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# The influence of optical materials on the performance of concentrated Triple Junction Cells used in H-CPV modules.


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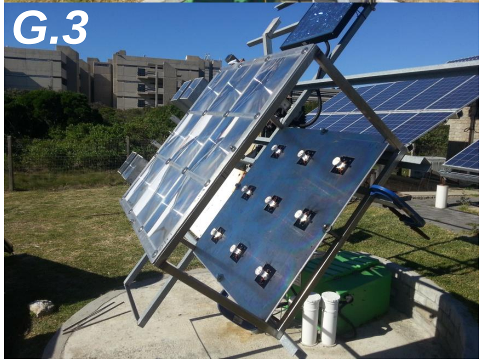
# Outline:

- H-CPV technology.
- Current generation from CTJ cells.
- Mechanical Reduction.
- Optical Reduction.
- Conclusion.

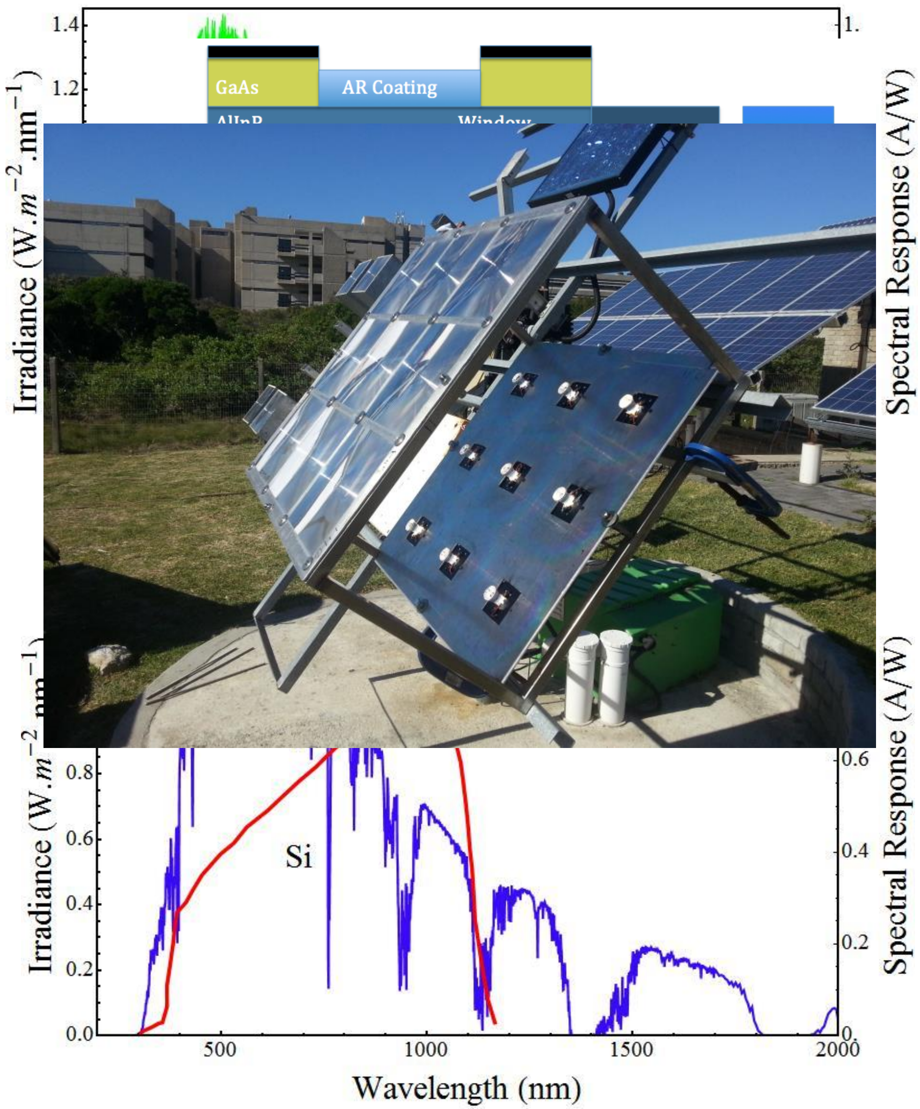

G.1


G.2


G.3

# Introduction:

- Multijunction (MJ) cells comprise of a number of monolithically grown subcells.
- Offer a better absorption of energy from a wider solar spectral range than that of conventional PV cells.
- Ideal for concentrator systems.




| | Si | CTJ |
|---|---|---|
| **Current Density** | 20.89 mA/cm$^{-2}$ | 13.10 mA/cm$^{-2}$ |
| **Voltage** | 0.6 V | 2.61 V |
| **Power** | 9.28 mW | 31.40 mW |
| **Efficiency** | 15.21% | 31.42 % |

# Identification of the Influence of the Optics:

***Current Generation:***

$$J_{sc} = \frac{I_{sc}}{\boxed{A}} = \int \boxed{R(\lambda)}\, \boxed{\phi_i\,(\lambda)}\, d\lambda.$$

***Device Influence:***

Semiconductor material.

- Spectral response
- Temperature

***Optical Influence:***

Spectral content.

- Absorption

Receiver Area.

- Intensity distribution

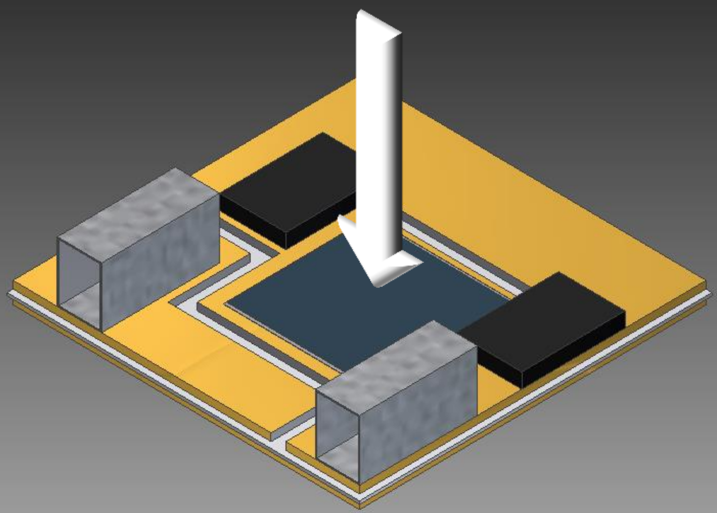
# Identification of the Influence of the Optics:

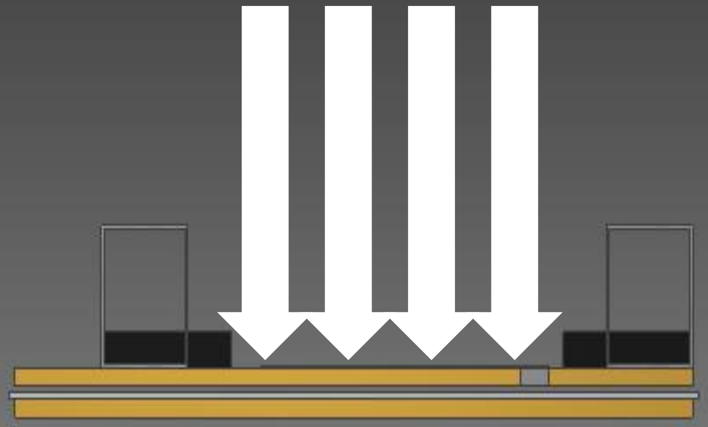
$$\uparrow J_{scc} = X_o.Min\{\int S(\lambda_n).\Phi_i(\lambda_n)\} \qquad n = 1,2,3\ldots$$

$$V_{oc} = \sum \frac{kT}{q} ln(\frac{C.I_{scn}}{I_{0n}}) \quad n = 1,2,3..$$

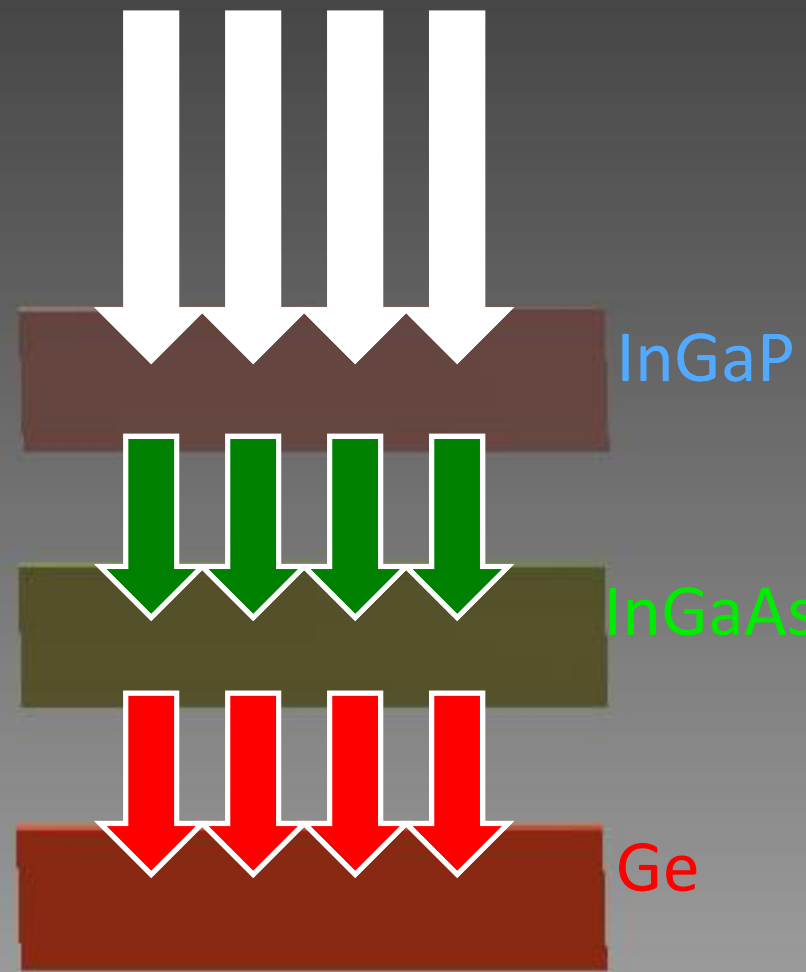
$$\eta_c = \frac{P_{out}}{P_{in}} \times 100 = \frac{V_{max} I_{max}}{X_o.Ir_d.A} \times 100$$

# Influence of Optical Concentration:

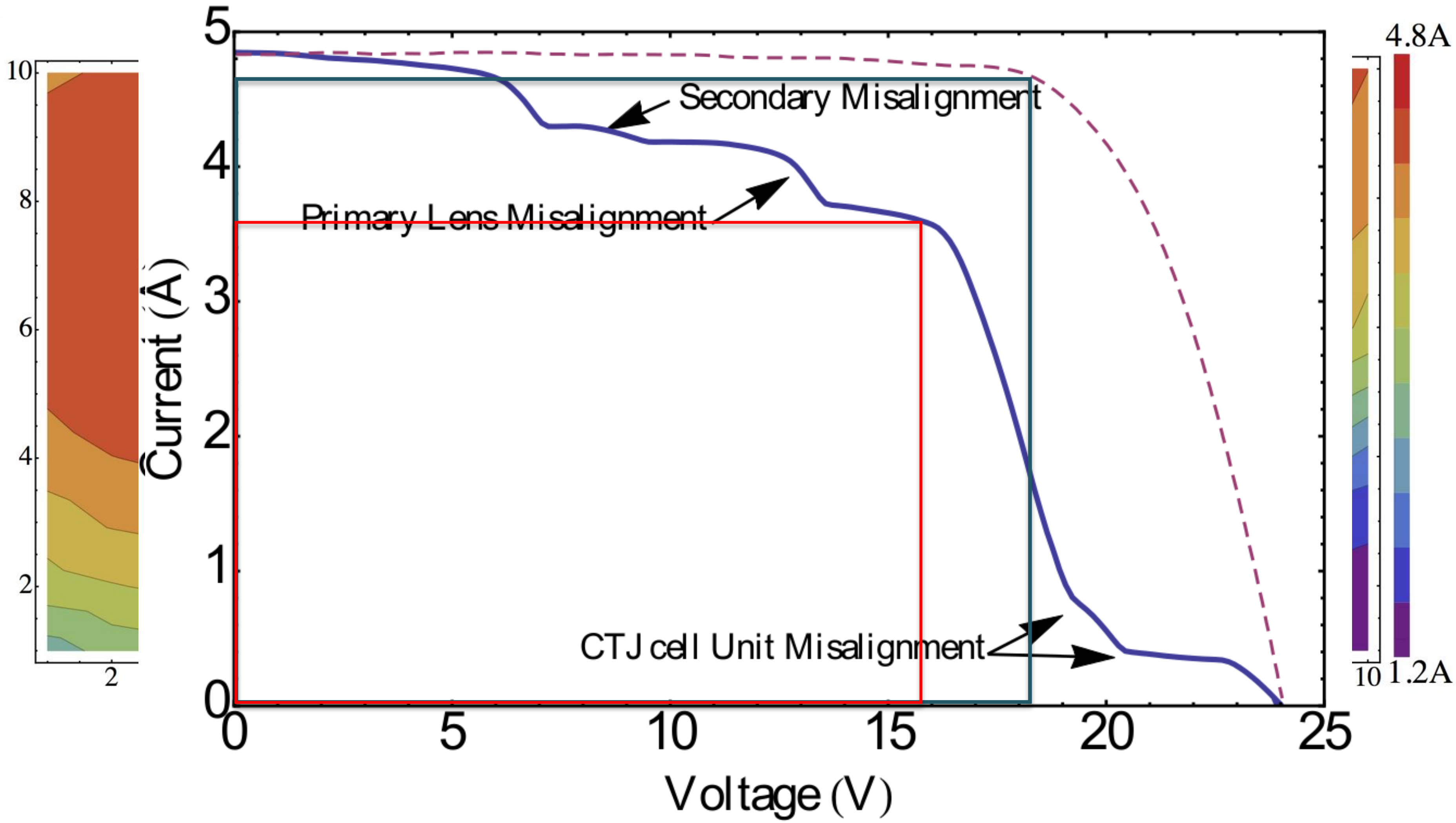




Combined intensity profile of $336X_o$ concentrated sunlight on a CTJ cell.

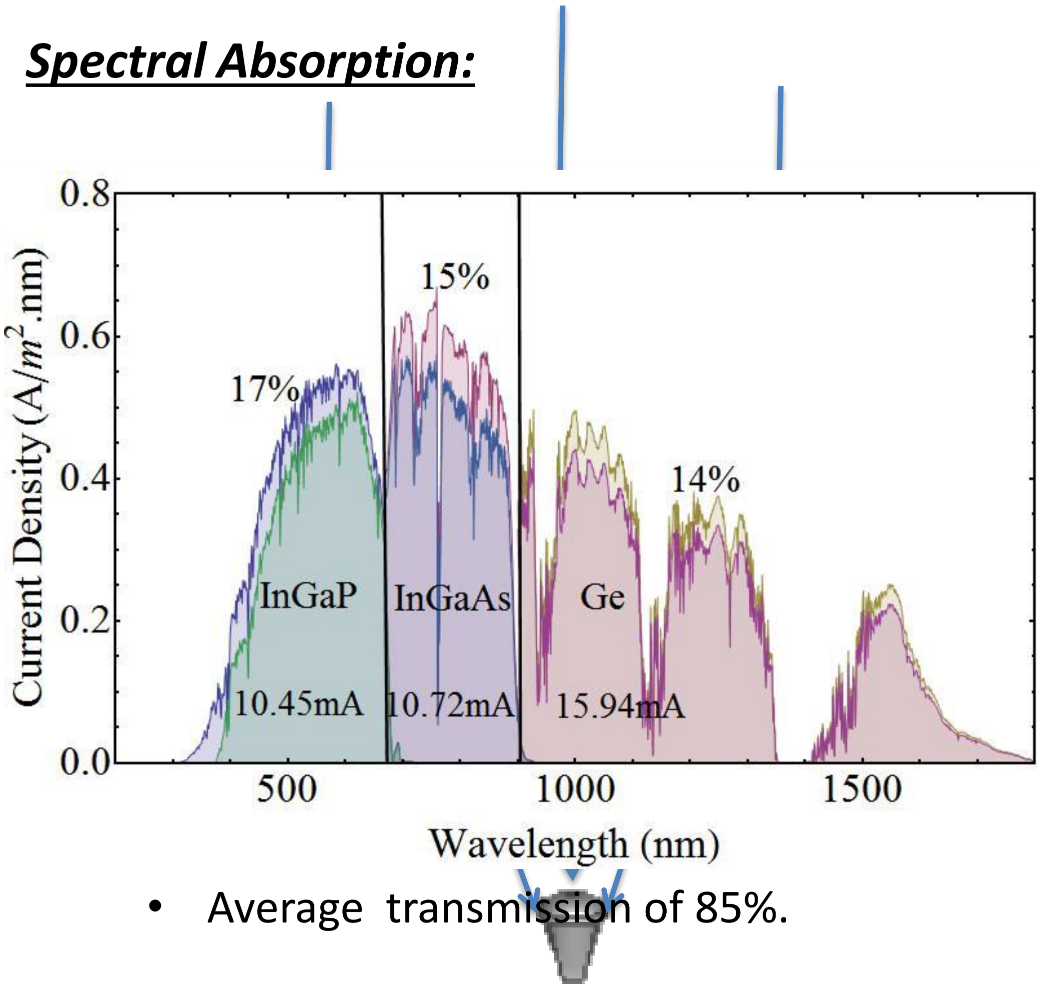


# Mechanical Misalignment:



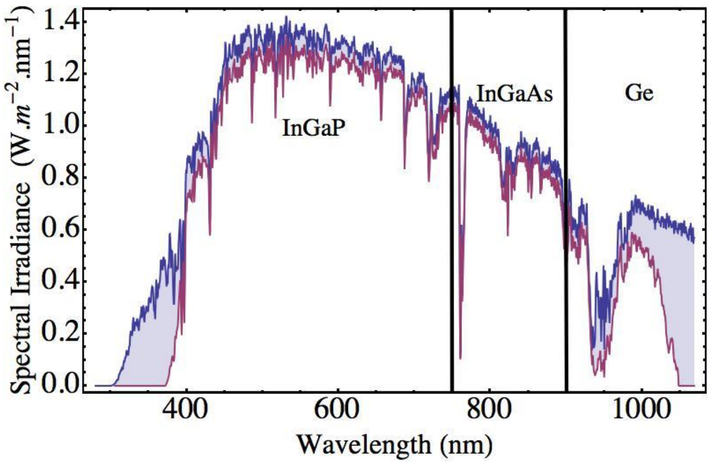
# Spectral Reduction:

***Spectral Absorption:***

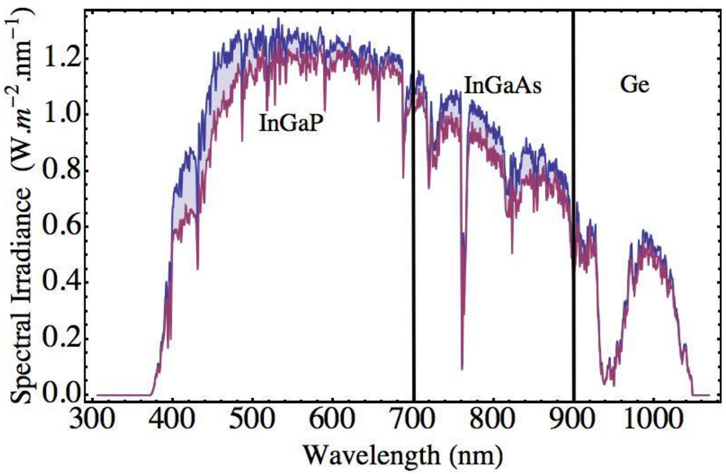



- Average transmission of 85%.

- Gross current production from the Ge subcell.

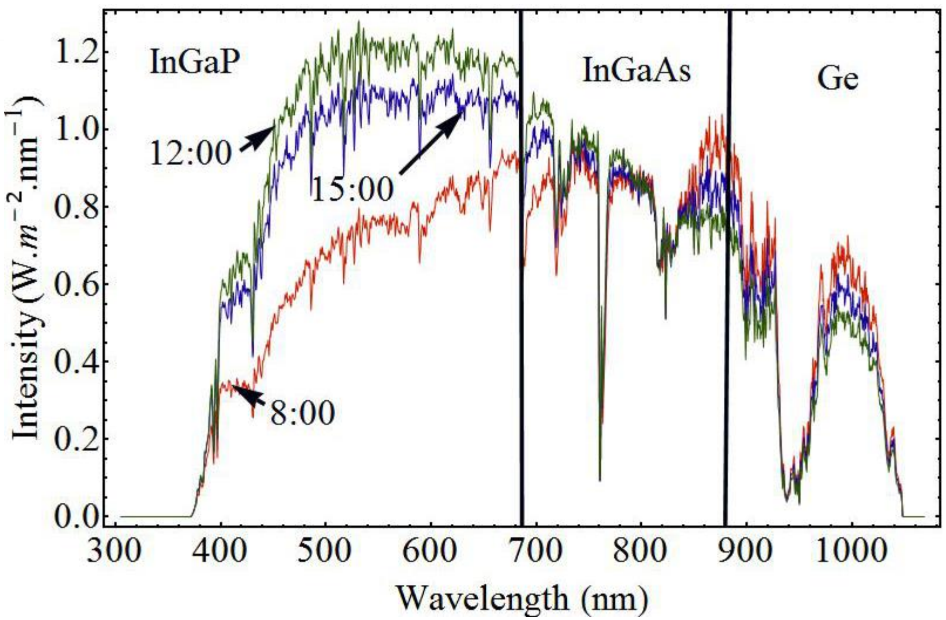



Wavelengths below 400nm cutoff.




InGaP subcell is the most affected.

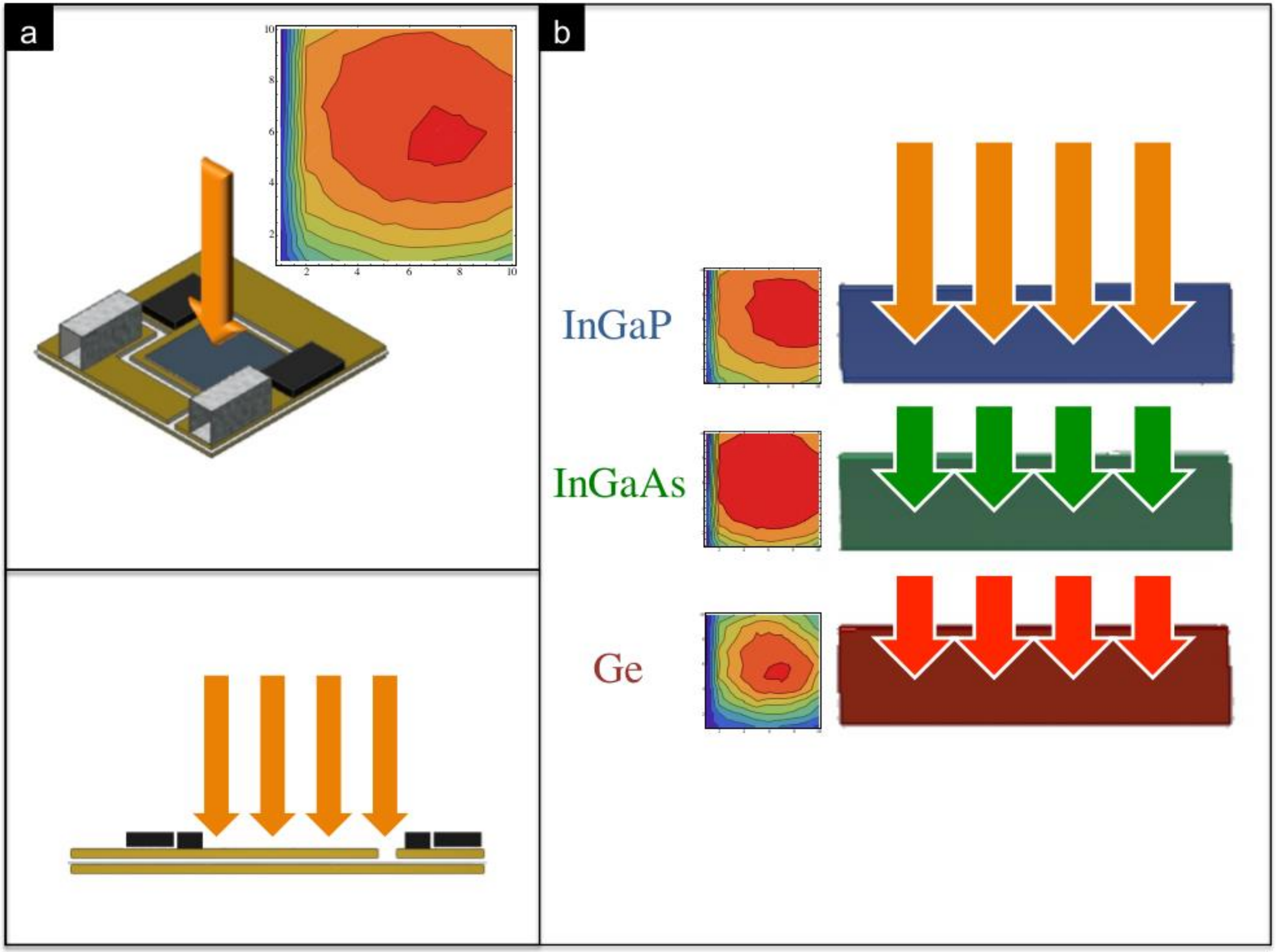
# Spectral Change:




| Time (h) | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|
| InGaP (mA/cm$^{-2}$) | 6.60 | 8.82 | 8.45 | 9.91 | 10.45 | 10.22 | 9.51 | 8.89 |
| InGaAs (mA/cm$^{-2}$) | 11.22 | 11.23 | 11.46 | 11.50 | 11.51 | 11.48 | 11.43 | 11.33 |
| Variation (%) | 42 | 22 | 17 | 14 | 10 | 11 | 17 | 21 |

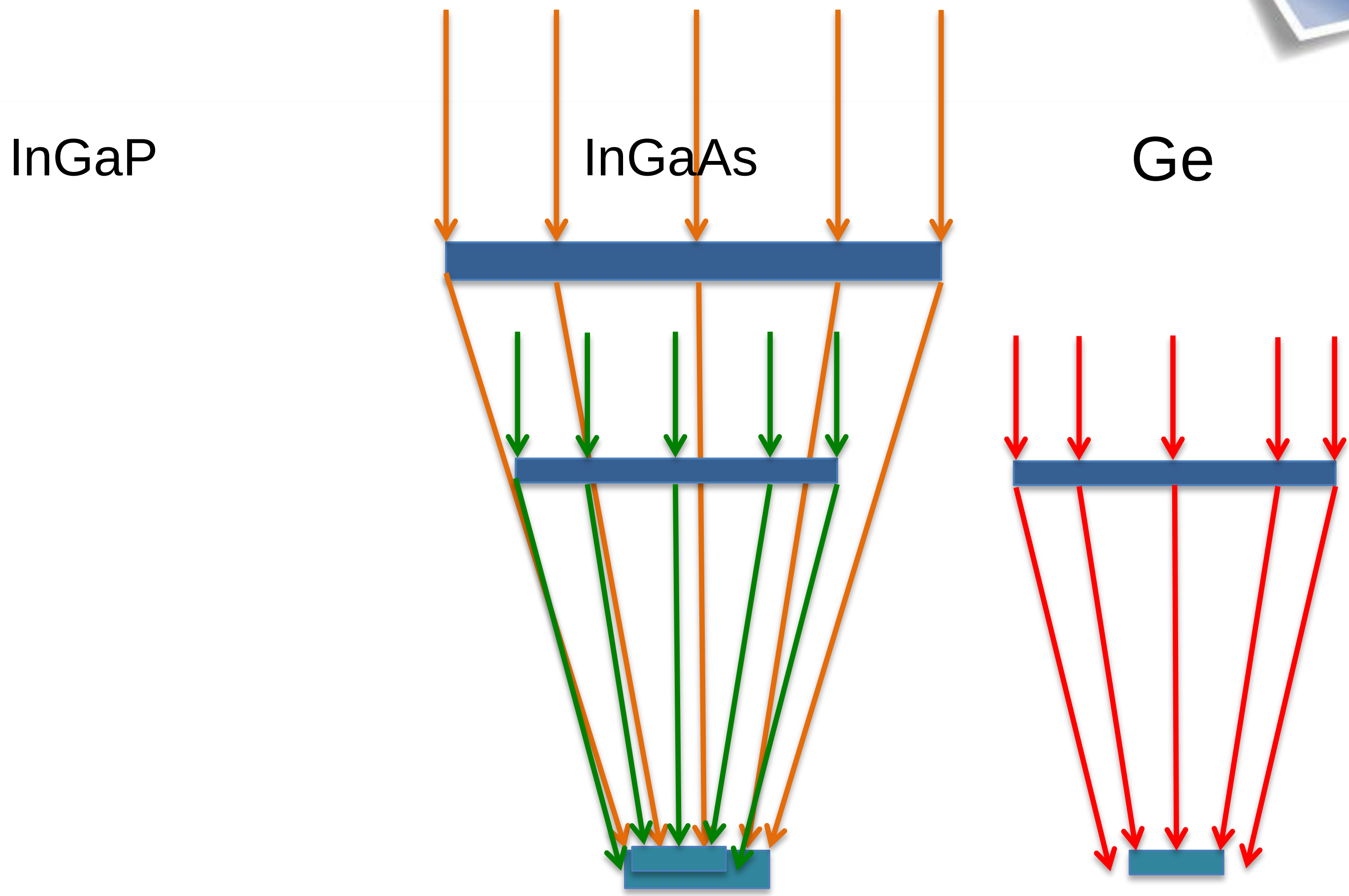
# Optical Intensity Profiles:

***Intensity profile of each subcell taken at solar noon.***

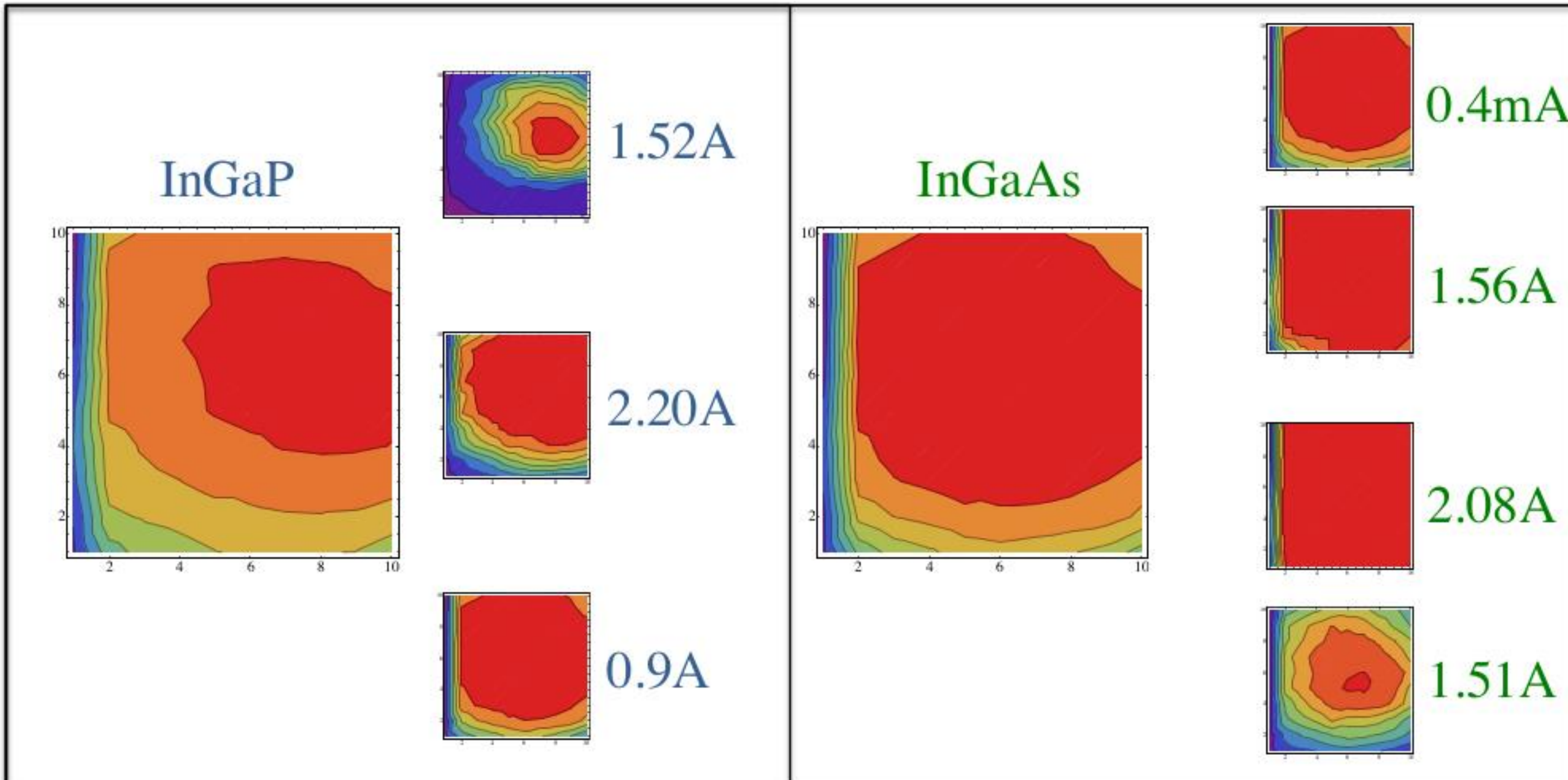


# Optical Intensity Profiles:

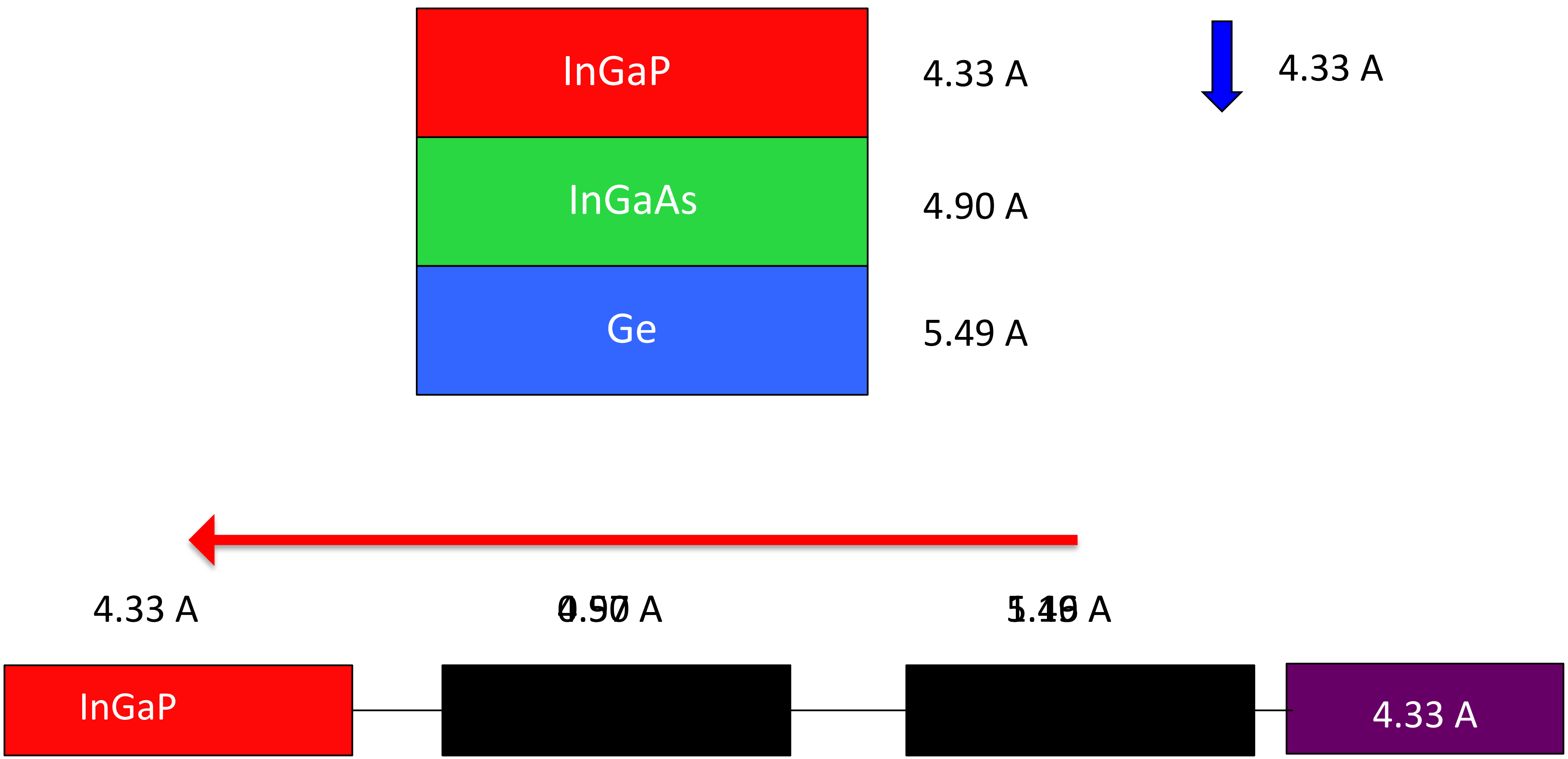
***Chromatic Aberrations:***



# Chromatic Aberrations Effects:



# Current Mismatch:



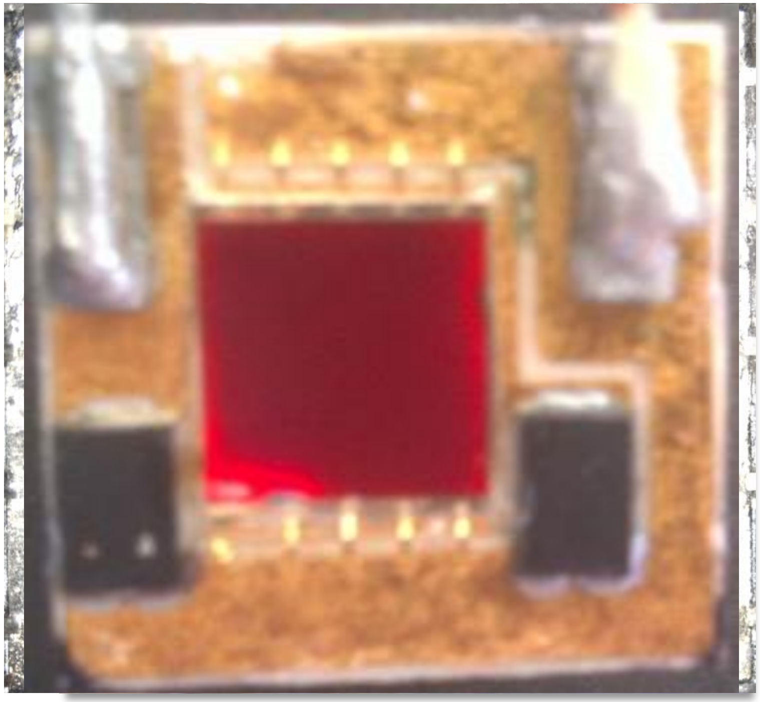
# Cell Damage:

## Visual damage:

- Creating burning and delamination of cell encapsulant.
- Decrease in active cell area.
- Decrease in power output.

## Microscale damage:

- Non-uniform luminescence pattern.
- Corresponds to the current density pattern at 330X.
- Low free carrier density in low luminescence intensity areas.
- Could leads to deficiencies in the free carrier concentrations.



# Conclusions:

- That the performance of the H-CPV module is highly dependent on the optical system.
- That the optical system can create an non-uniform intensity distribution resulting from mechanical misalignment and chromatic aberrations.
- The optical system materials reduce the concentrated spectrum unequally within the subcell region.
- These reductions created an uneven current production from each subcell which may leads to current mismatch.
- Current mismatch lead to a decrease in performance, cell damage or complete device failure.

# Acknowledgements:

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# Intensity Distribution Measurements:

- X-Y raster scanner programmed in LabVIEW.
- Optic fibre allows for measures of the spectrum at each point.
- Creates an intensity topography for the cell area.