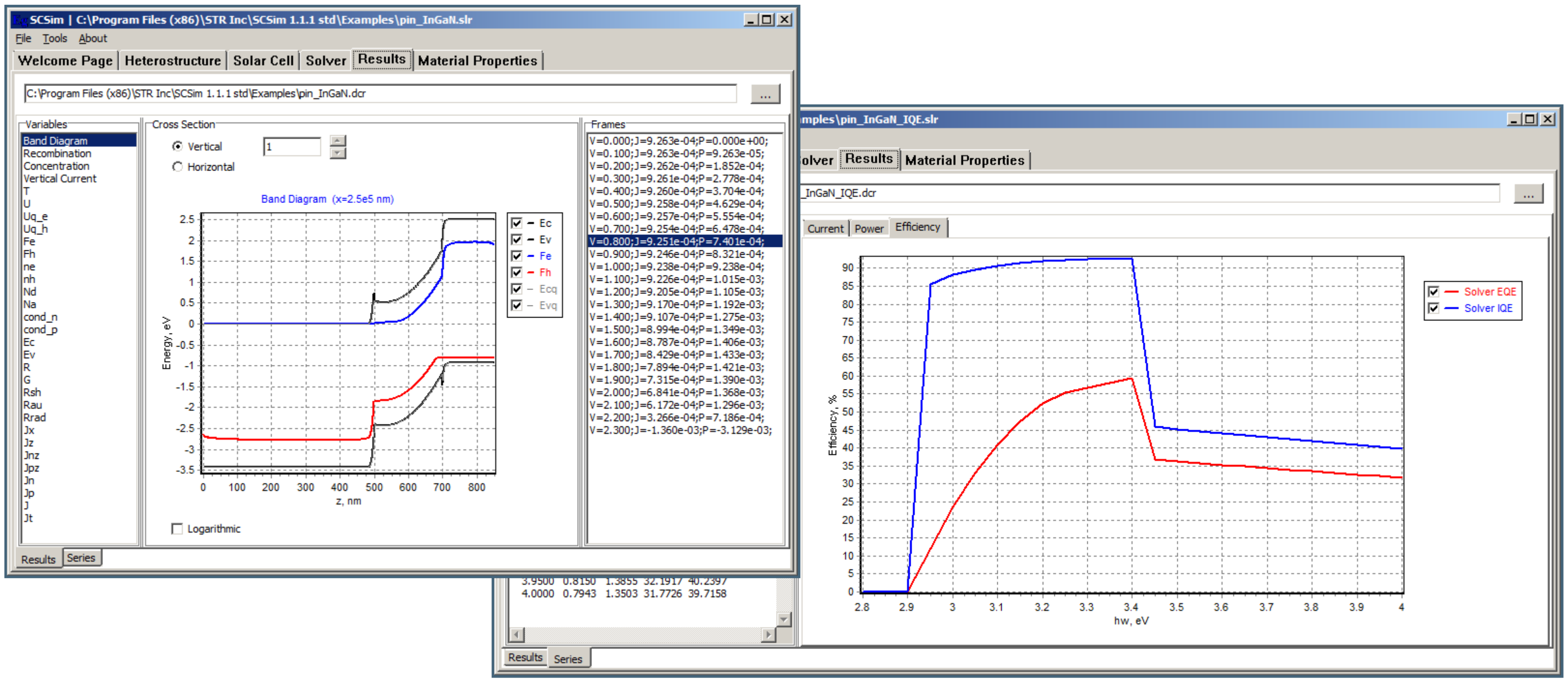
- ✓ 1D drift-diffusion model
  - ✓ Poisson equation for the electric potential
  - ✓ Drift-diffusion carrier transport equations
  - ✓ Generation and recombination rates
- ✓ Account for specific III-nitride features
  - ✓ Spontaneous polarization and piezoeffect
  - ✓ Manual specification of the partial strain relaxation is possible
  - ✓ Original model for recombination at dislocation cores
- ✓ Simulation of multi-cascade solar cells
  - ✓ Tunnel junction characteristics can be either specified manually or computed by simulation of the band-to-band tunneling
- ✓ Advanced numerical algorithms improve convergence and reduce computation time

Simulation results

- ✓ Single computation with given excitation and bias
  - ✓ Current / current density, conversion efficiency
  - ✓ Band diagram, electric potential, electric field
  - ✓ Carrier concentration, ionized impurity concentration
  - ✓ Generation rate, recombination rate (different mechanisms)
  - ✓ Carrier fluxes
- ✓ Series computations with varying bias
  - ✓ I-V characteristic and conversion efficiency
  - ✓ Short-circuit current, open-circuit voltage, fill factor
- ✓ Series computations with varying excitation wavelength
  - ✓ Spectral dependence of IQE and EQE

User-friendly interface

- ✓ **Editable database of material properties**
- ✓ **Most of parameters can be specified as functional or tabulated dependencies on the temperature, wavelength, material composition, etc.**
- ✓ **Flexible specification of the excitation spectrum, including standard light sources, custom sources, monochromatic excitation. Concentration effect can be studied.**
- ✓ **Built-in visualization of the simulation results**



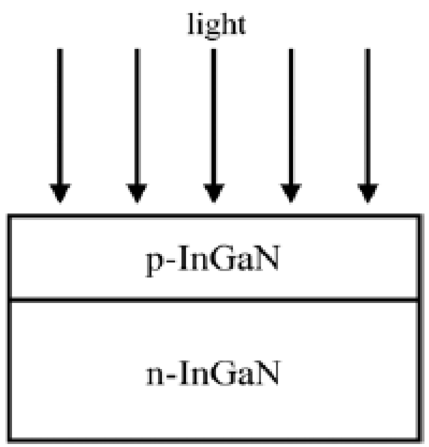
Case 1: comparison with other simulations

Ref.: Zhang et. al., J. Phys. D: Appl. Phys. 40 (2007) 7335–7338

The paper studies $In_{0.65}Ga_{0.35}N$ homojunction. Similar results can be obtained with PVcell by making the input data being equal to that specified in the paper.

Some discrepancy can be explained by the difference in the simulation parameters which were not mentioned in the paper.

	PVcell	Published theoretical results
Short circuit current density (mA/cm^2)	30.5	29.6
Open circuit voltage (V)	0.86	0.83
Fill factor (%)	82.3	82.2
Conversion efficiency (%)	21.6	20.3



Case 2: comparison with experiment

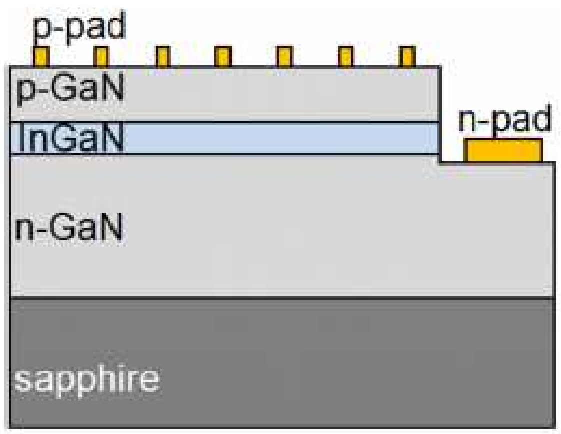
Ref.: Matioli et. al., Appl. Phys. Lett. 98, 021102 (2011)

✓ Some strain relaxation may occur in 60 nm thick $In_{0.1}Ga_{0.9}N$ layer. Two limit cases of completely strained structure and complete relaxation are presented below.

✓ The short circuit is in reasonable agreement with result for smooth surface (the computational model refers to the case of smooth surface).

✓ Open-circuit voltage is overestimated in PVcell even in both cases. A lower experimental open-circuit voltage can be attributed to the additional conductivity related to the dislocations or other extended defects which acts as a shunt.

	PVcell No relaxation	PVcell 100% relaxation	Experiment (smooth surface)
Short circuit current density (mA/cm²)	0.78	0.78	0.83
Open circuit voltage (V)	2.41	2.43	1.83
Fill factor (%)	92.2	89.3	76.6
Conversion efficiency (%)	1.74	1.61	1.16



Case 2: comparison with experiment