COMSOL CONFERENCE BANGALORE 2013

Gallium Nitride based Metal-Semiconductor-Metal UV Photodetectors

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Outline

- Why III-nitride semiconductors?
- Metal-semiconductor-metal photodetectors
- Semiconductor Equations
- Comsol Model
- Interdigitated electrodes with corrugations
- Results and Conclusions

The Periodic Table

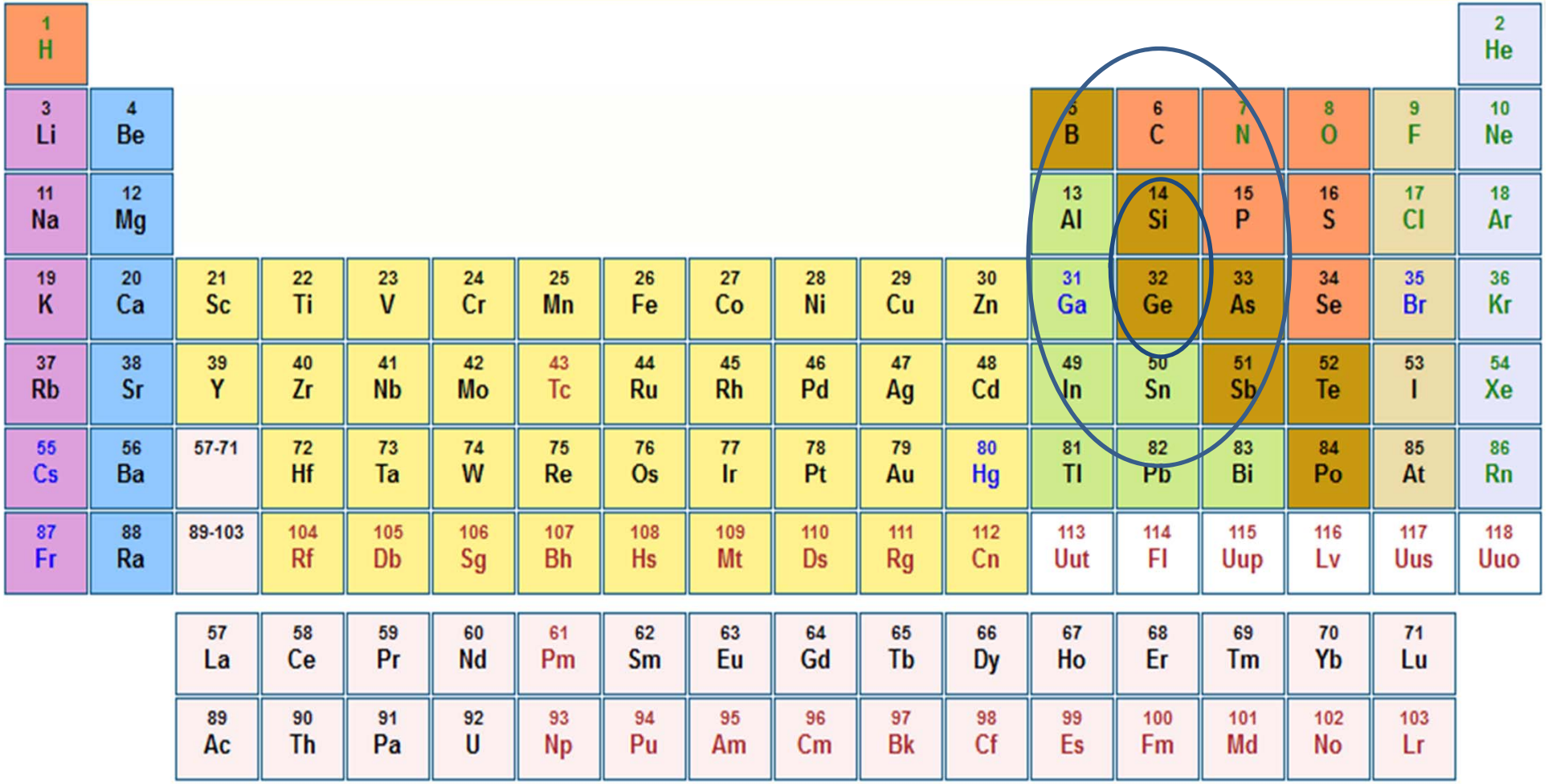


Image source: http://www.chemicool.com

Semiconductors

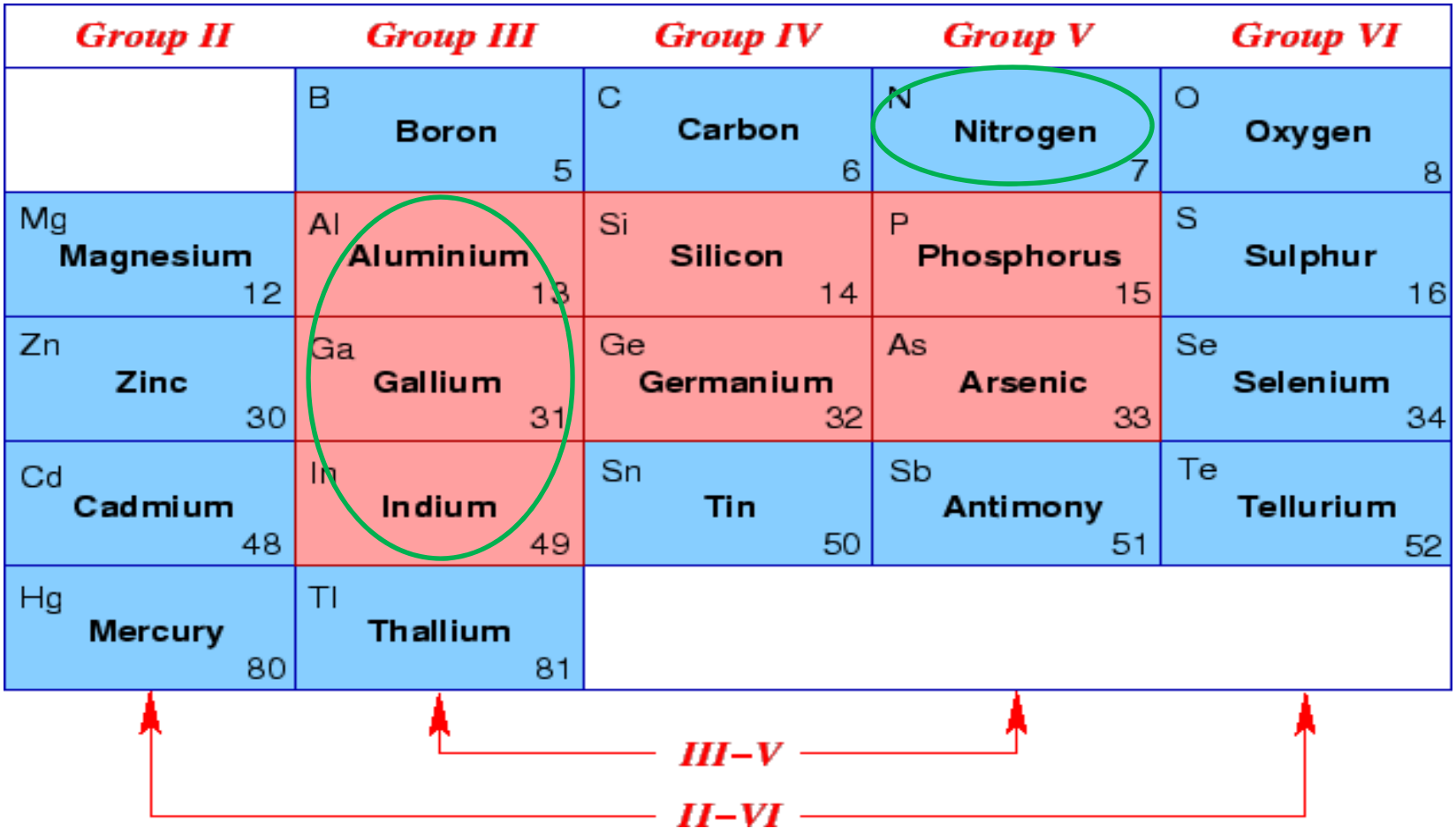
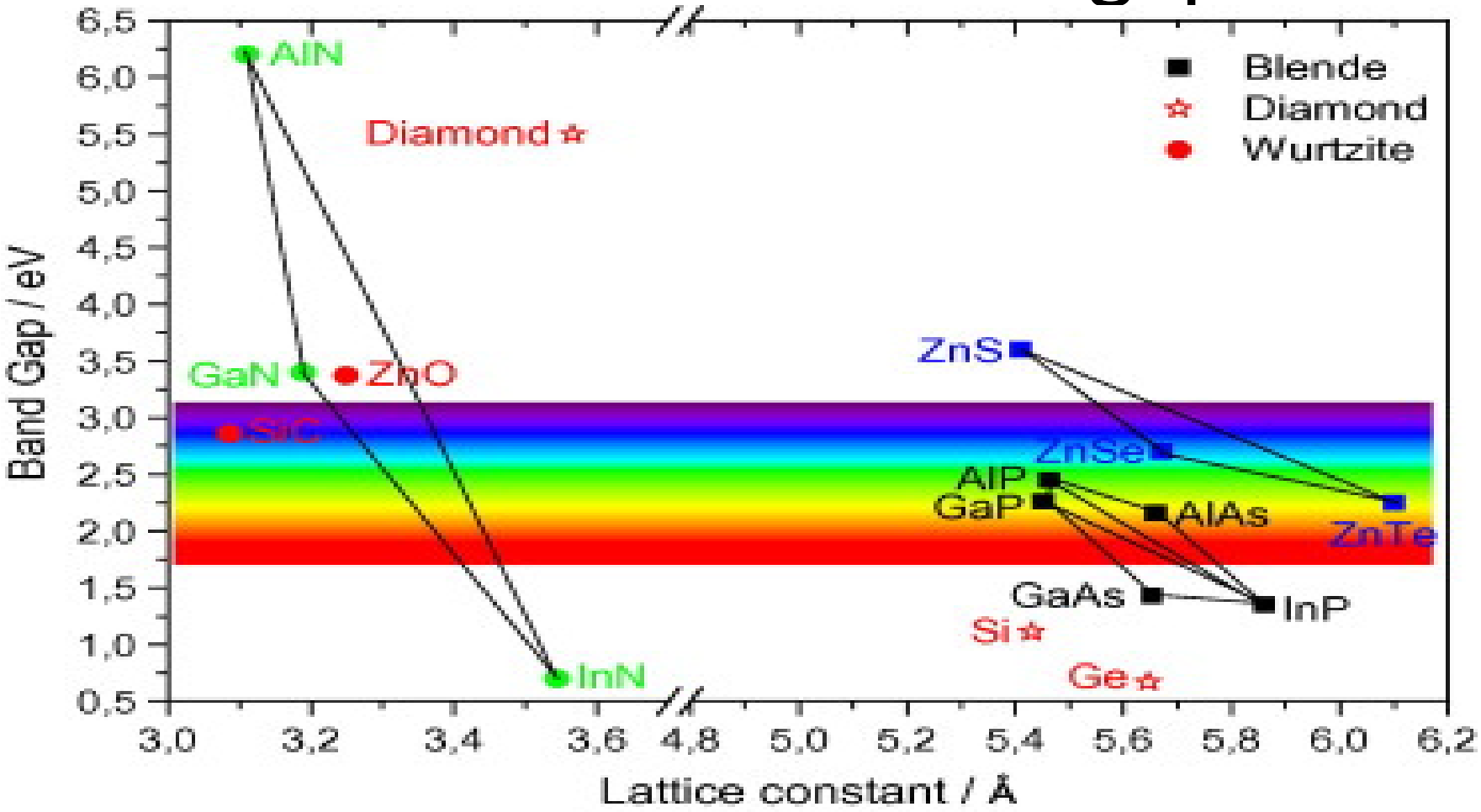


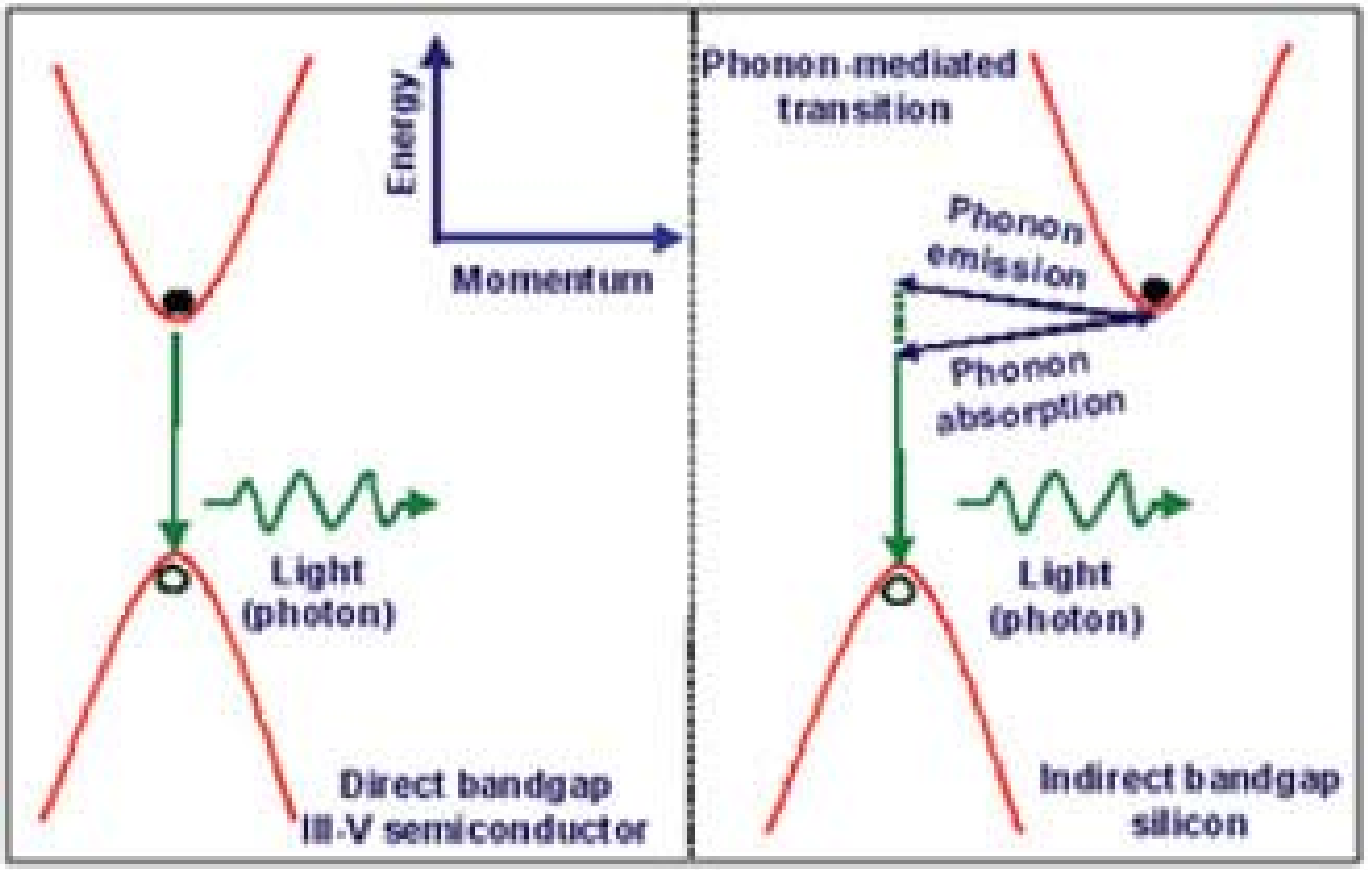
Image source: http://www.iue.tuwien.ac.at/phd/palankovski/node18.html

Semiconductor Bandgap



Ref: Ugo Lafont et al, “Increasing the reliability of solid state lighting system via self-healing approaches: A review”, Microelectronic Reliability 52(2012) 71-89

Direct and Indirect Bandgap



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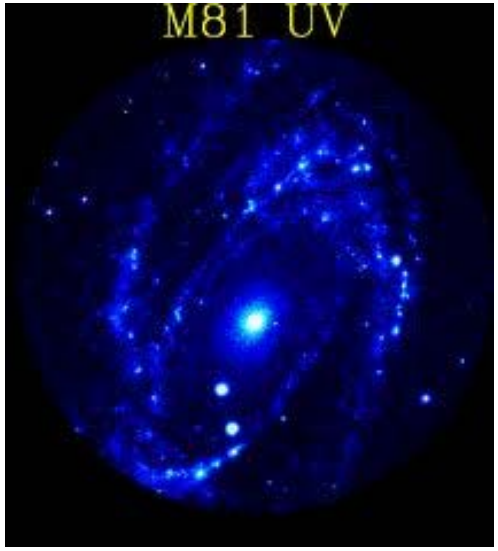
UV Photodetector Applications

Flame detectors

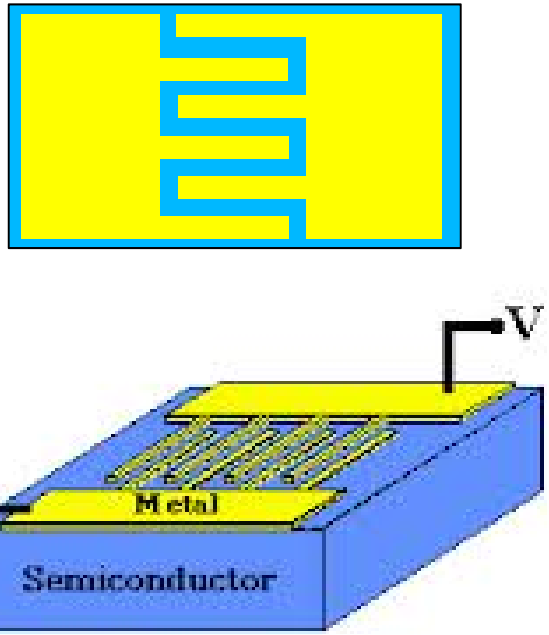
Ozone layer monitoring

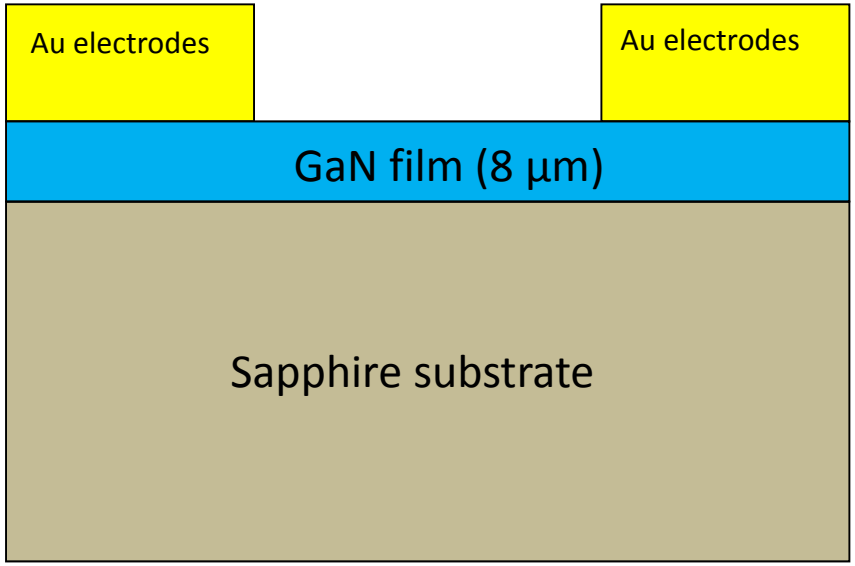
UV astronomy



Pollution monitoring

Metal-semiconductor-metal photodetector structure





MSM photodetector advantages:

- Ease of fabrication
- Inherently low capacitance
- Greater receiver sensitivity

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Semiconductor Equations

- Poisson's Equation

Required	$\nabla.(\nabla V) = -q(p - n + ND^{+} - NA^{-})$
Comsol	$\nabla.(\nabla V) = -q(p - n + ND^{+} - NA^{-})$

Semiconductor Equations

- Continuity Equation

Required	$\frac{\partial n}{\partial t} = \frac{1}{q}\nabla . J_n - U_n + G_n$ $\frac{\partial p}{\partial t} = \frac{1}{q}\nabla . J_p - U_p + G_p$
Comsol	$\frac{\partial n}{\partial t} = \frac{1}{q}\nabla . Jn - Un$ $\frac{\partial p}{\partial t} = \frac{1}{q}\nabla . J_p - U_p$

$$\emptyset = \emptyset_0 \exp[-\alpha(z - z_0)]$$

$$G = \alpha\emptyset$$

$$G = \alpha\emptyset_0 \exp[-\alpha(z - z_0)]$$

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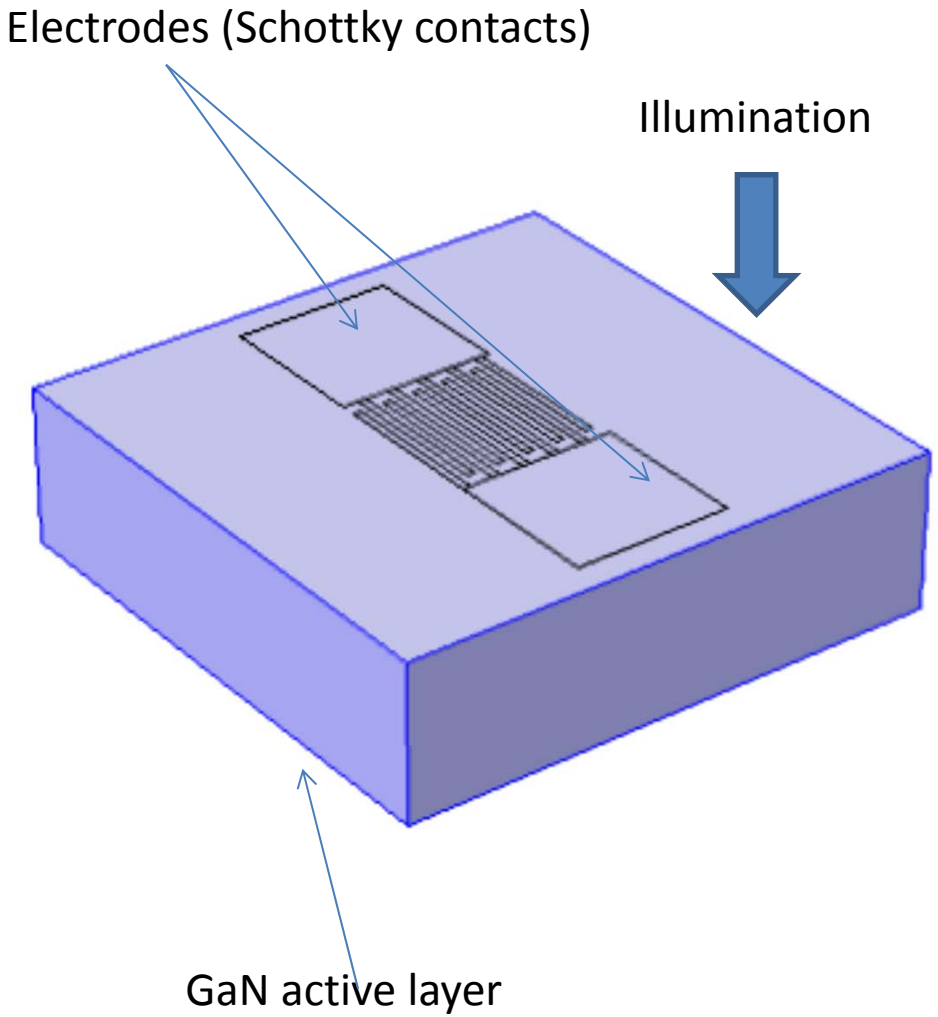
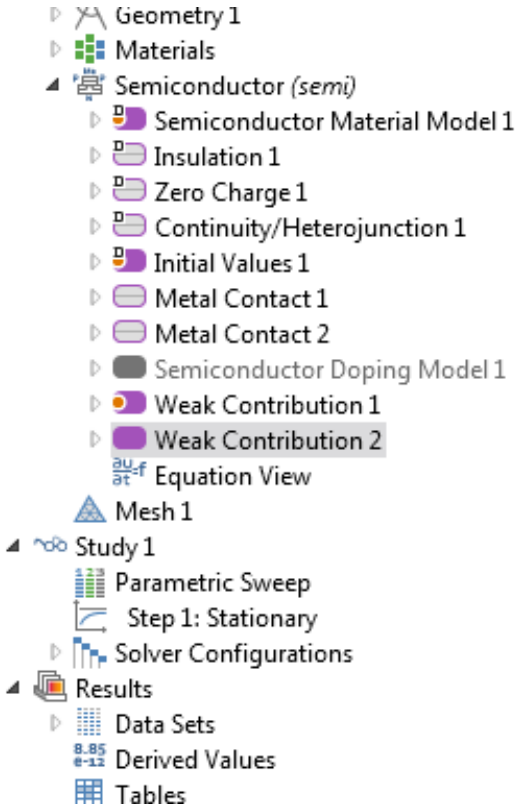
Comsol Model





Weak contribution node added to account for optical generation of electrons and holes

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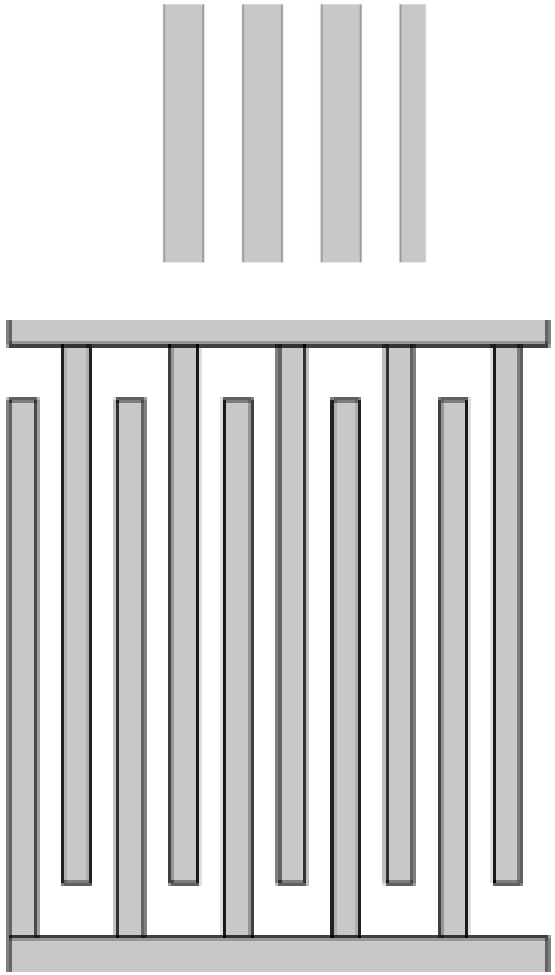
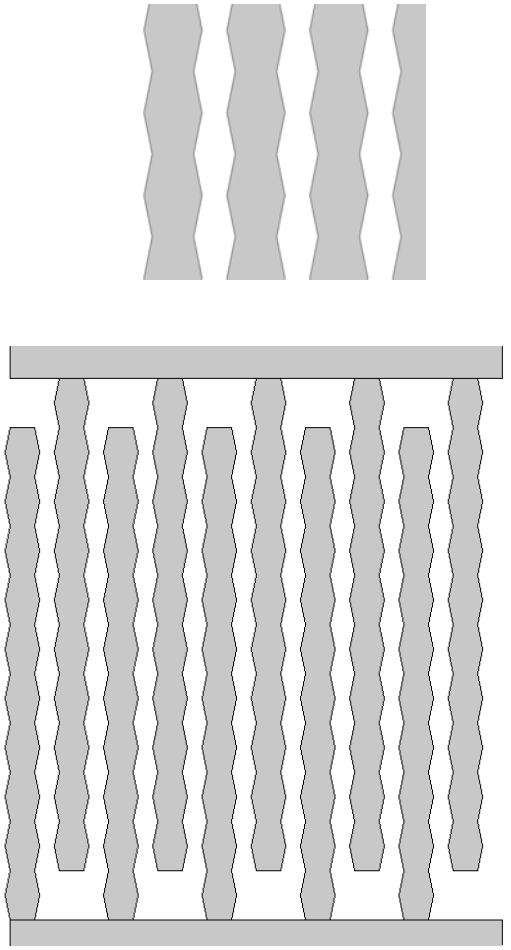
Corrugated Interdigited Electrodes





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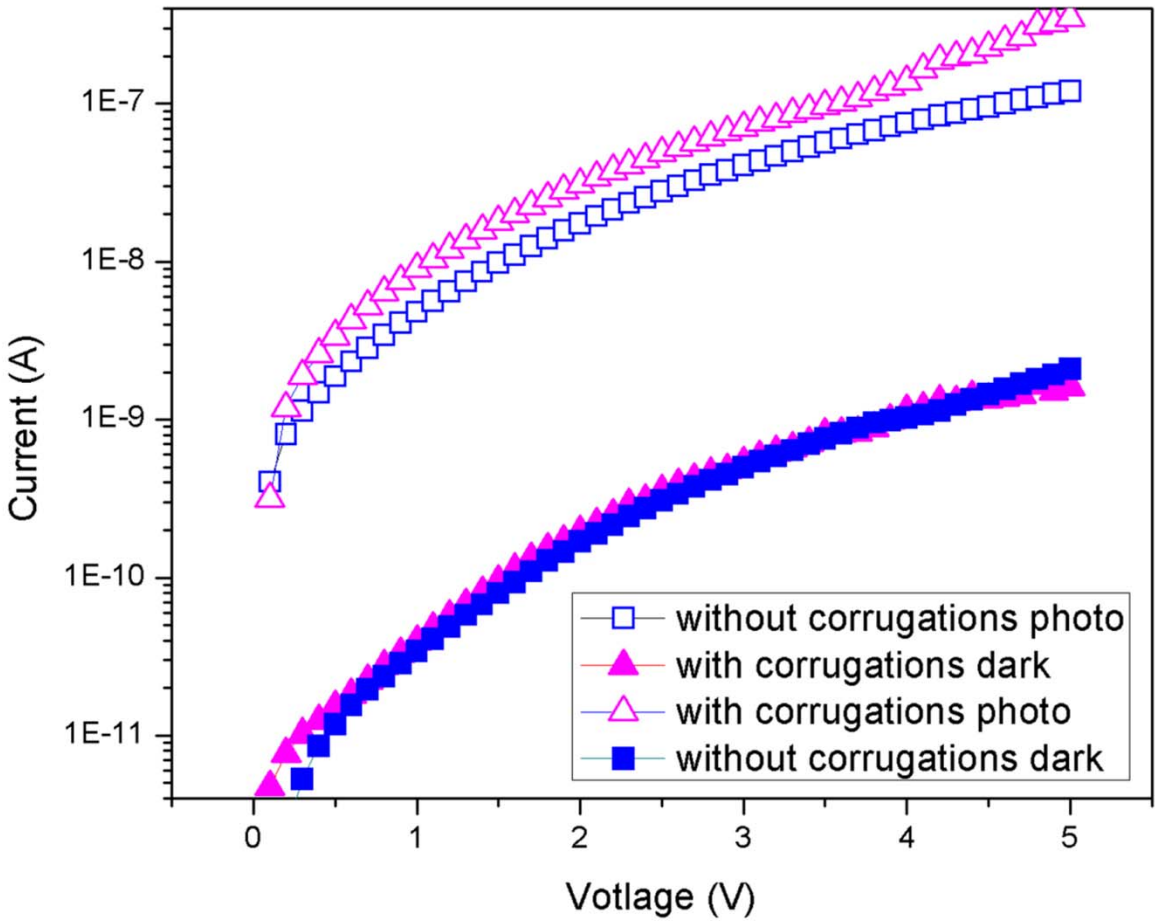
Photoresponse



- Increase in photoresponse!
- No free lunch!
  - R ↑ RC delay ↑
- Circular interdigited electrodes?
  - C ↓ RC delay ↓

Conclusions

- GaN based MSM photodetector modelled
- Photoresponse properties improved by using corrugated interdigitated electrodes
- Semiconductor module to be coupled with RF module in the future to sweep over incident frequencies