XII International Scientific and Practical Online Conference
"Renewable Energy and Energy Efficiency in the XXI Century"

DIGITAL MODELLING OF INFLUENCE OF TEMPERATURE ON PHOTO-ELECTRIC PROCESSES IN SILICON SOLAR CELLS

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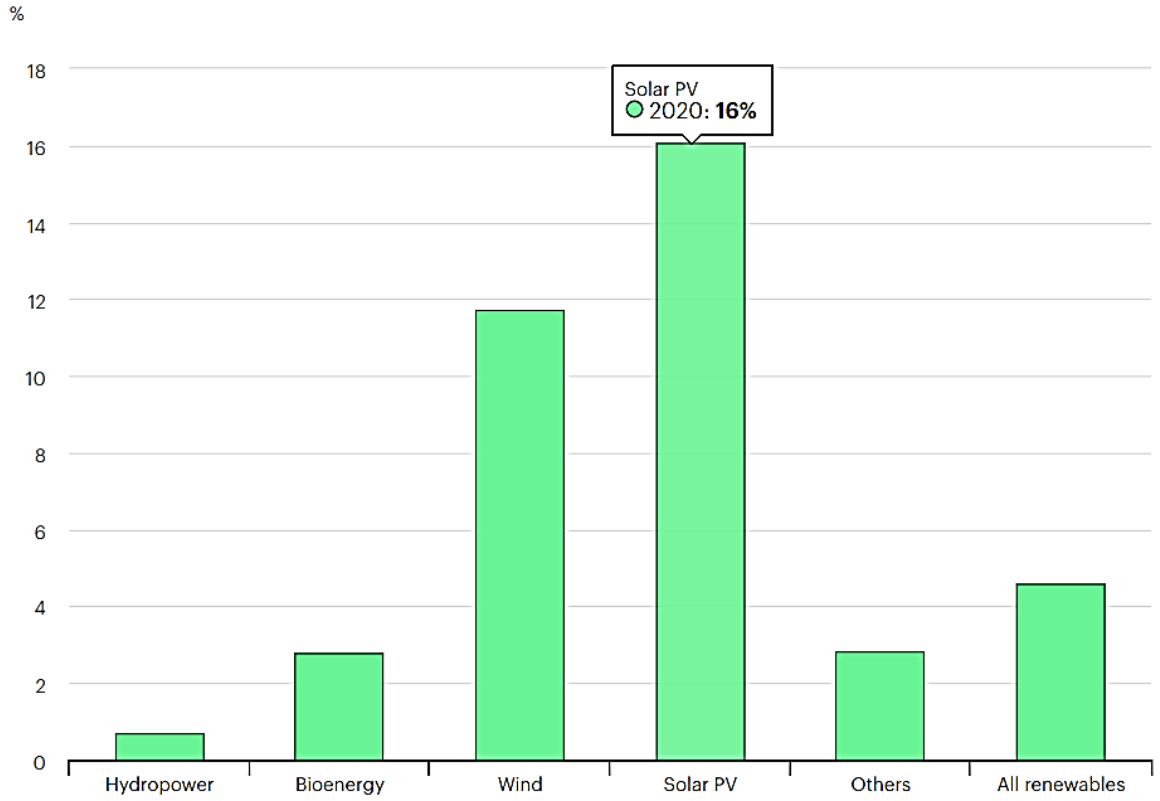
Content

- Types of solar cells
- Modeling
- Modeling silicon solar cell with metal nanoparticles
- The temperature influence on silicon properties
- I-V characteristics of solar cells in various temperatures
- Results

Introduction

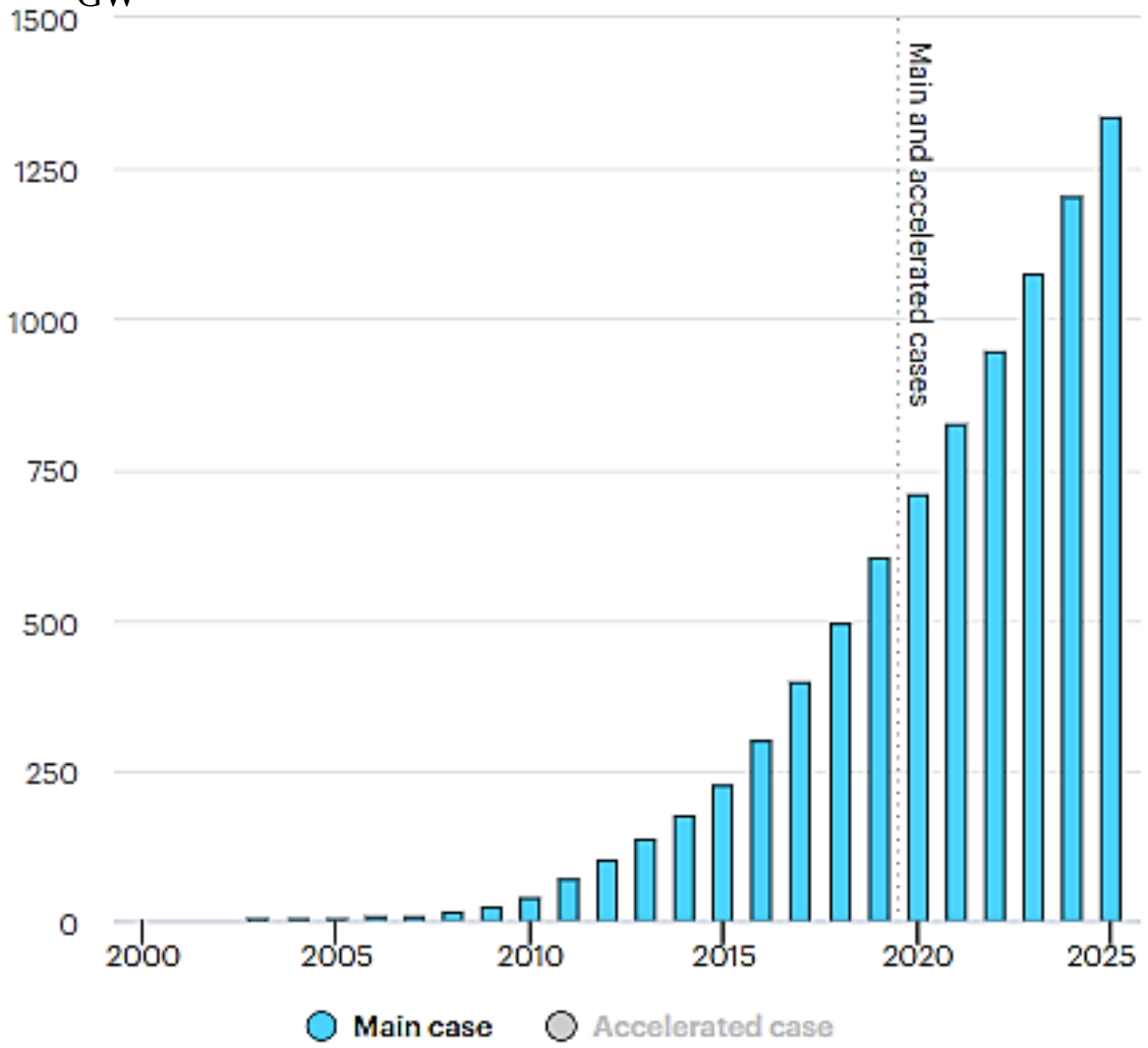
Annual growth for renewable electricity generation by source



IEA, Annual growth for renewable electricity generation by source, 2018-2020, IEA, Paris https://www.iea.org/data-and-statistics/charts/annual-growth-for-renewable-electricity-generation-by-source-2018-2020

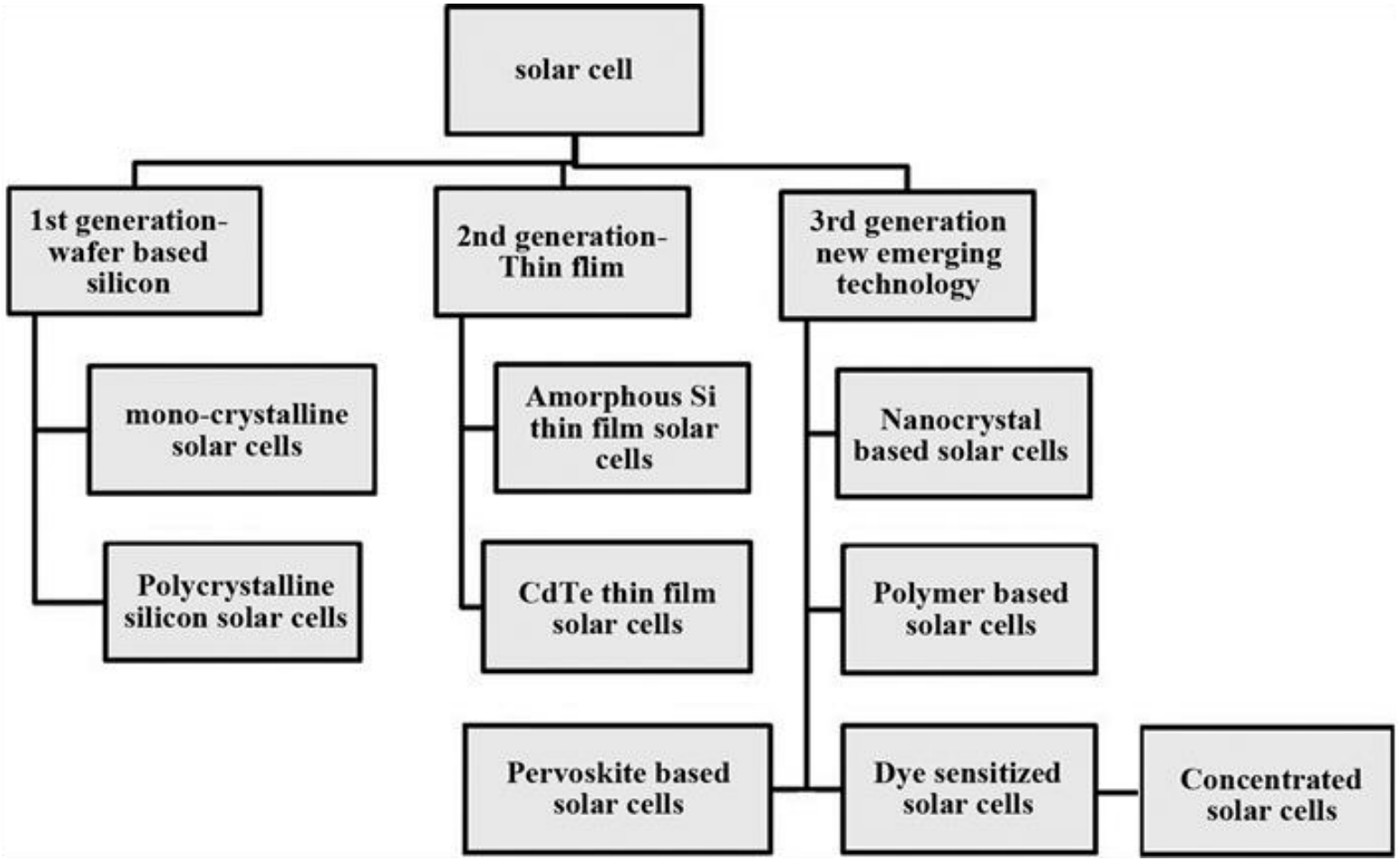
Introduction

Annual growth for renewable electricity generation by source PV capacity, main and accelerated case, World, 1990-2025



IEA (2020), *Renewables 2020 Data Explorer*, IEA, Paris https://www.iea.org/articles/renewables-2020-data-explorer

Types of solar cells



Types of industrial silicon solar cell

MONO

Most efficient, more expensive, less sustainable to produce

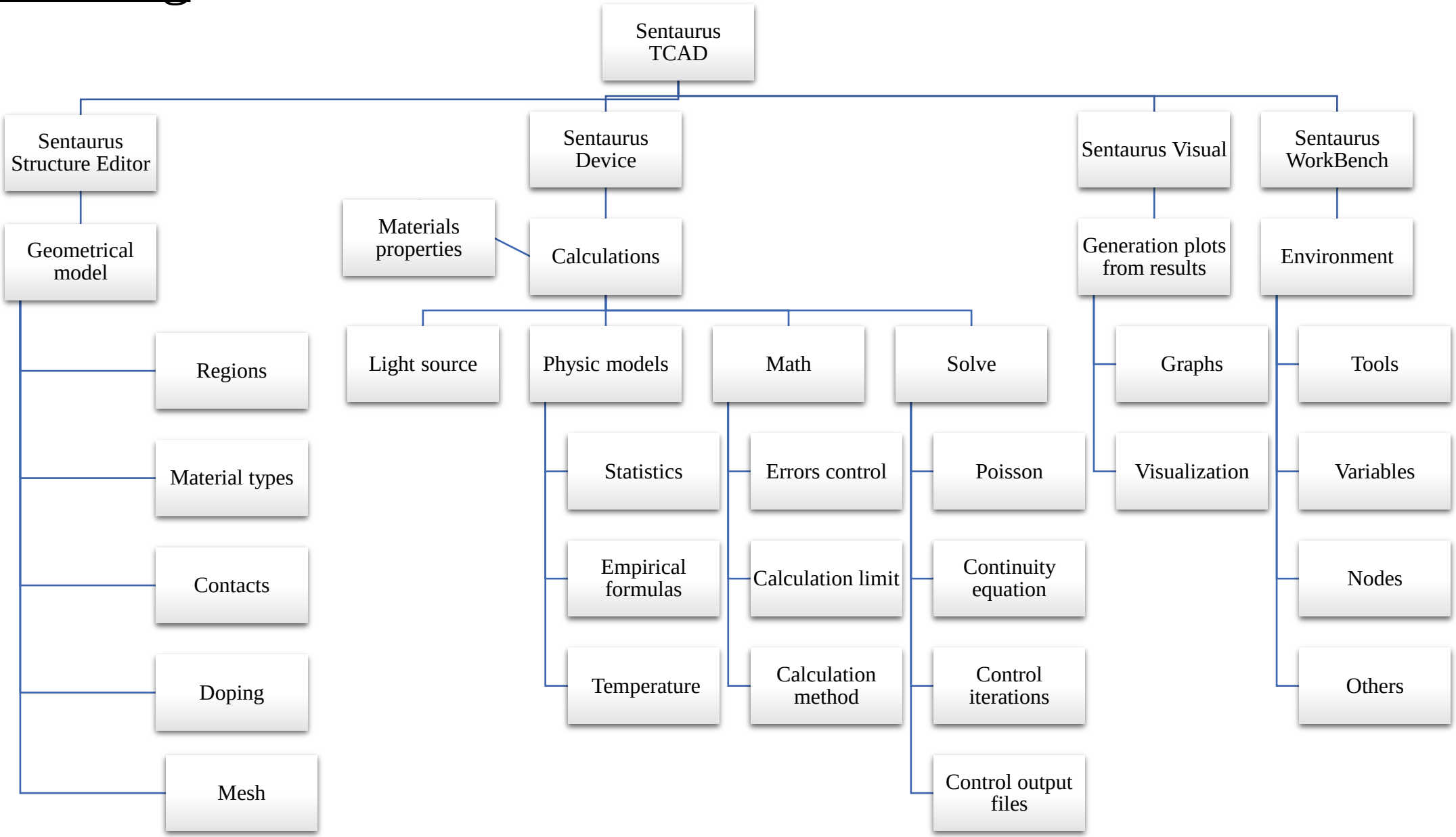
POLY

Least efficient, least expensive, most sustainable to produce

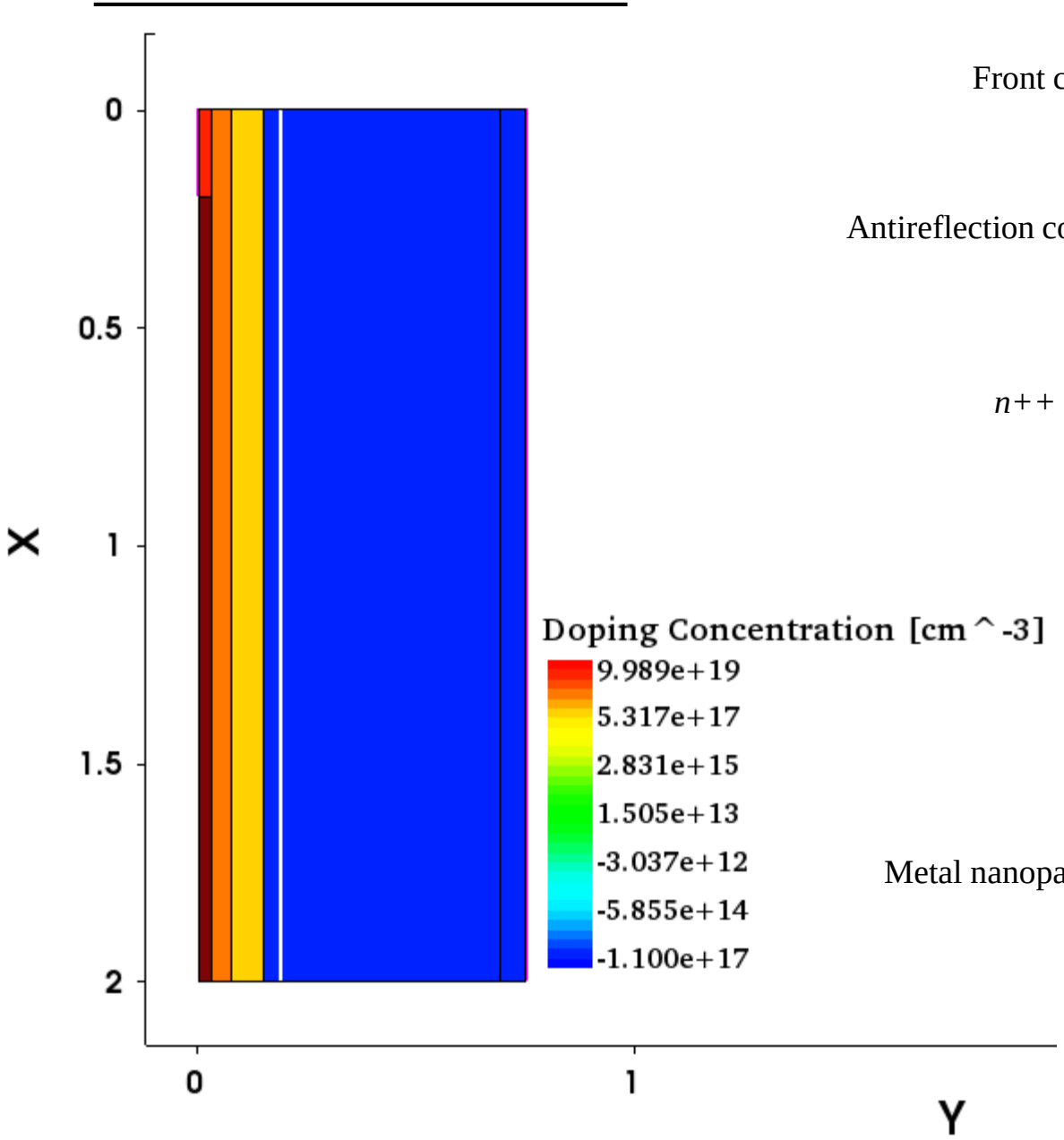
THIN FILM

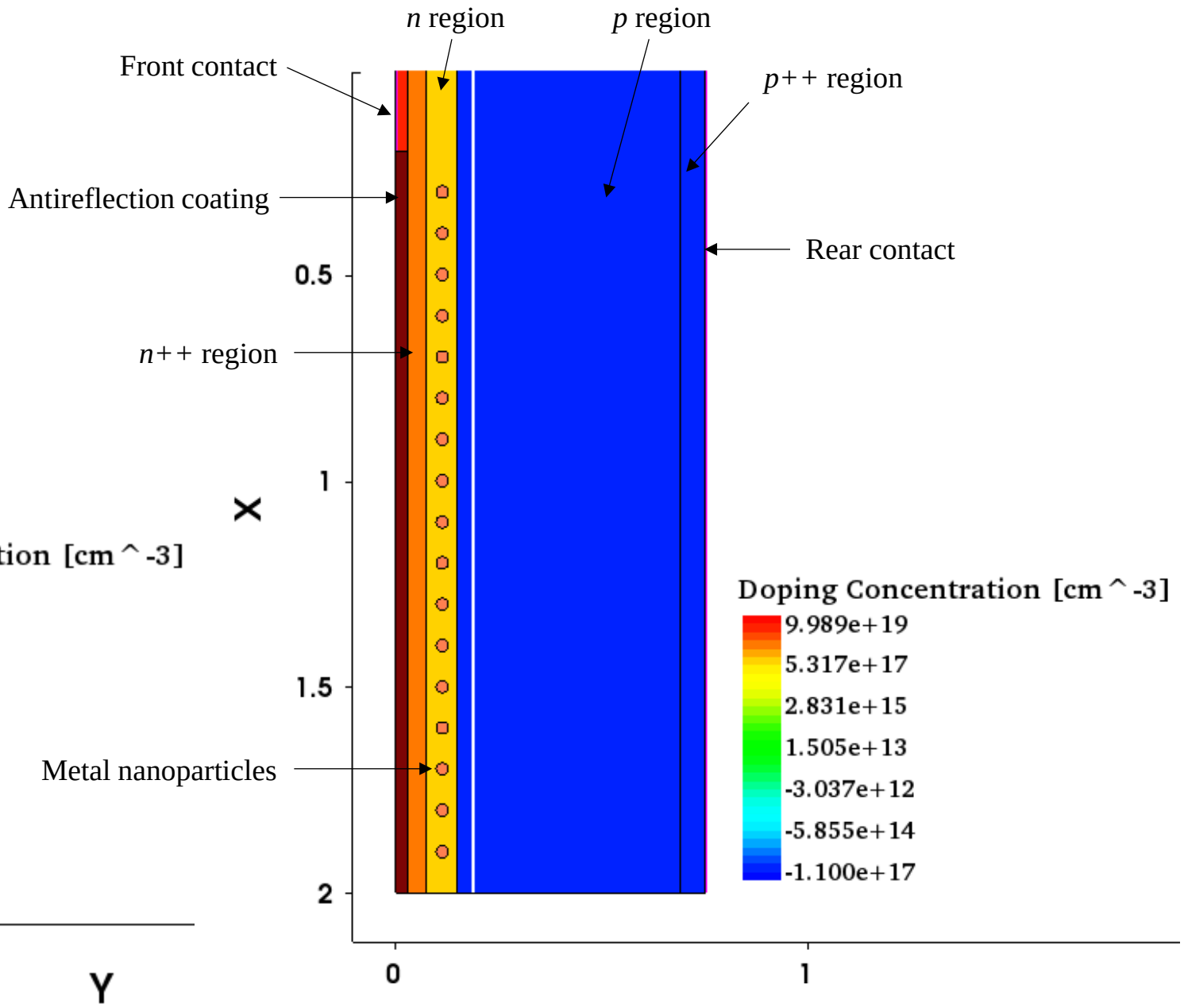
Least efficient, least expensive, most sustainable to produce

Modeling

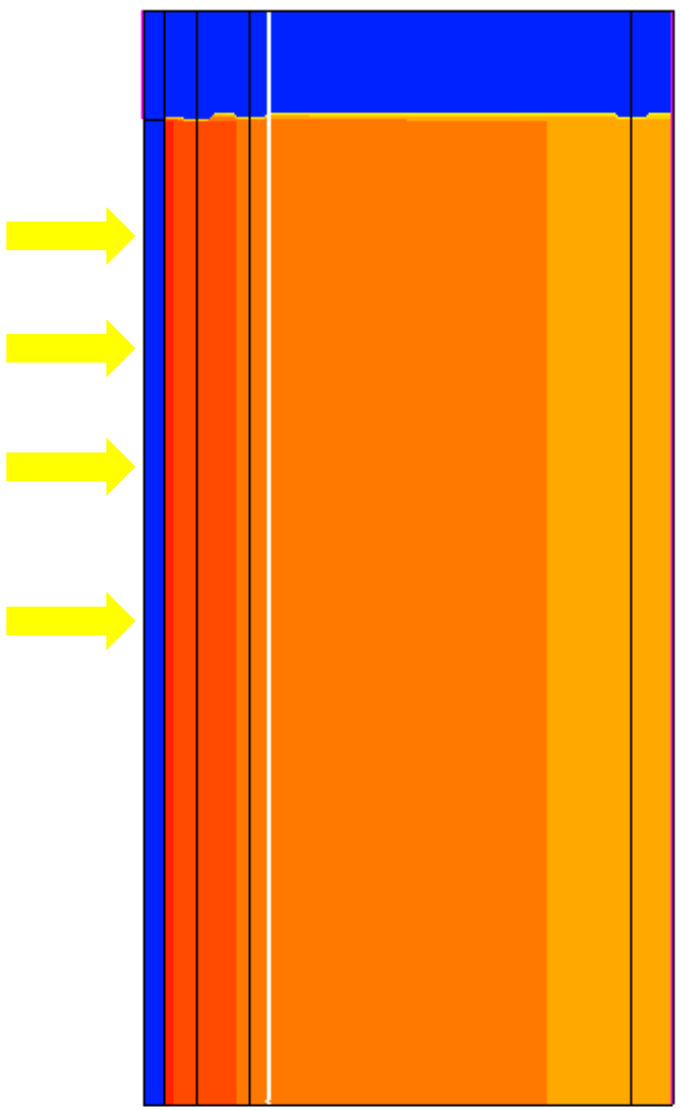

Sentaurus TCAD
Sentaurus Structure Editor
Sentaurus Device
Sentaurus Visual
Sentaurus WorkBench
Geometrical model
Materials properties
Calculations
Generation plots from results
Environment
Regions
Material types
Contacts
Doping
Mesh
Light source
Physic models
Math
Solve
Graphs
Visualization
Tools
Variables
Nodes
Others
Statistics
Empirical formulas
Temperature
Errors control
Calculation limit
Calculation method
Poisson
Continuity equation
Control iterations
Control output files

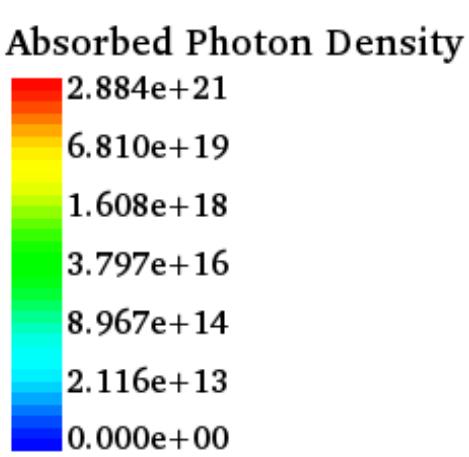
Geometric model

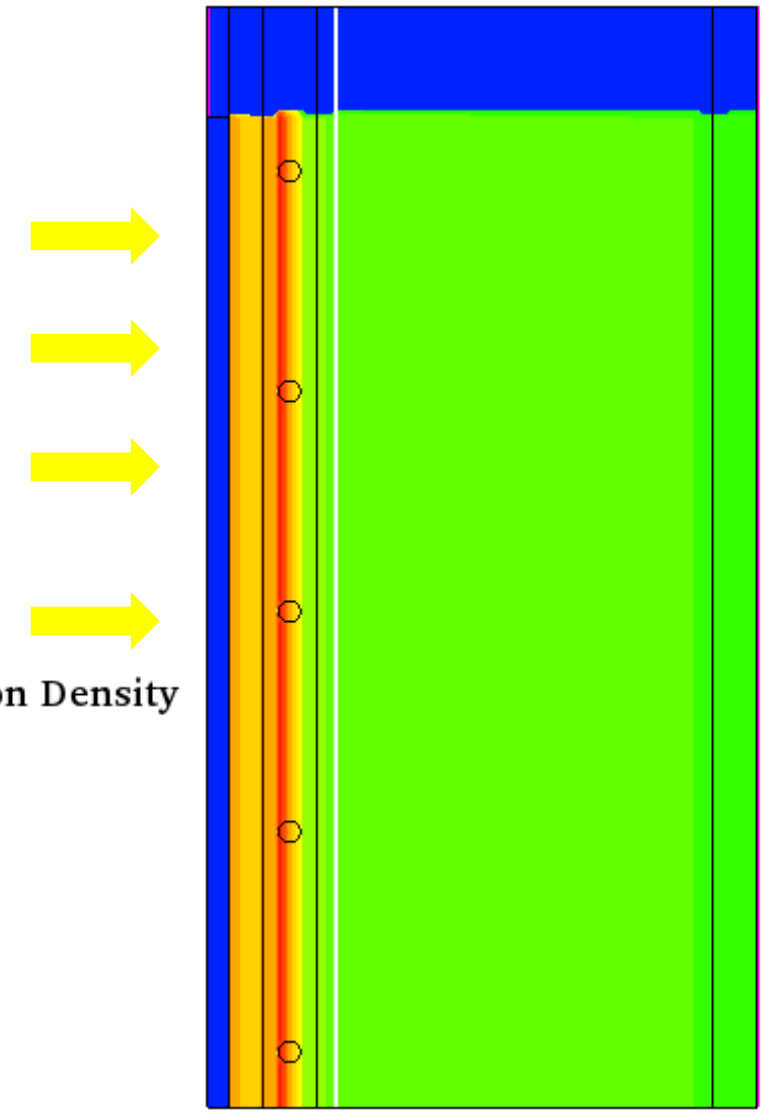


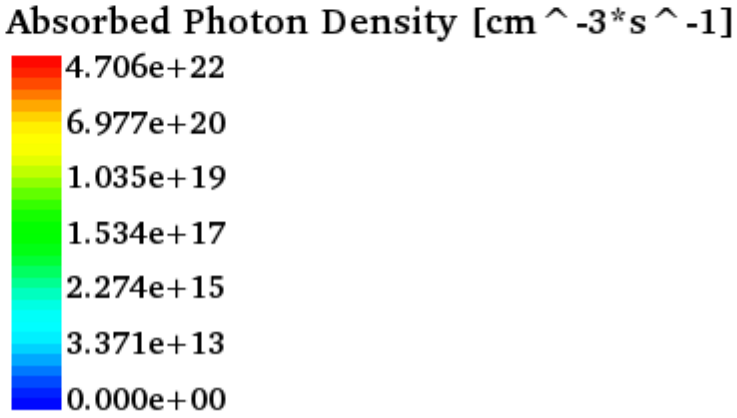


Absorption

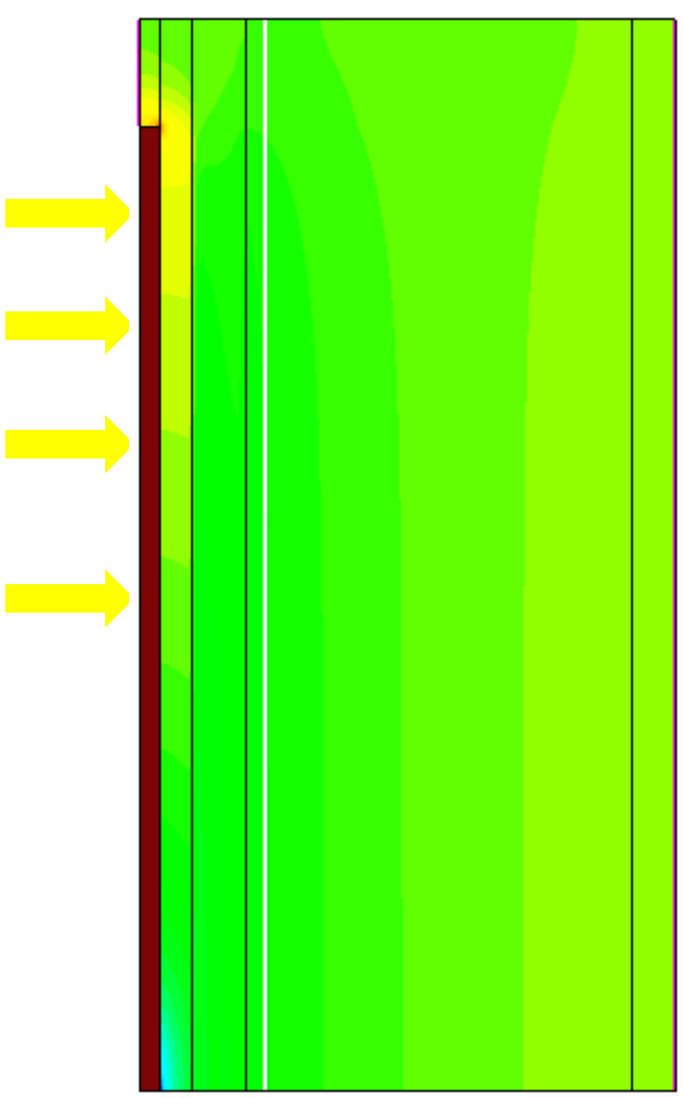


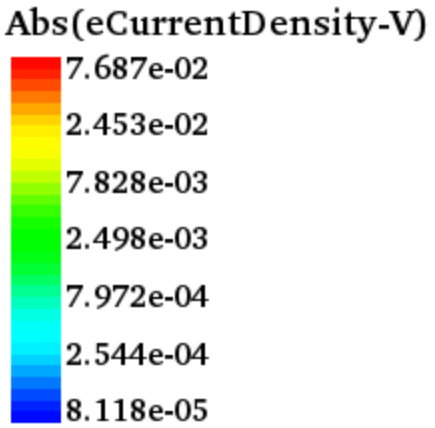

Absorbed Photon Density
2.884e+21
6.810e+19
1.608e+18
3.797e+16
8.967e+14
2.116e+13
0.000e+00

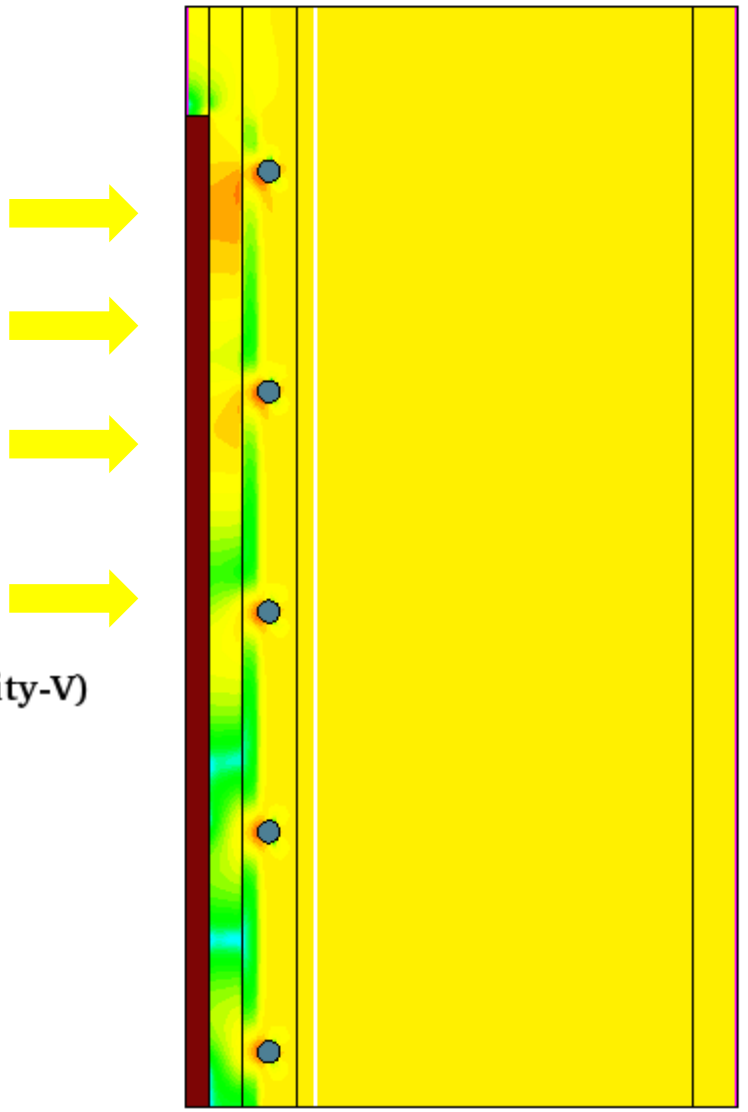


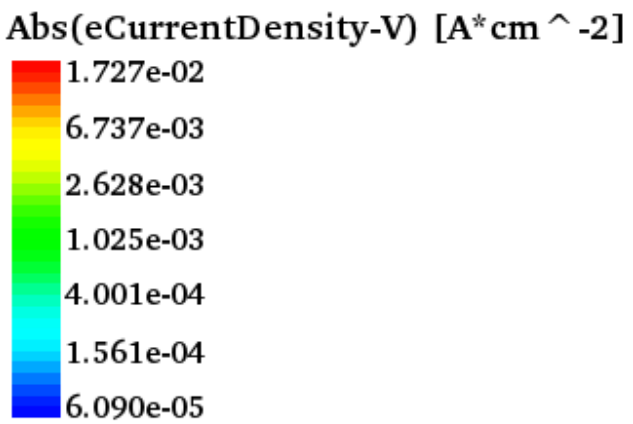

Absorbed Photon Density [cm ^ -3*s ^ -1]
4.706e+22
6.977e+20
1.035e+19
1.534e+17
2.274e+15
3.371e+13
0.000e+00

Electron current density

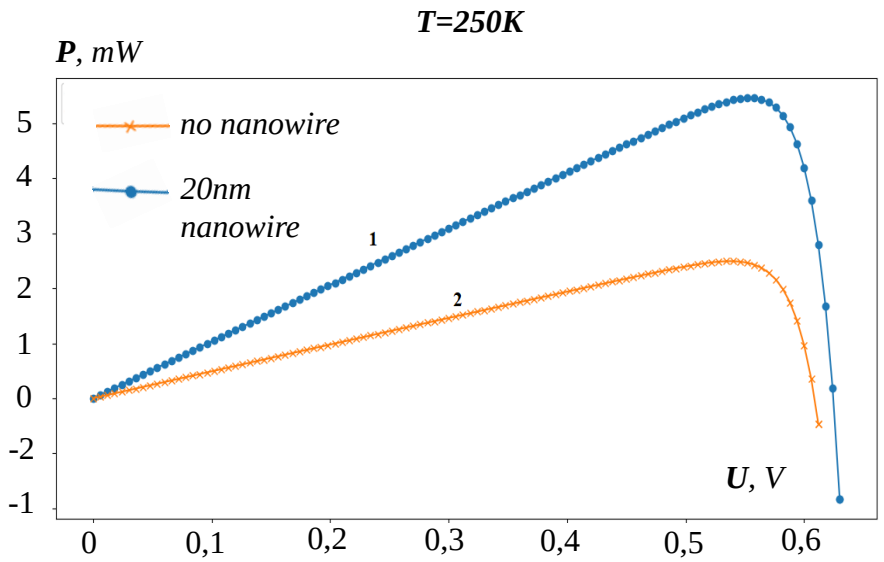


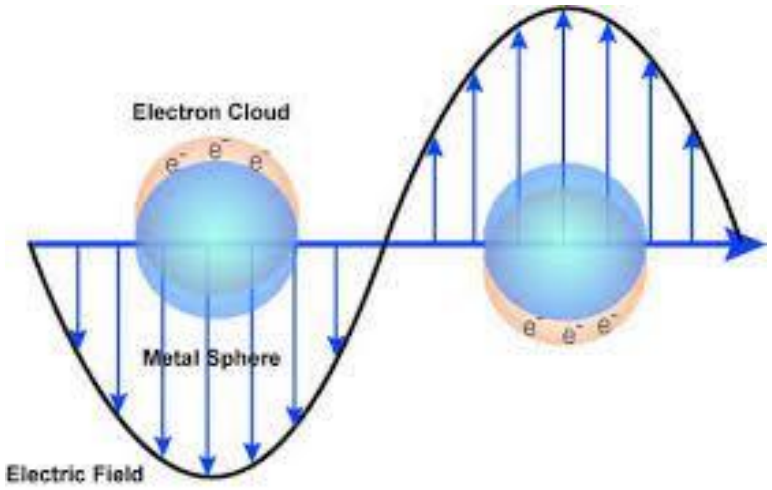






Main findings





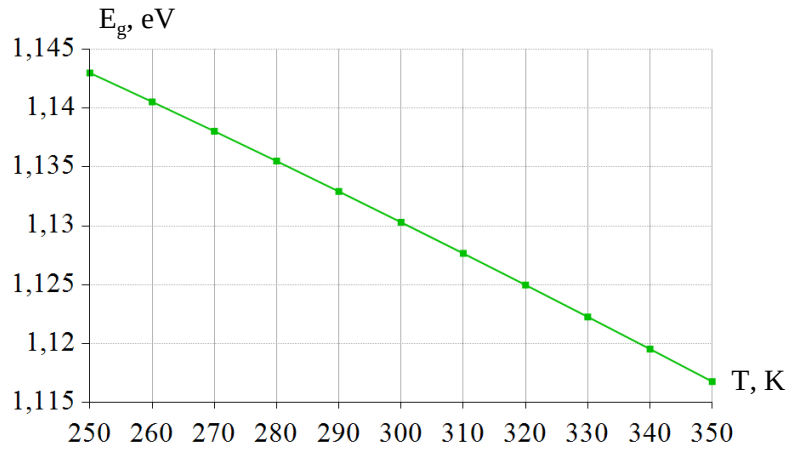
- Increase output power of solar cell due to plasmonic effect
- Plasmonic effect – oscillations of free electrons in the material due to electromagnetic waves

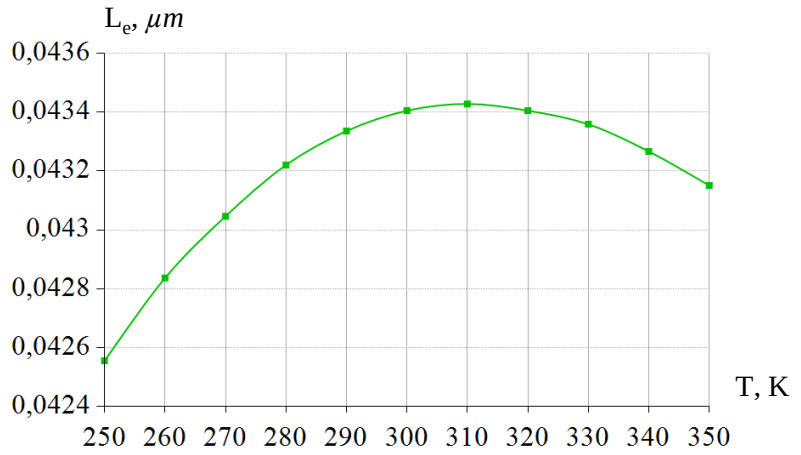
Quality of nanoplasmonics depend on nanoparticles type and size.

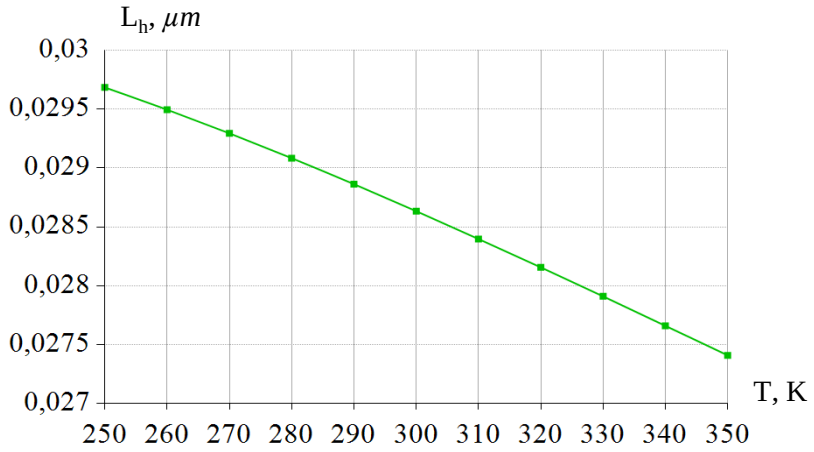
We investigated good conditions of nanoparticles to enhence solar cells efficiency.

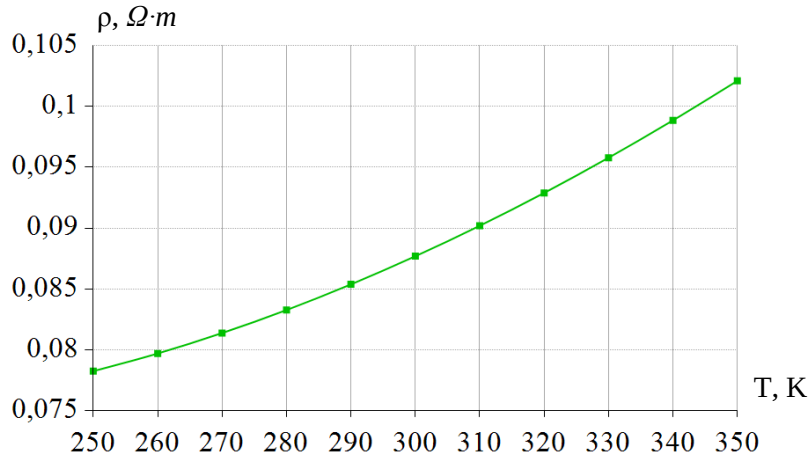
- Material type: Pt
- Size: r=5÷20 nm
- Distance between neighbour nanoparticles:100 nm
- Place: n region of solar cell

Temperature influence on silicon properties







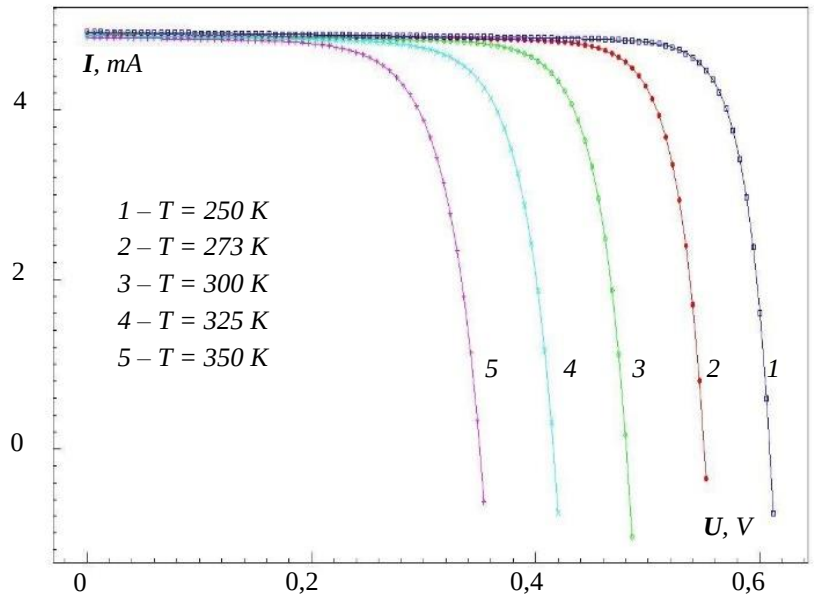


Material type: *Monocrystall silicon* ***Doping type:*** *Fosfor* ***Doping concentration:*** *1e17 cm^{-3}*

T – temperature, ***E_g – band gap energy,*** ***L_e – electron diffusion length,*** ***L_h – hole diffusion length,*** ***ρ - resistivity***

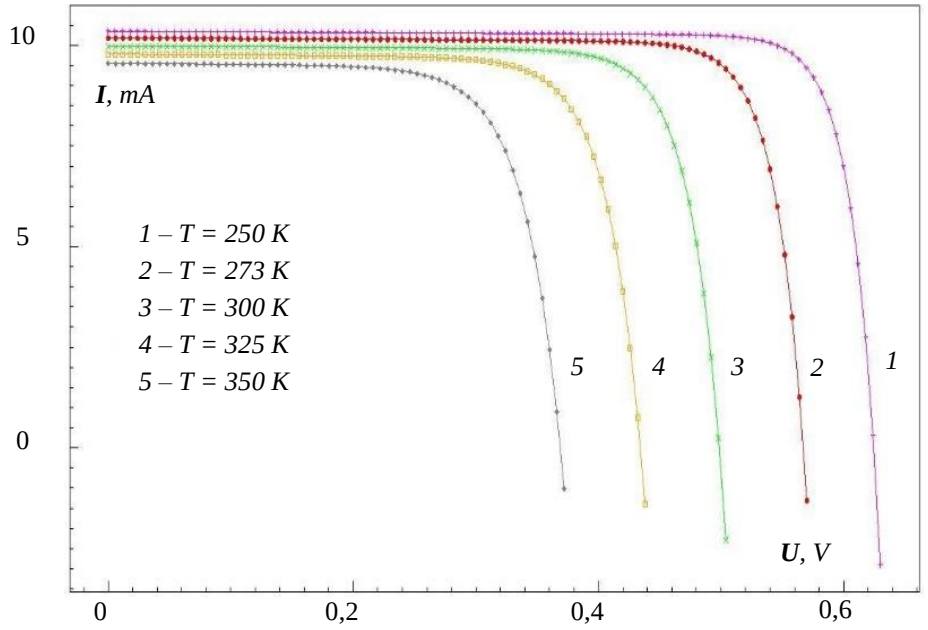
I-V characteristics in various temperatures

No nanowire



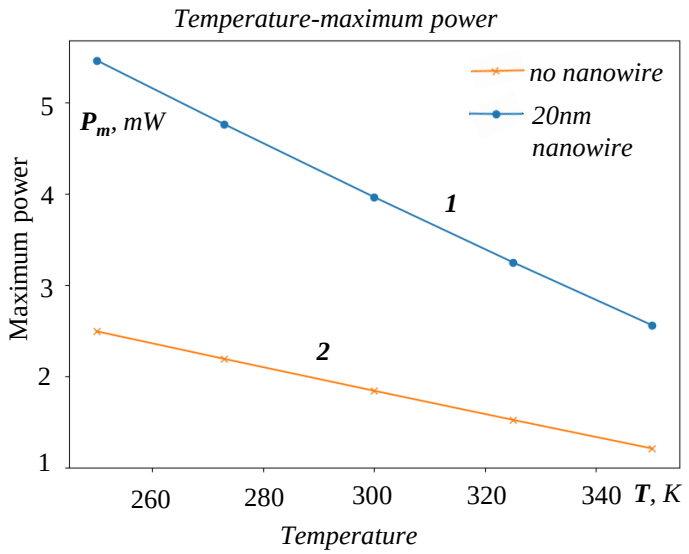
Simple solar cell

20 nm nanowire



Solar cell with *Pt* nanoparticles

Main findings



Material	Temperature coefficients of solar cell parameters				
	dV_{oc}/dt (mV / °C)	dJ_{sc}/dt (mA / sm² °C)	dFF/dt (1 / °C)	dP_m/dt (mW/sm² °C)	dη/dt (1 / °C)
Si	-2,56	0,00067	-0,0012	-0,0128	-0,0128
Si (Pt)	-2,56	0,0079	-0,0012	-0,0290	-0,0290

Nanoparticles can influence on temperature coefficients of photoelectric parameters.

Nanoparticles change silicon solar cell electrical and optical properties.

Reason:

→ nanoparticles convert infrared electromagnetic wave to visible light.

→ nanoparticles create extra free electrons.

Therefor,

- Short circuit current is increased.
- Absorption coefficient is enhanced.

Thank you for your attention!