NUMERICAL MODELING OF p–i–n SOLAR CELL

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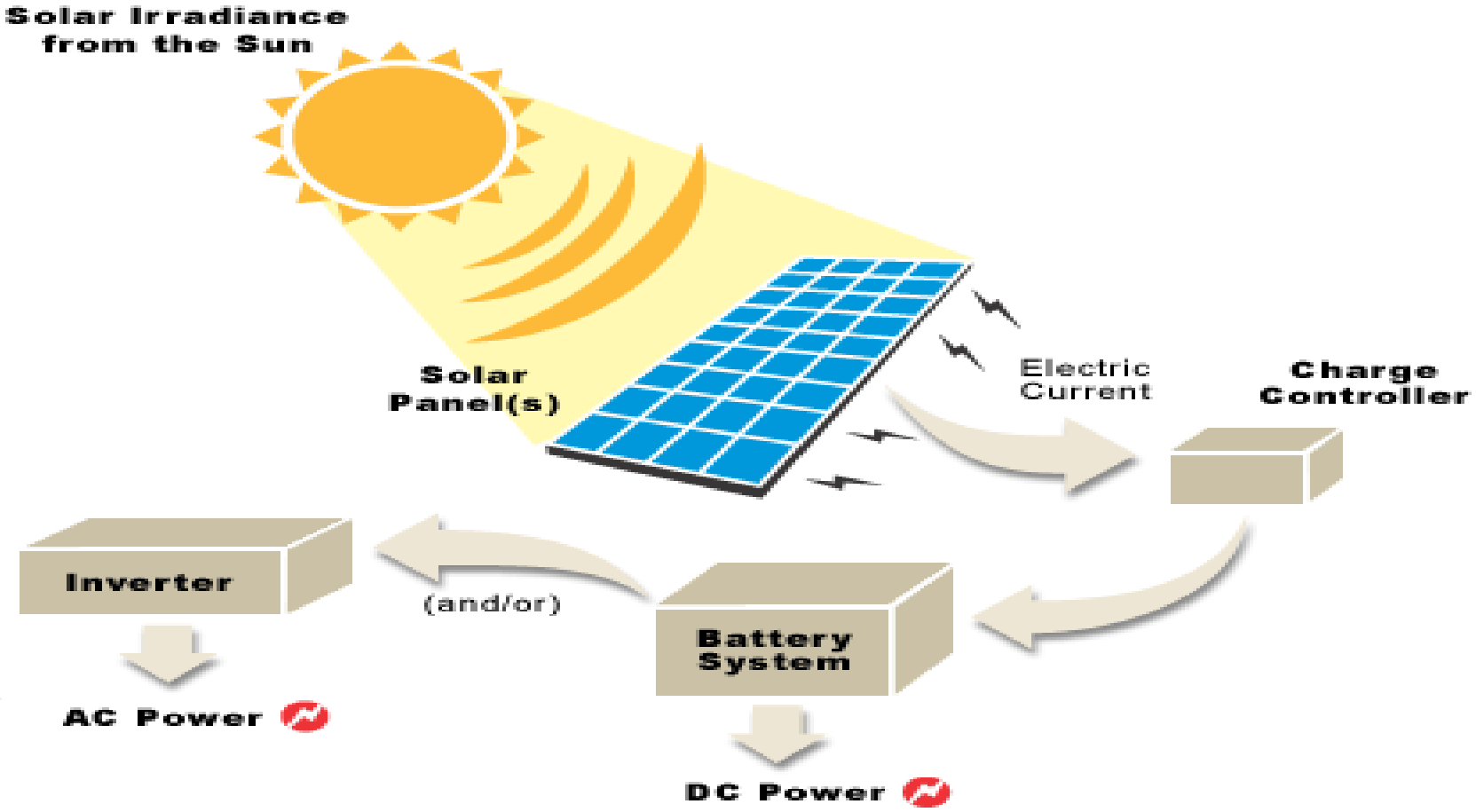
ROADMAP

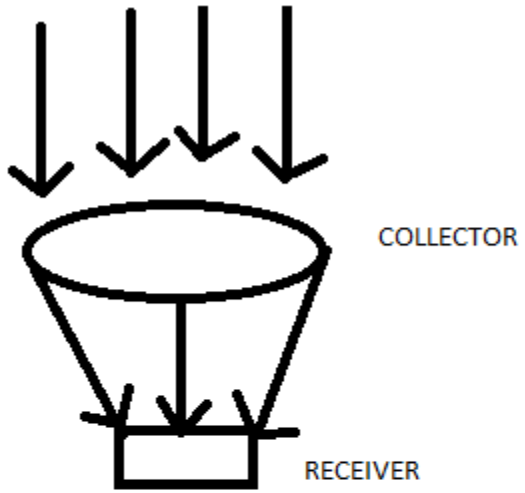
- WHAT A SOLAR CELL IS?
- WORKING PRINCIPLE
- THEORETICAL ANALYSIS
- STRUCTURAL DESIGN OF p-i-n SOLAR CELL
- PARAMETER STUDY USING COMSOLv4.3b
- PROPOSED DESIGN
- CONCLUSION
- SCOPES FOR FUTURE WORK
- MULTIJUNCTION SOLAR CELL
- REFERENCES

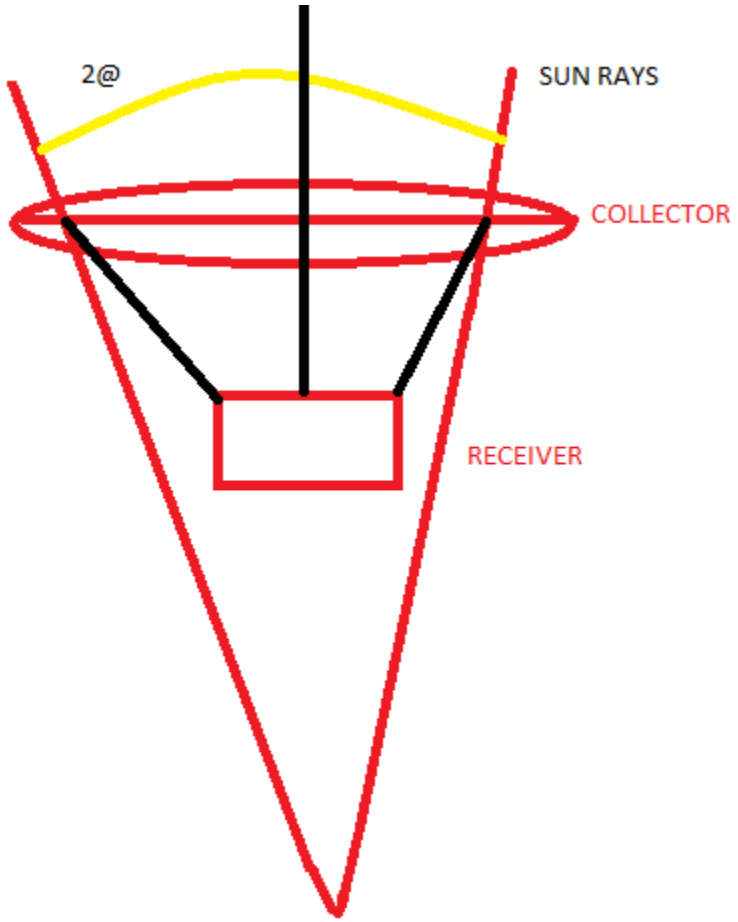
WHAT A SOLAR CELL IS ?



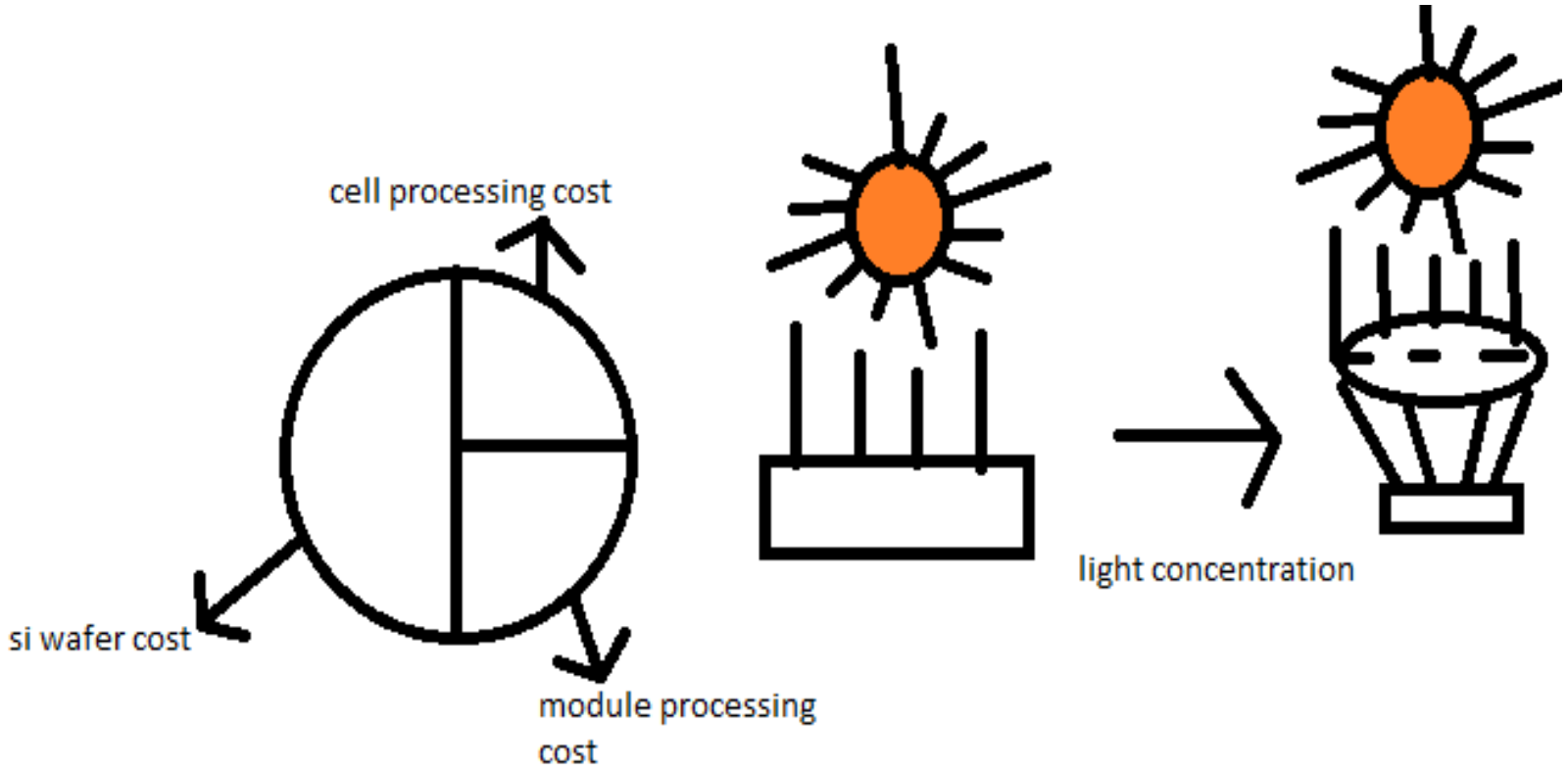
[Fig. 1– Overview of a photovoltaic power distribution system]

CONCENTRATOR





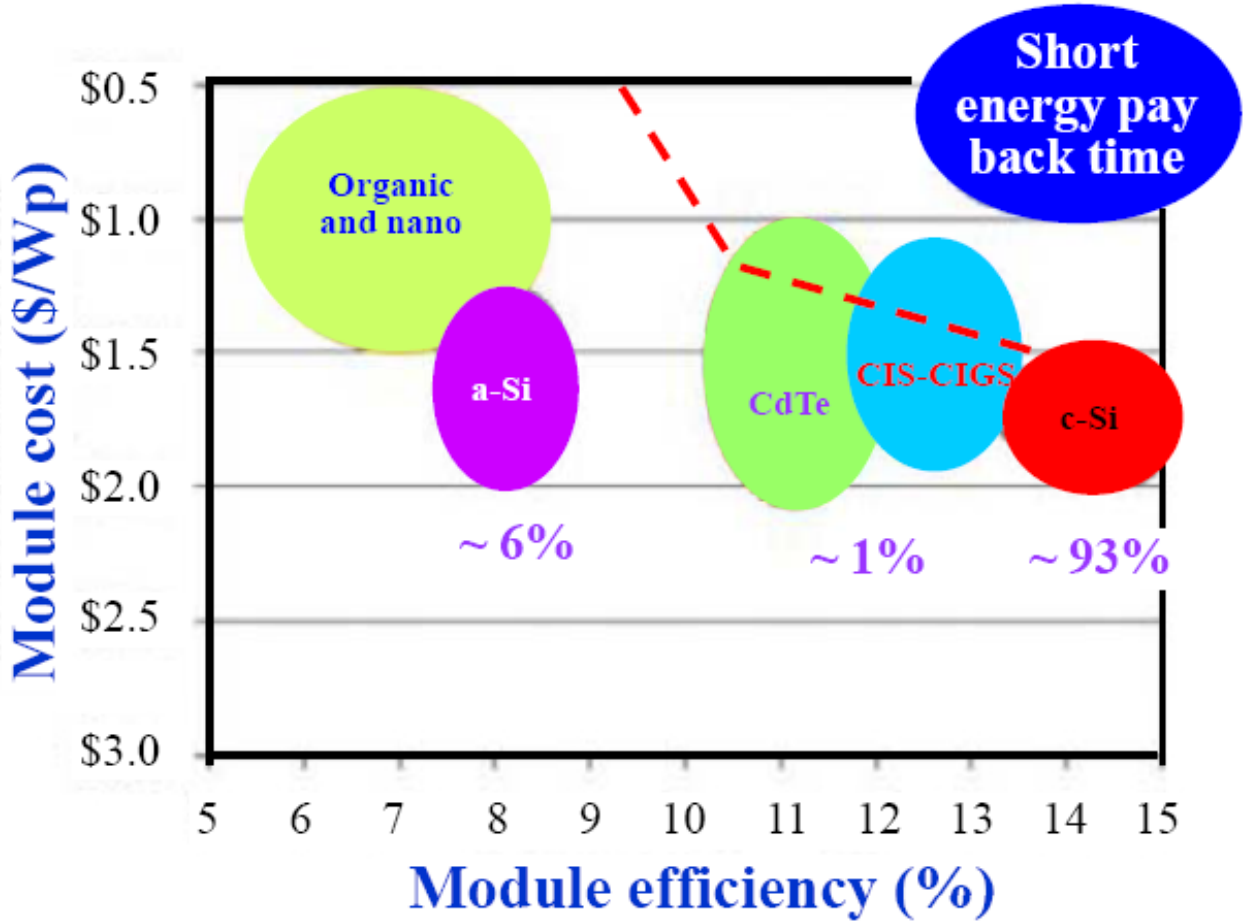
LIGHT CONCENTRATOR



COMPARISION STUDY

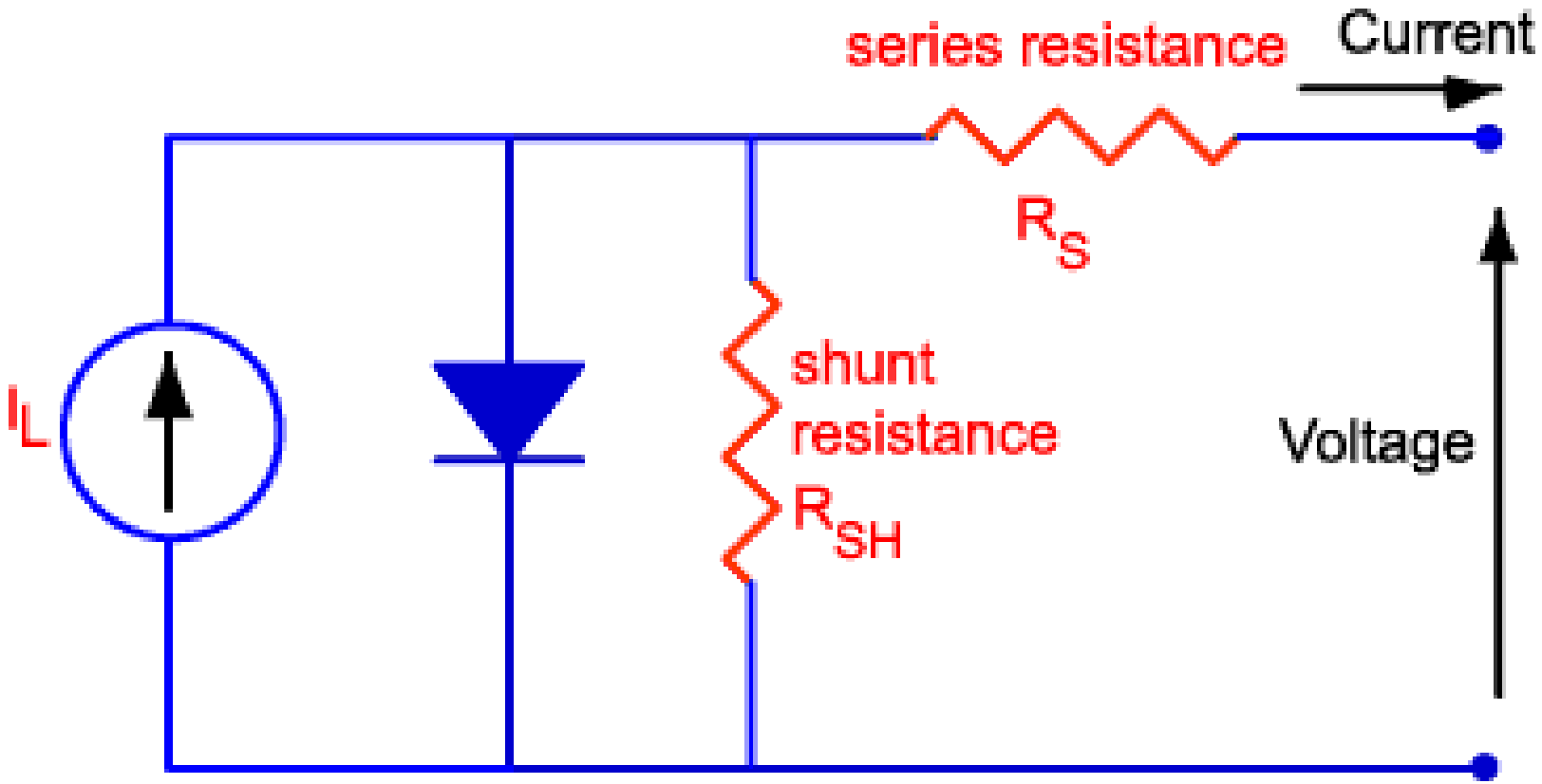
classification	Efficiency (%)	Area (cm^2)	Voc (v)	Jsc ma/cm^2	Ff(%)	description
Silicon	25.0	4.00 ap	0.706	42.7	82.8	Sandia-99
Ga-as(thin)	27.6	0.998 ap	1.107	29.6	8.1	Nrel-11
CIGS	19.6	0.996 ap	0.713	34.8	79.2	Nrel-09
Cd-Te	12.5	35.03 ap	0.838	21.2	70.5	Nrel-10
di-sensitize	9.9	17.11 ap	0.719	19.4	71.4	Aist-10
Organic polymer	8.3	1.031 ap	0.816	14.46	70.2	Nrel-11
Organic 2cell tandem	8.3	1.087 ap	1.733	8.03	59.5	Fhg-ise-10

Efficiency vs. cost



Ref: [1] B. Rand, P. Peumans and R. Forrest, Journal of Appl.Physics 96, p.7519, 2004.

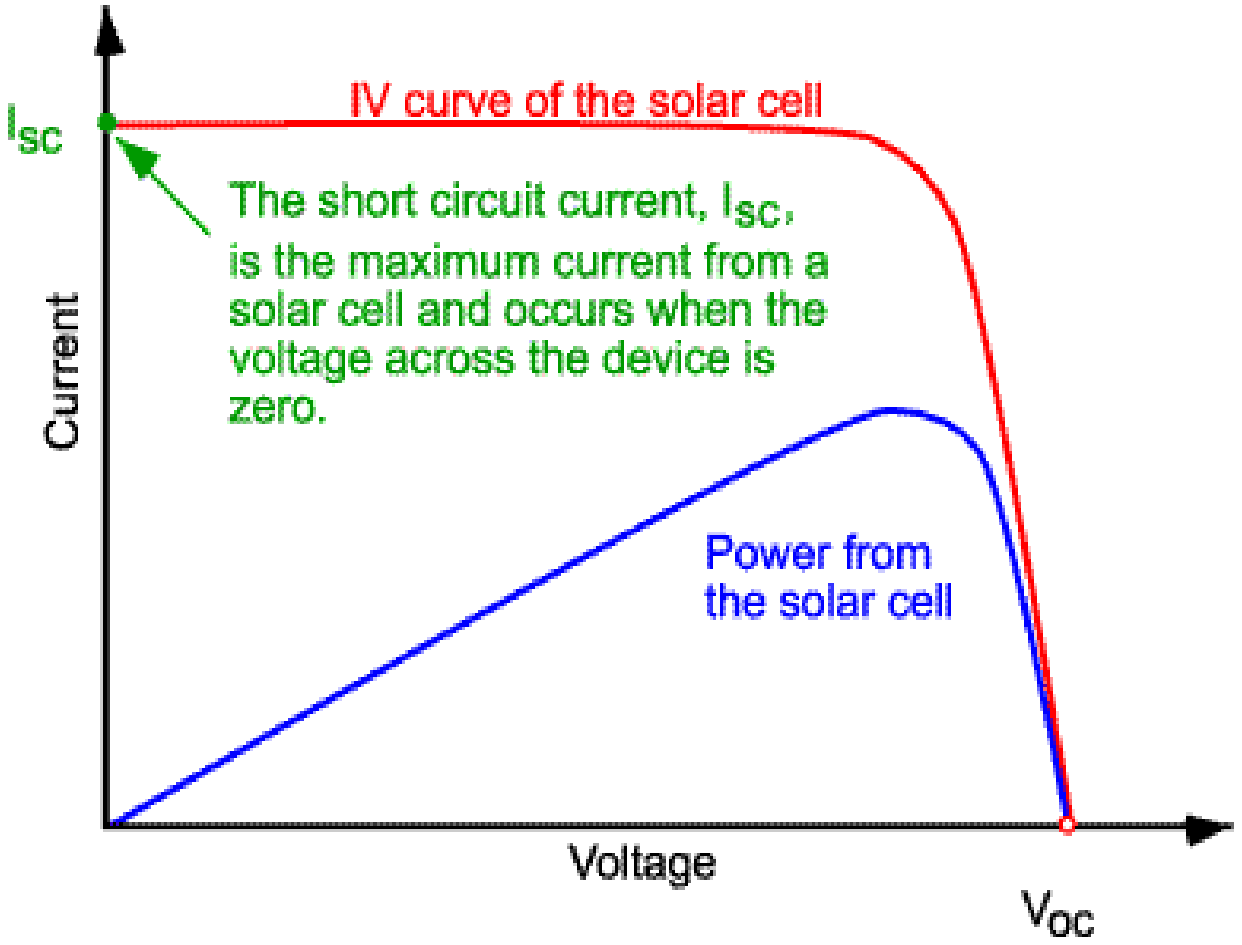
EQUIVALENT CIRCUIT



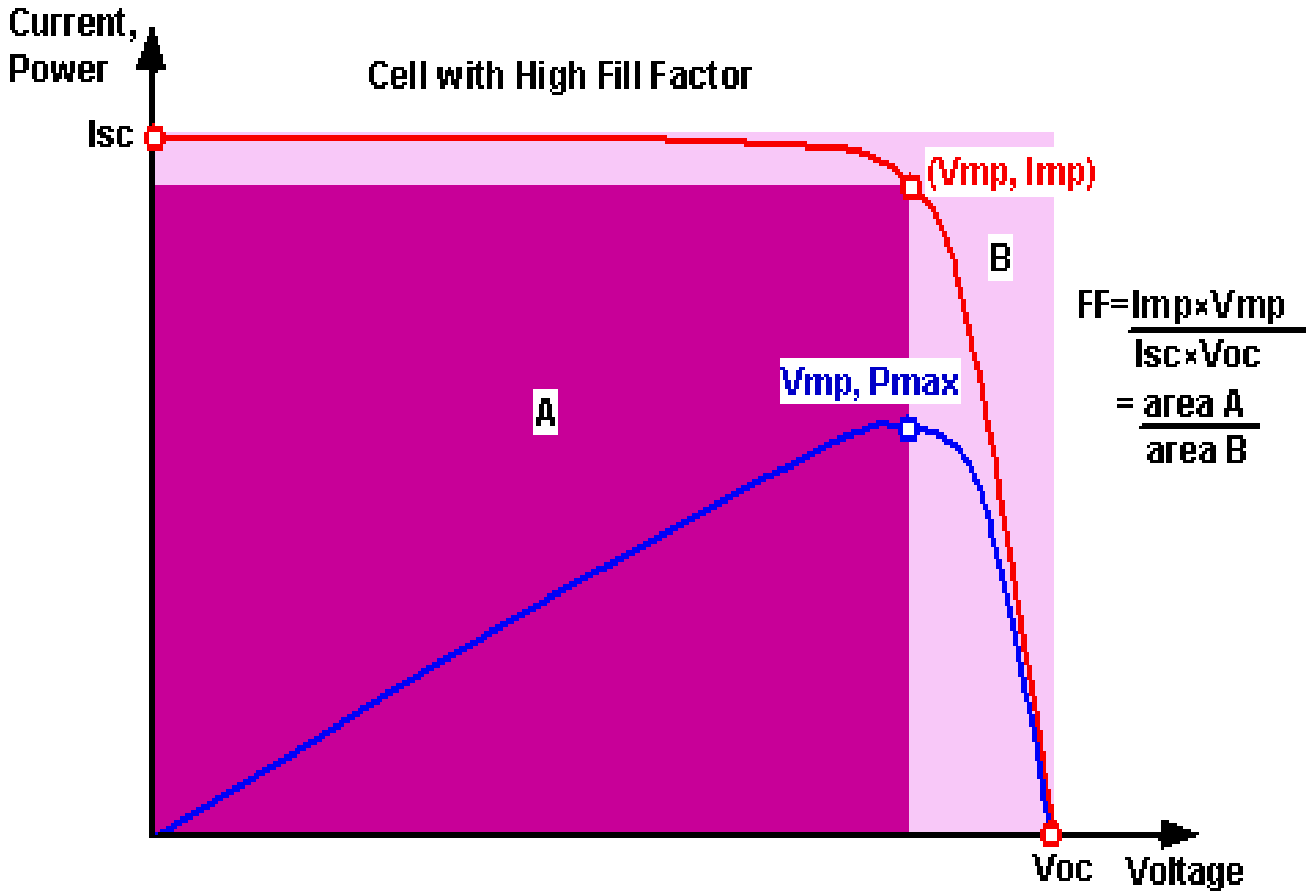
SOLAR CELL PARAMETERS

- Short-Circuit Current
- Open-Circuit Voltage
- Fill factor
- Efficiency

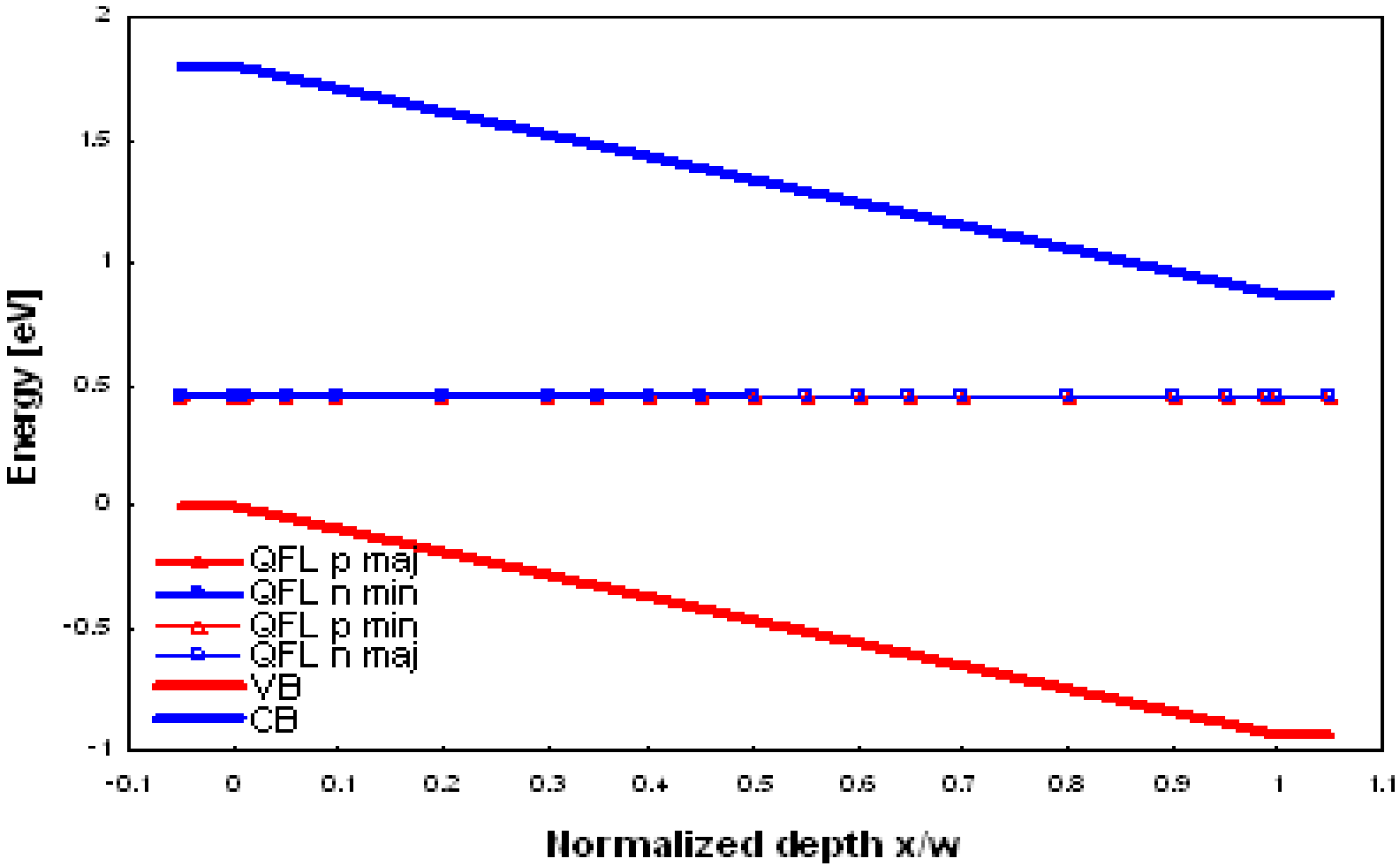
IV CHARACTERISTICS



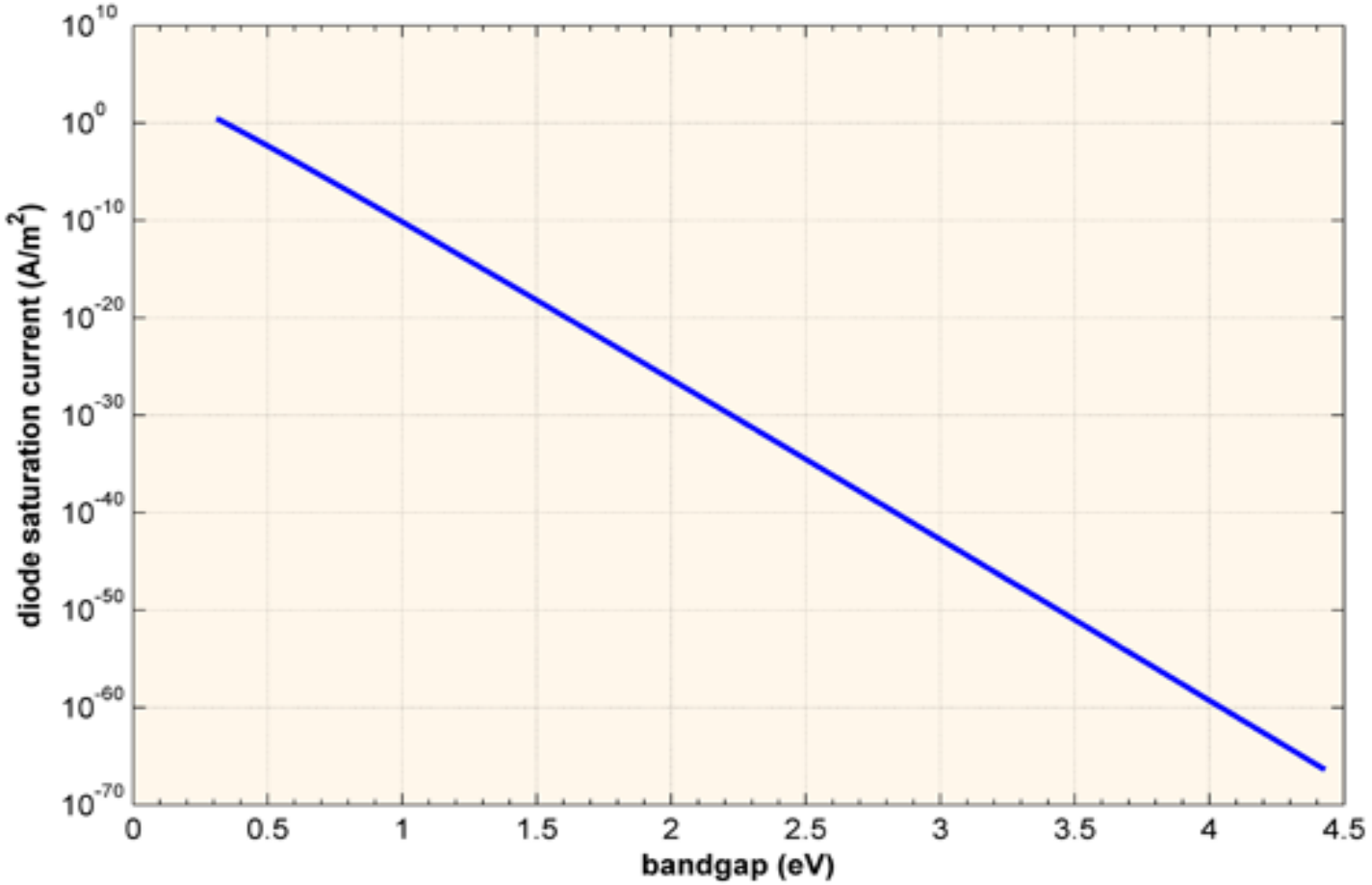
FILL FACTOR


Current,
Power
Cell with High Fill Factor
Isc
(Vmp, Imp)
B
A
Vmp, Pmax
Voc
Voltage
FF=Imp×Vmp / Isc×Voc
= area A / area B

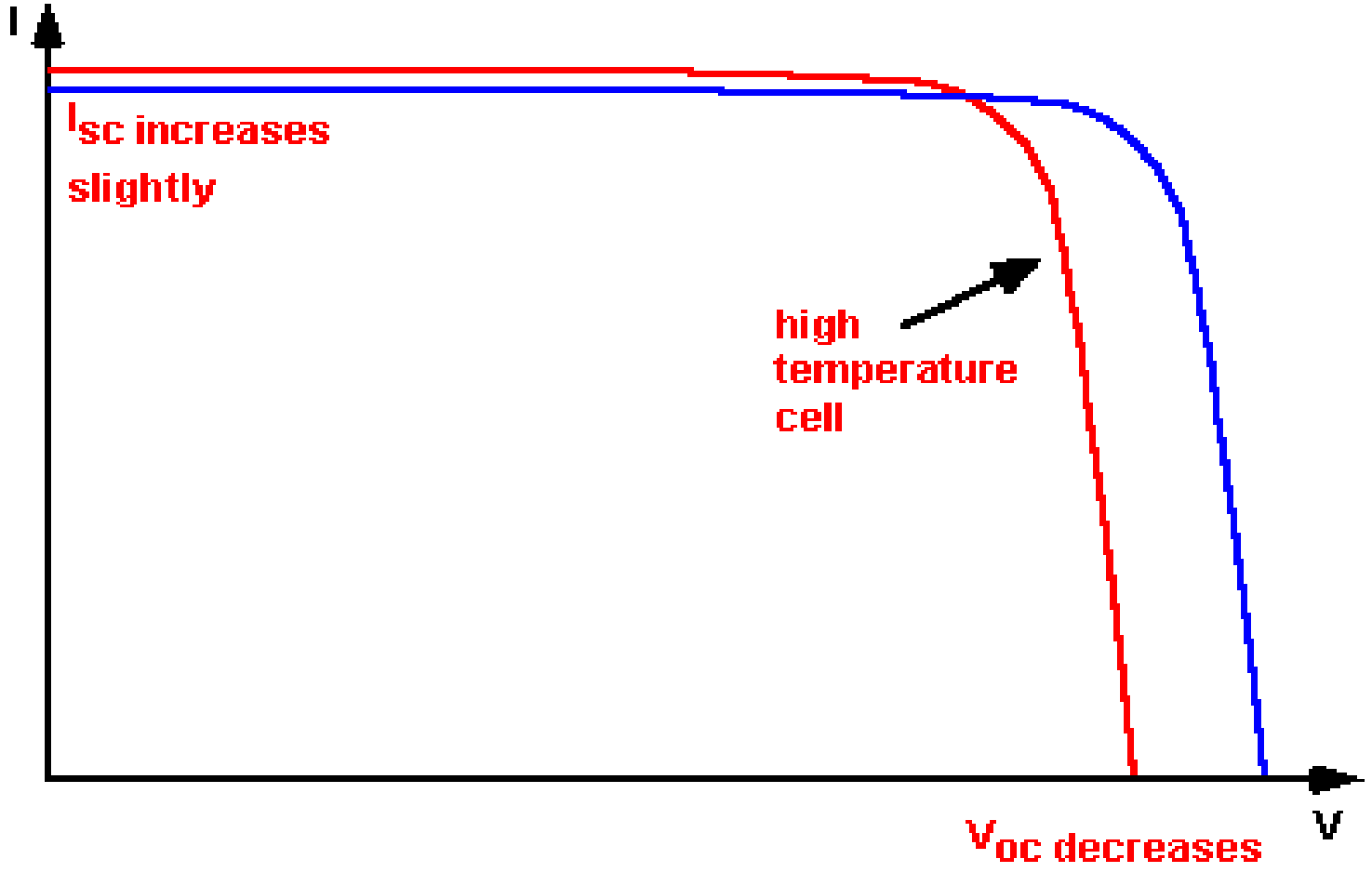
NORMALIZED DEPTH VS ENERGY



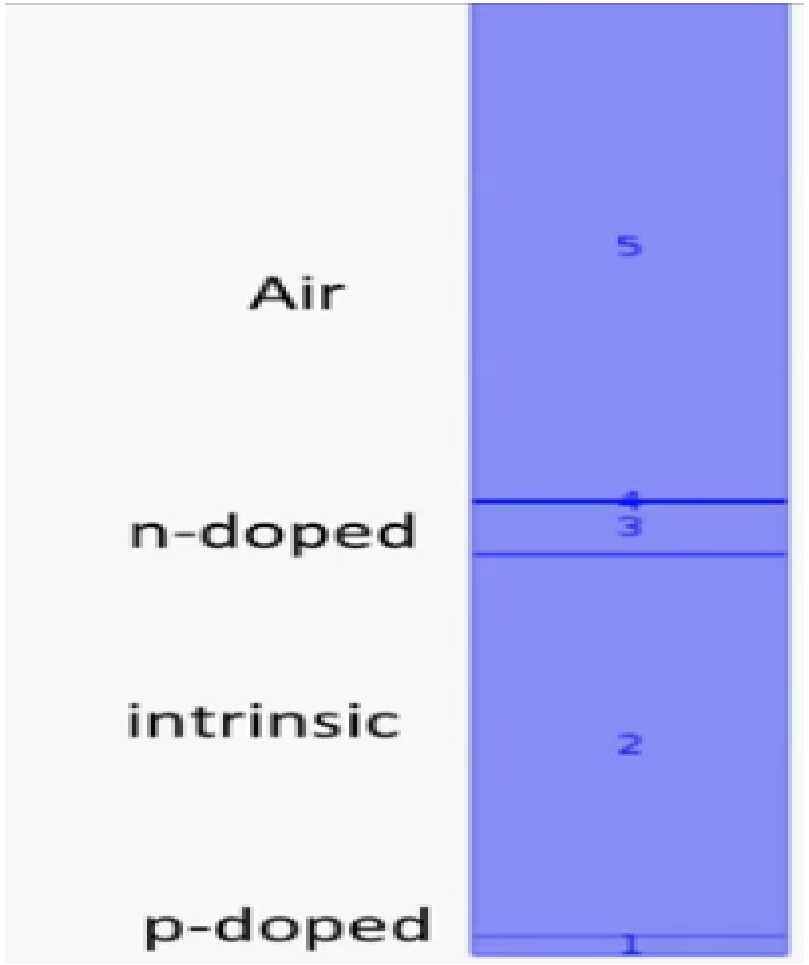
DIODE SATURATION CURRENT VS. BANDGAP



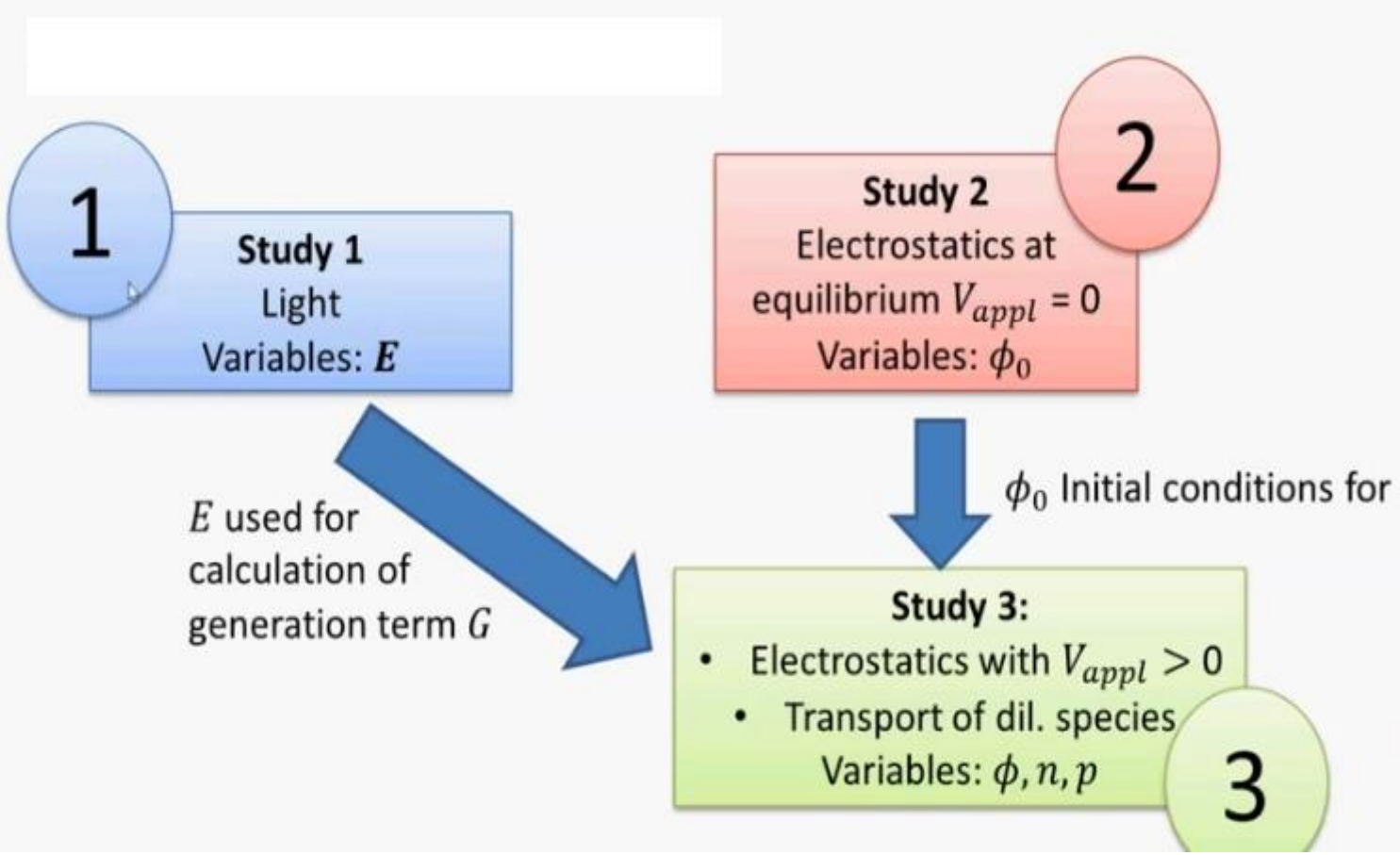
EFFECT OF TEMPERATURE



Model of p–i–n solar cell

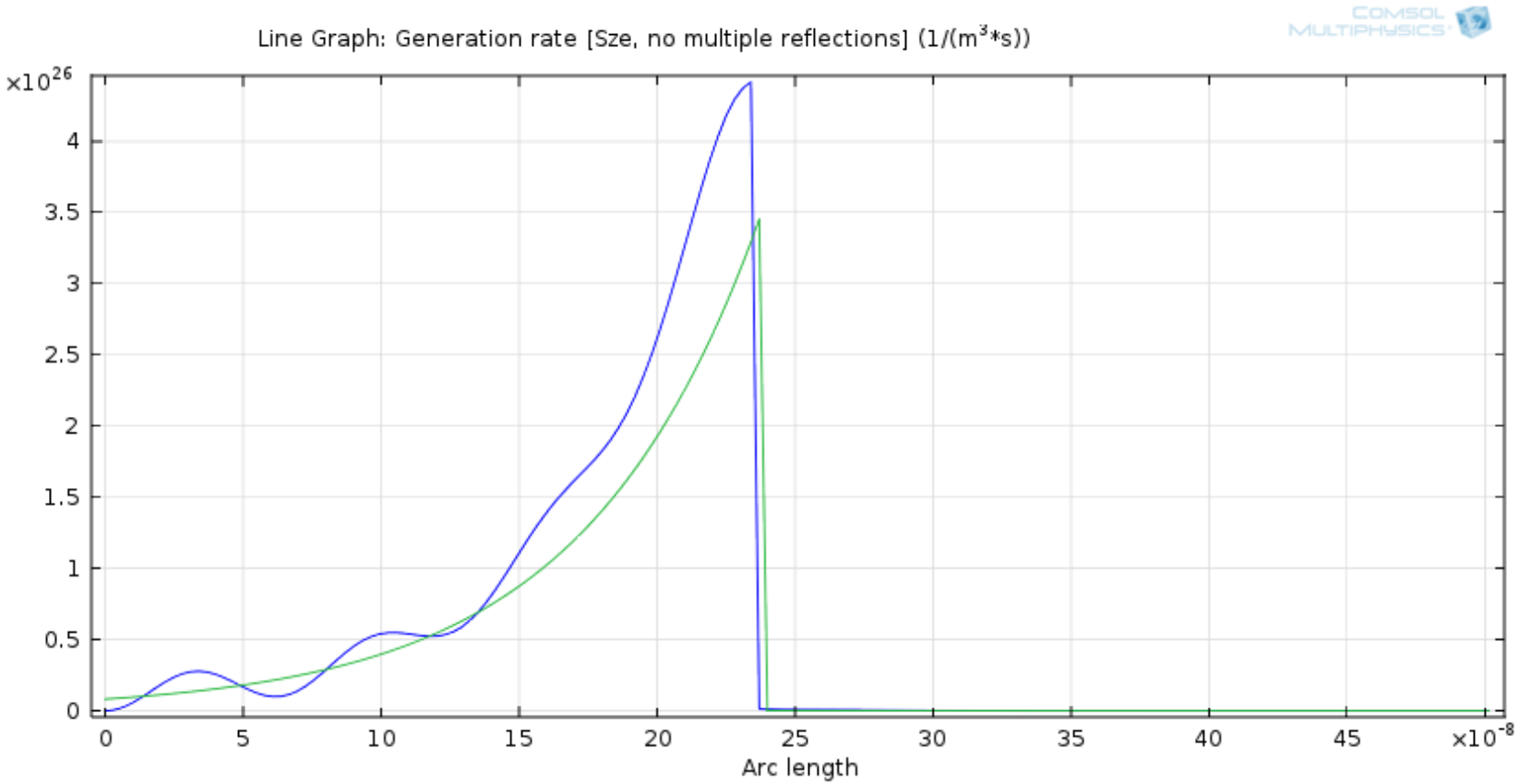


STUDY

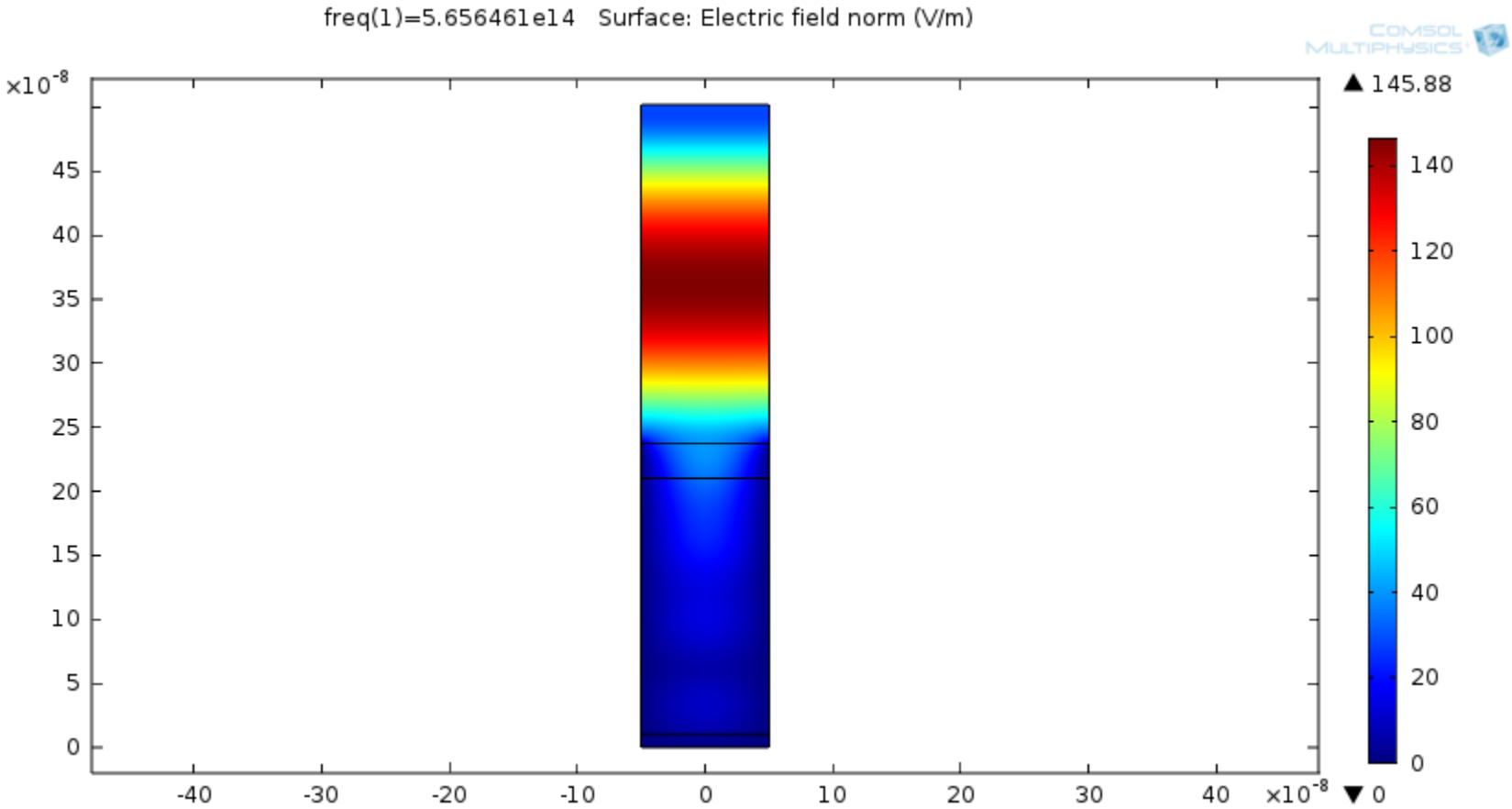


Ref: Dr. Samuele Lilliu, Masdar Inst. Of Sc. & Tech.

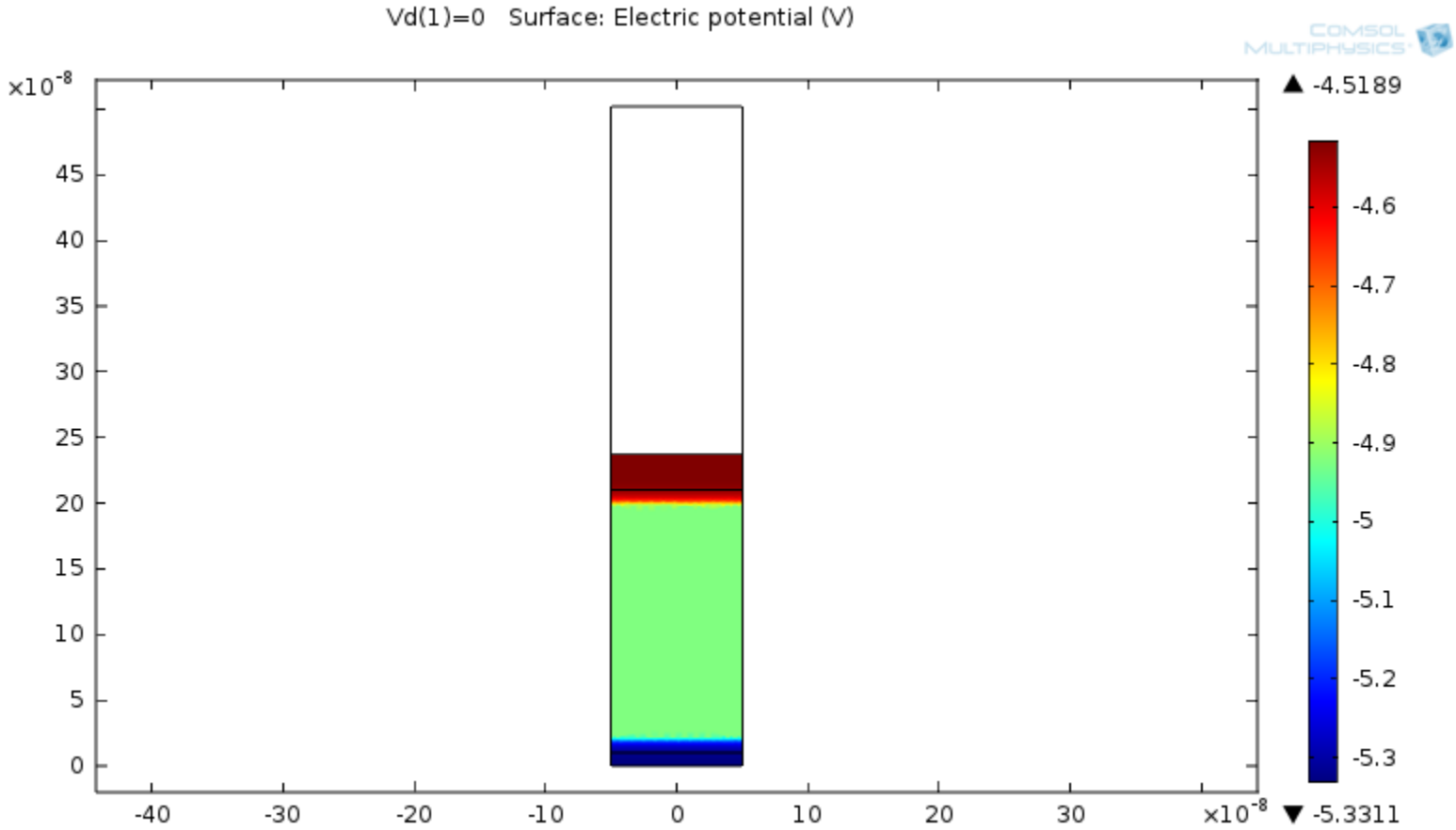
WAVELENGTH VS GENERATION RATE



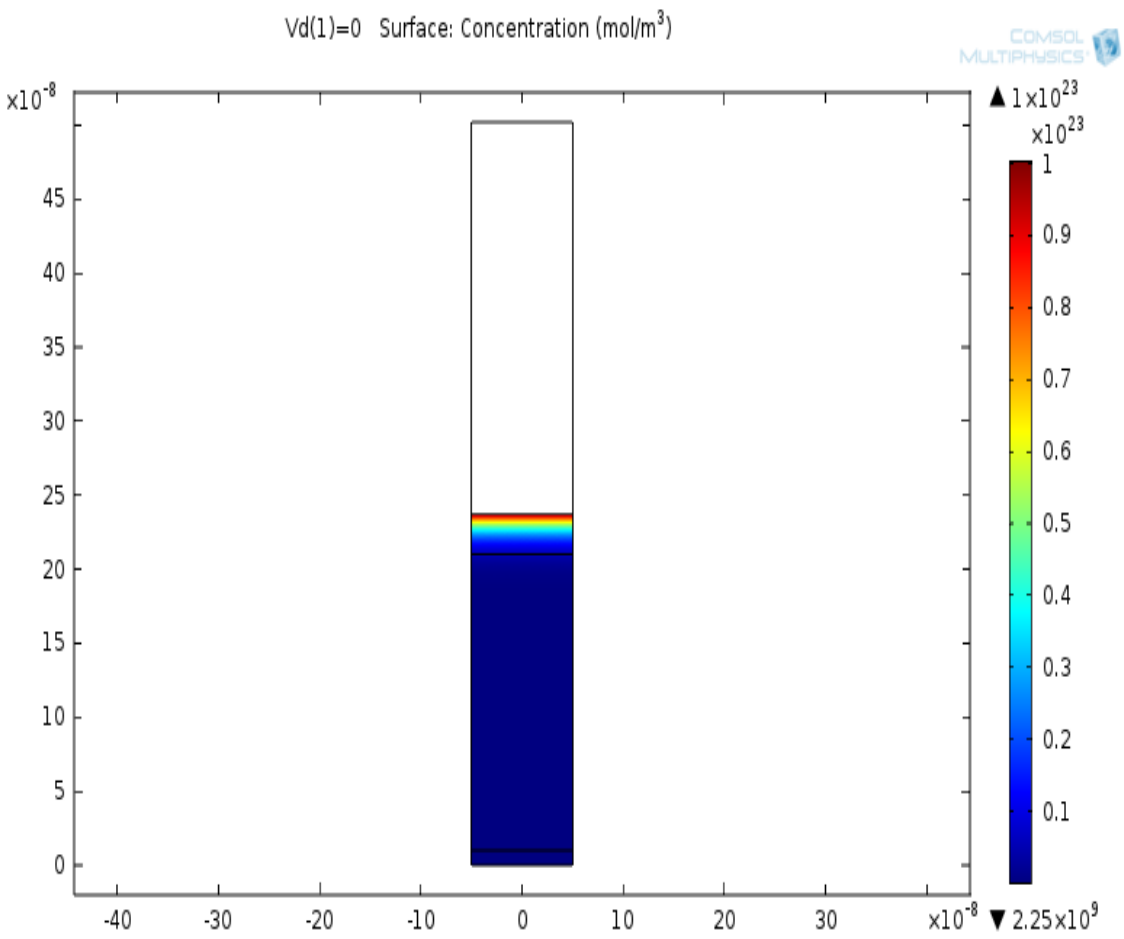
VARIATION OF WAVELENGTH



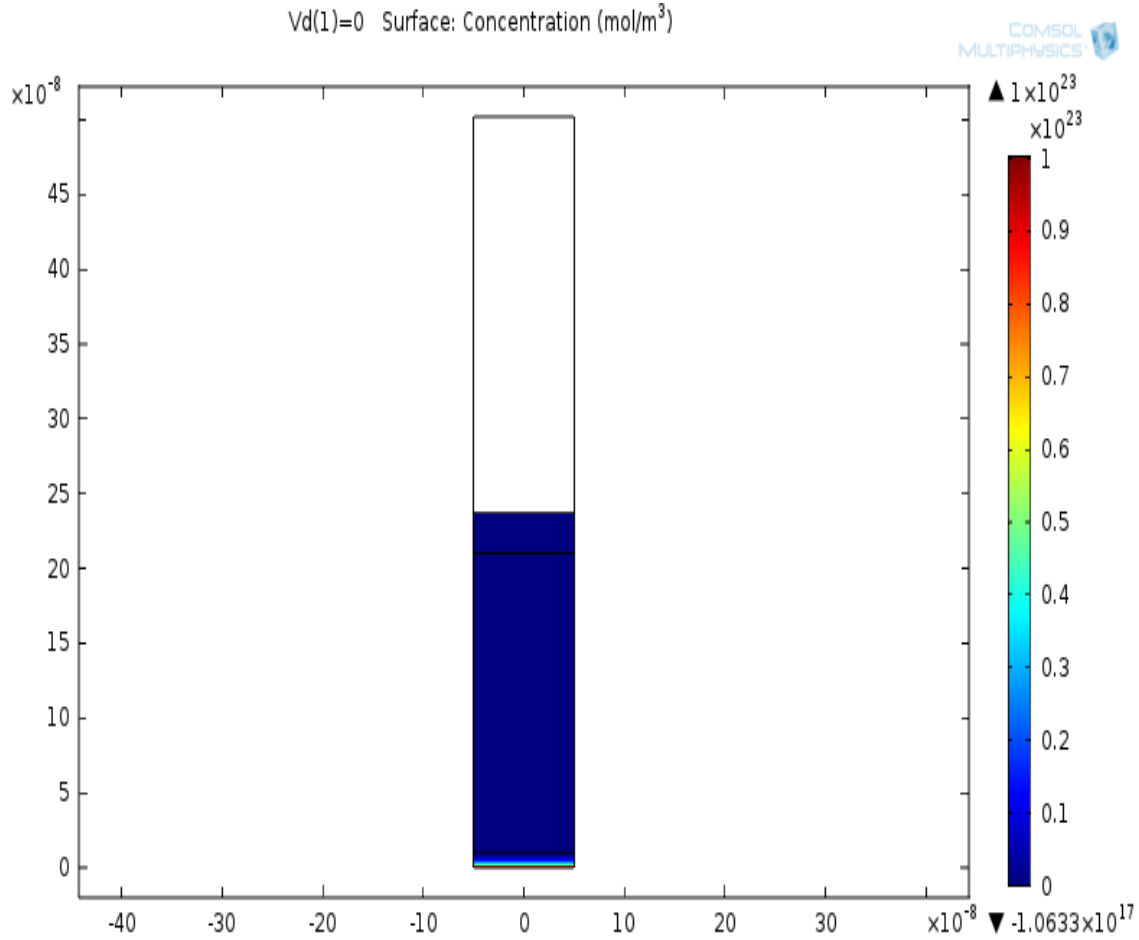
VARIATION OF SURFACE POTENTIAL



SURFACE CONCENTRATION

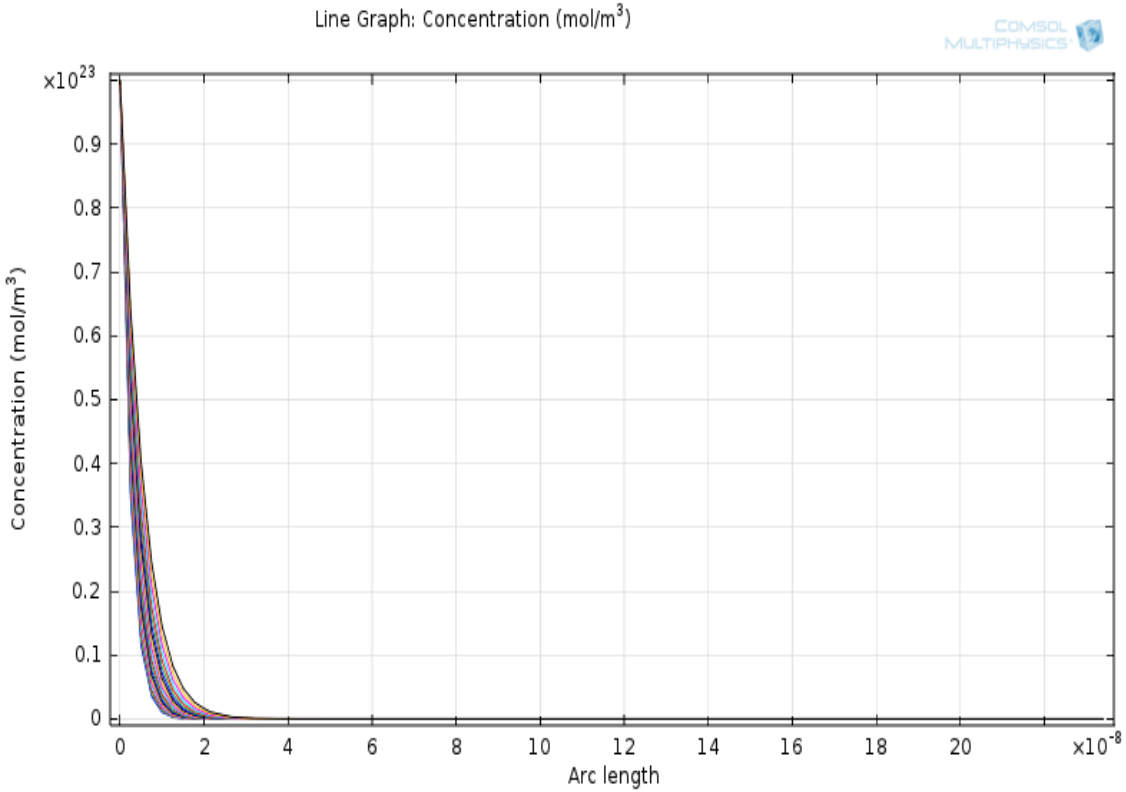


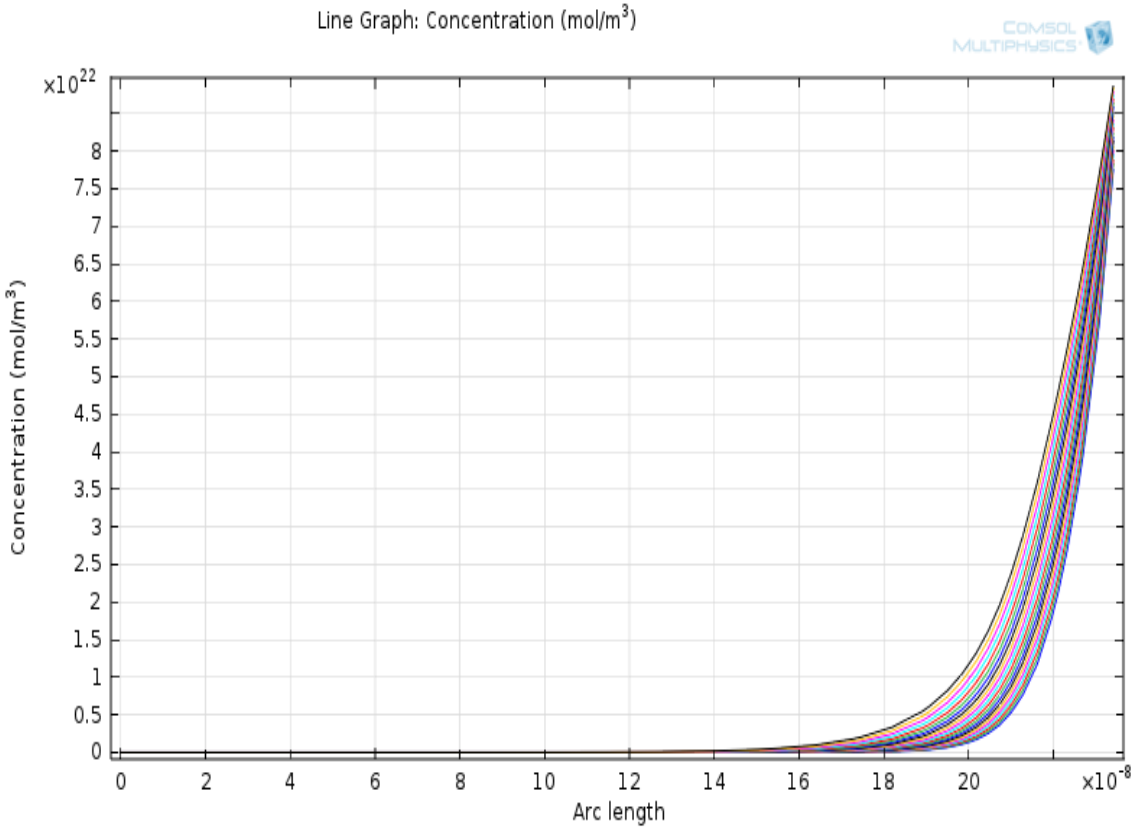
FOR ELECTRON



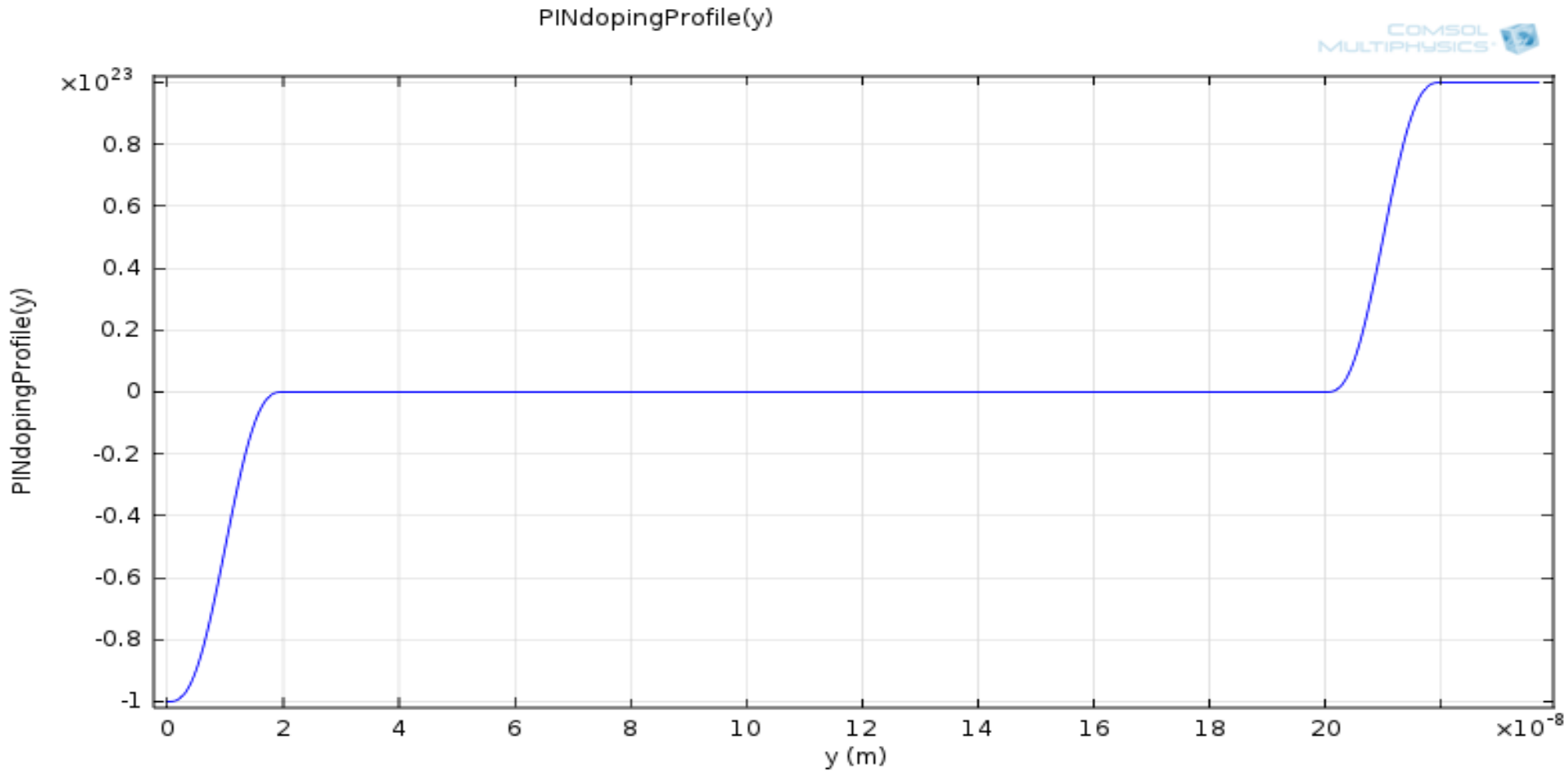
FOR HOLES

CONCENTRATION IN 1D PLOT

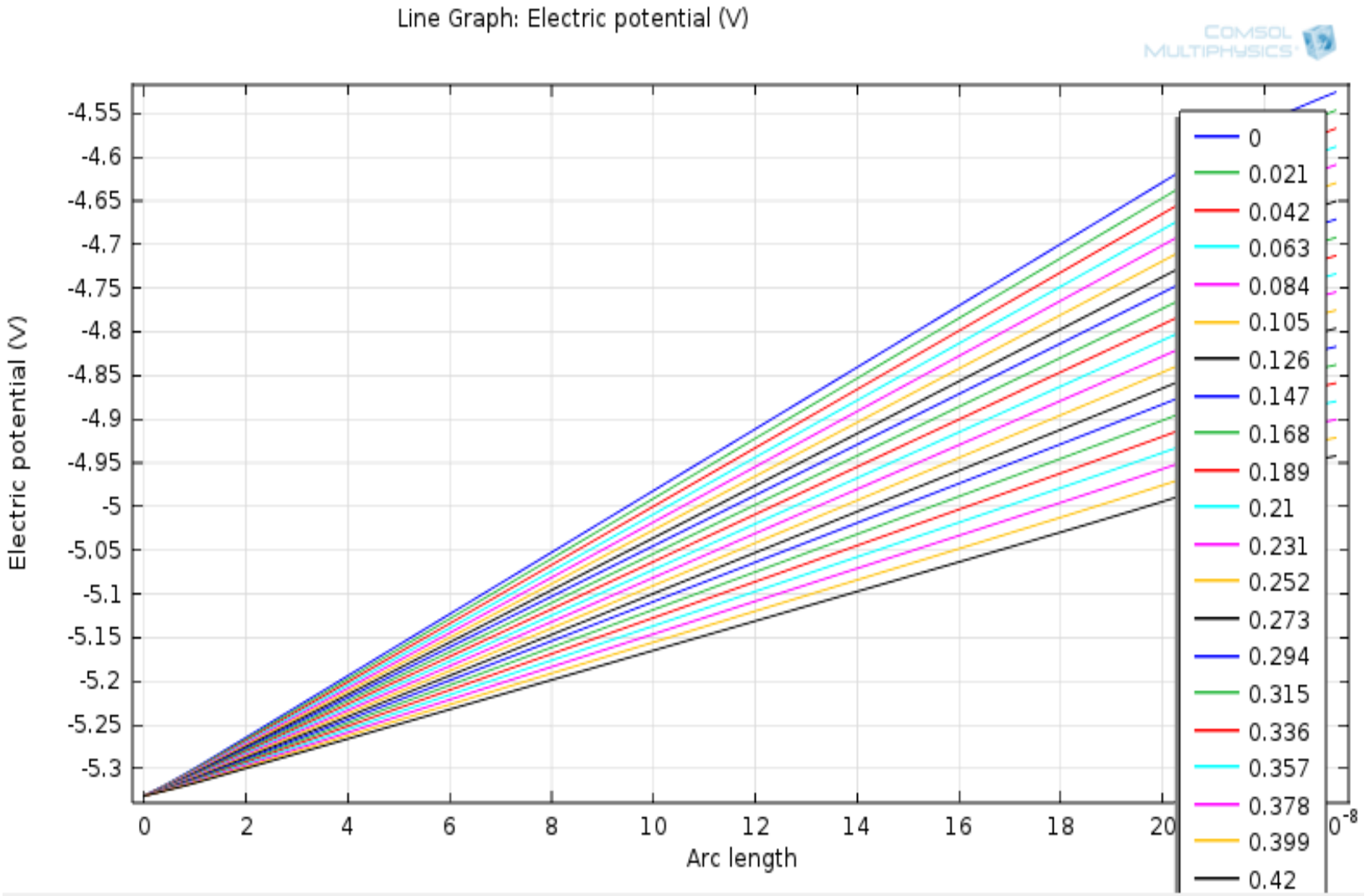




DOPING PROFILE



VOLTAGE SWEEP



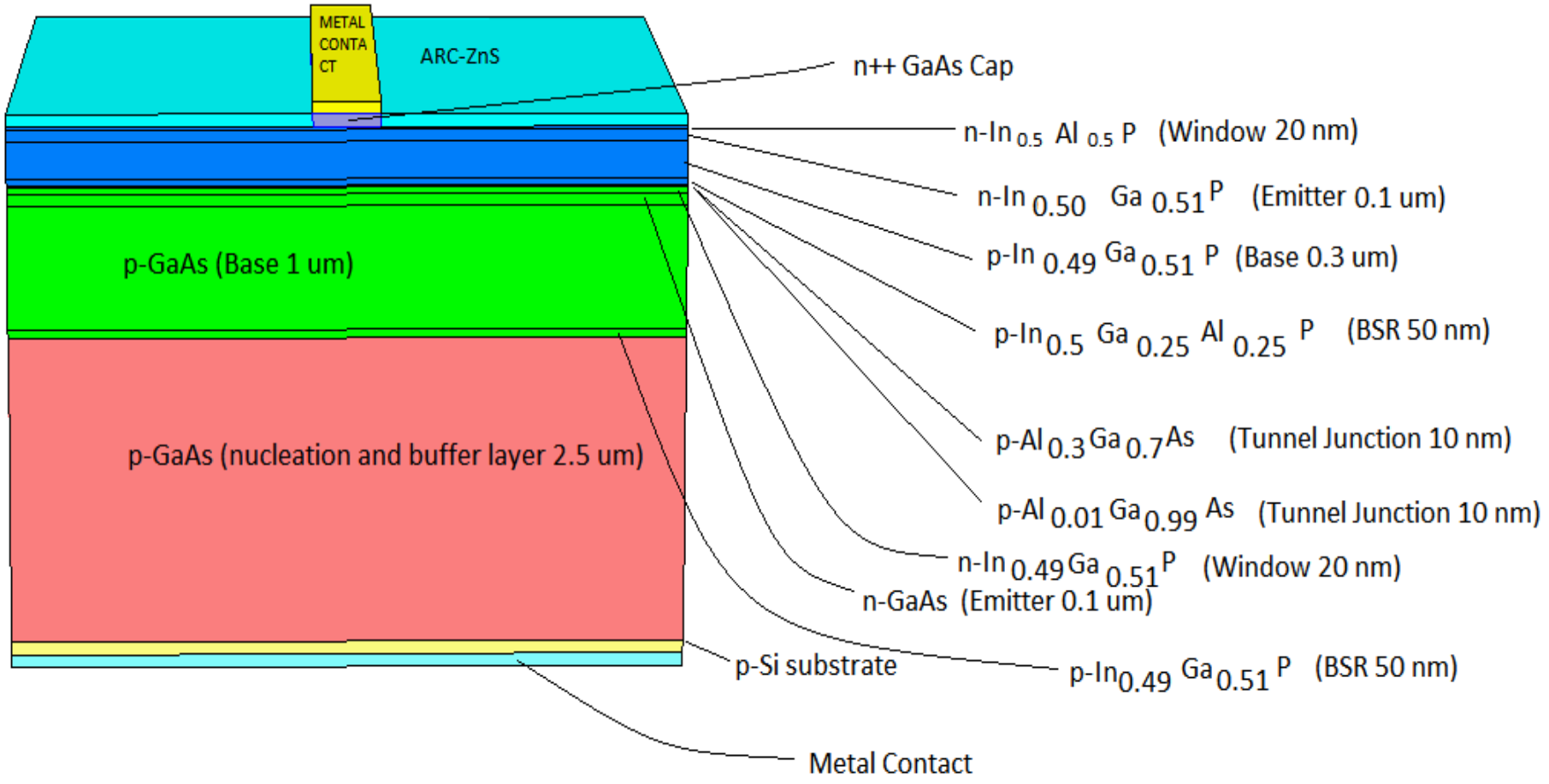
CONCLUSION

- Varying doping profile inside the device
- Change of refractive index of Si with thickness
- Deviation of actual generation term “G” from the generation predicted by Beer-Lambert.
- Change of concentration of electrons and holes inside the device under illumination condition
- How wavelength changes inside the device

FUTURE SCOPE & CHALLENGES

- This model is a basic heterojunction structure.
- Study of advanced devices like multijunction solar cell.
- After modeling multijunction solar cell optimizations can be carried out for various parameters.
- In the current model, we have given the irradiance to be 1000[w/m^2].

MULTIJUNCTION SOLAR CELL



LIGHT AT THE END OF THE TUNNEL

- High efficiency
- Low cost
- Small size
- Less heat
- Light weight

REFERENCES

- Ref [1] - B. Rand, P. Peumans and R. Forrest, Journal of Appl.Physics 96, p.7519, 2004.
- Ref [2]-R. R. King et al., “40% efficient metamorphic GaInP/GaInAs/Ge multijunction solar cells”.
- Ref [2]-M. Green et al., "Solar cell efficiency tables (version 41)," *Progress in Photovoltaics.*
- Ref [3]-National Renewable Energy Laboratory Website - http://www.nrel.gov/ncpv/.
- Ref [4]- Nikhil Jain “Design of multijunction solar cell on silicon substrate” , Virginia Polytechnic Institute.

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- Ref[5]. N.V. Yastrebova et al., "High-efficiency multi junction solar cells: Current status and future potential," University of Ottawa, 2007.

- Ref[6]. D. Shahrjerdi, et al., "High-efficiency thin-film InGaP/InGaAs/Ge tandem solar cells enabled by controlled spalling technology, " *Applied Physics Letters*, vol. 100, 2012, pp. 53901.

- Ref[7]. J. Luther, World in transition – towards a sustainable energy system, German Advisory Council on Global Change (WBGU), pp.3.

- Ref[8]. Solar photovoltaics by dr SOLANKI (book).

THANK YOU