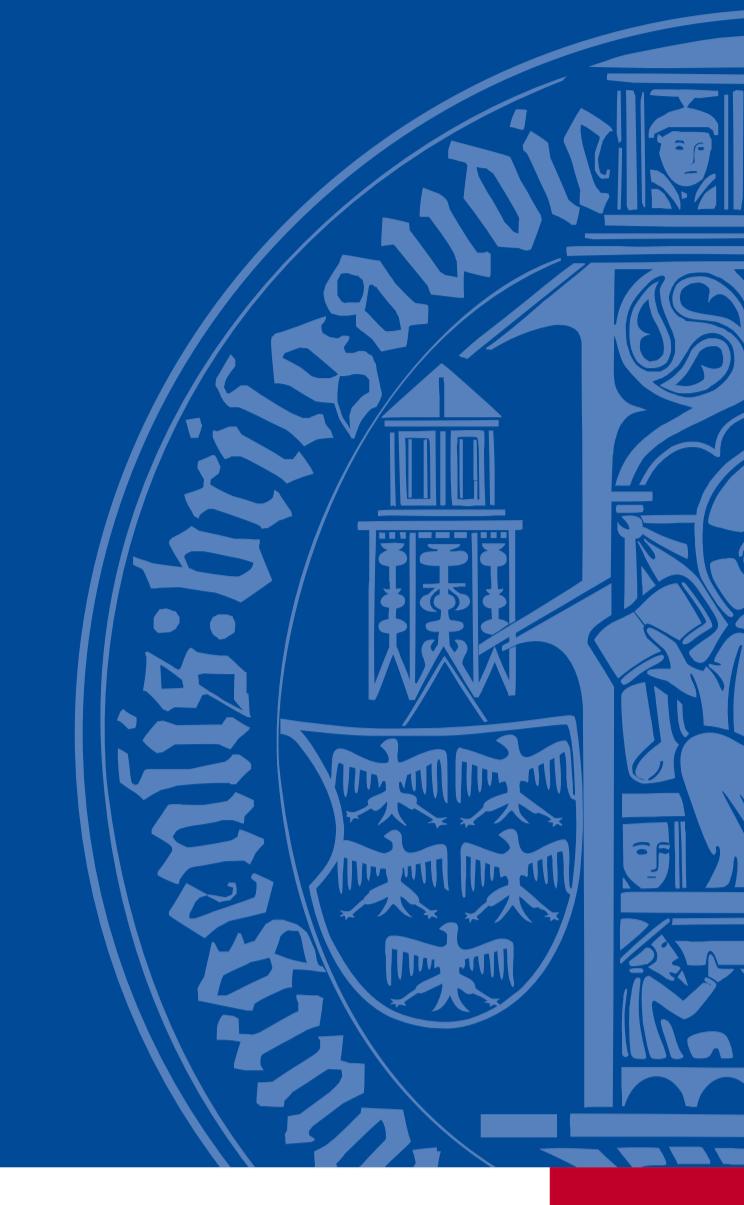


Effect of Temperature on Performance of Solar Cells

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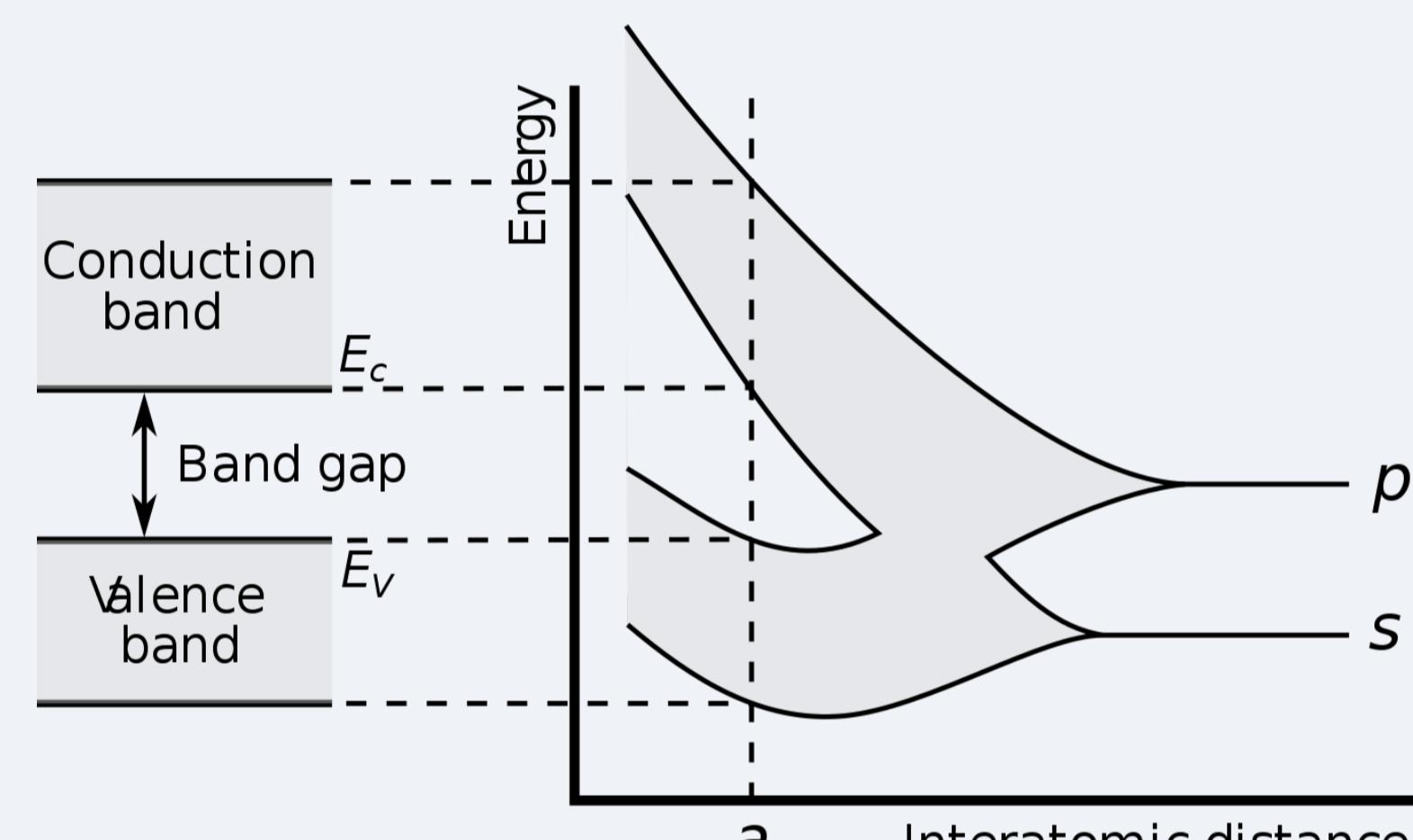
Introduction

- Climate change affects temperature
 2018 : Warmest summer, 8 of 9 hottest years since 1881 (DWD)
- The performance of Solar cell is affected by temperature
- Temperature dependency response to changing environment

Theoretical Background

- Temperature dependent parameters

$$\uparrow T \rightarrow \uparrow J_{sc} \rightarrow \downarrow\downarrow V_{oc} \rightarrow \downarrow P_{max}$$

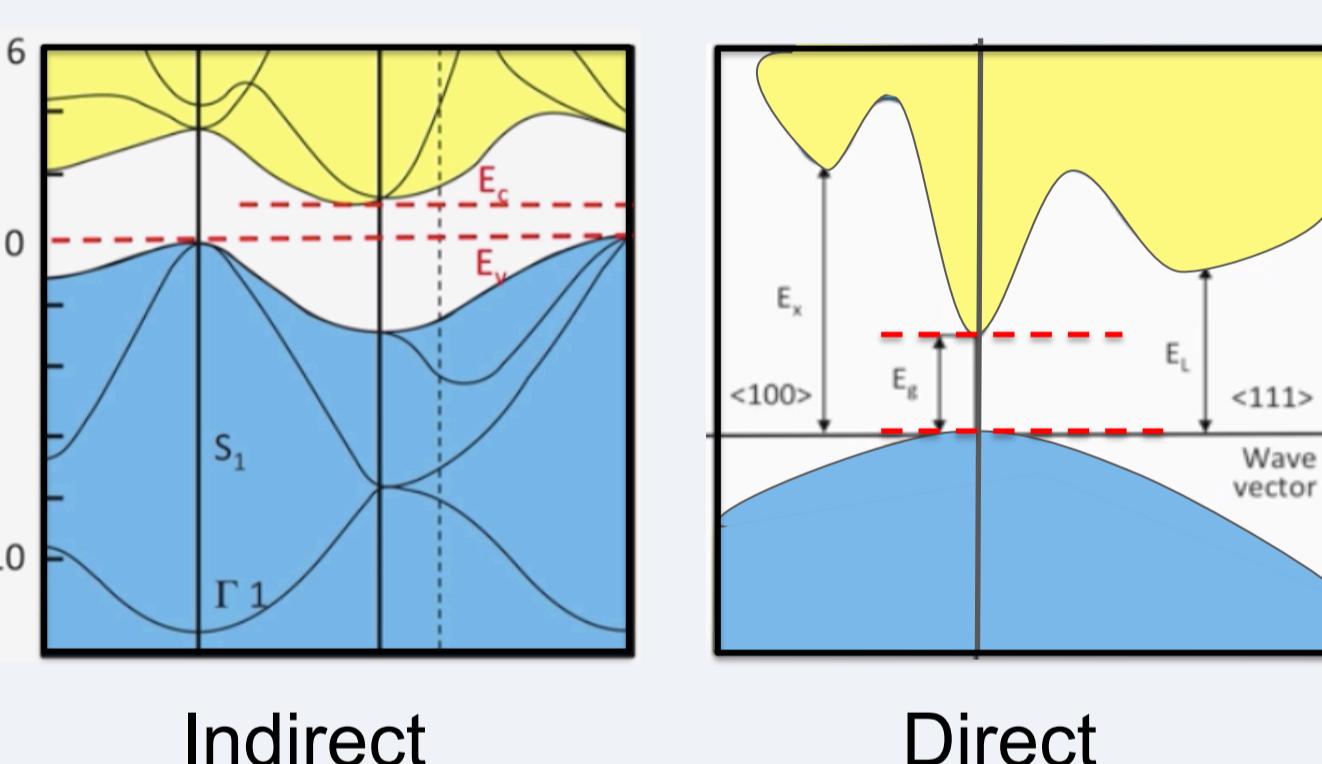


Source: https://en.wikipedia.org/wiki/Band_gap

Where, J_{sc} : Short circuit current density,
 V_{oc} : Open circuit voltage,
 P_{max} : Peak Power,
 E_{G0} : Band gap at absolute zero,

$$E_{G0} = qV_{G0}$$

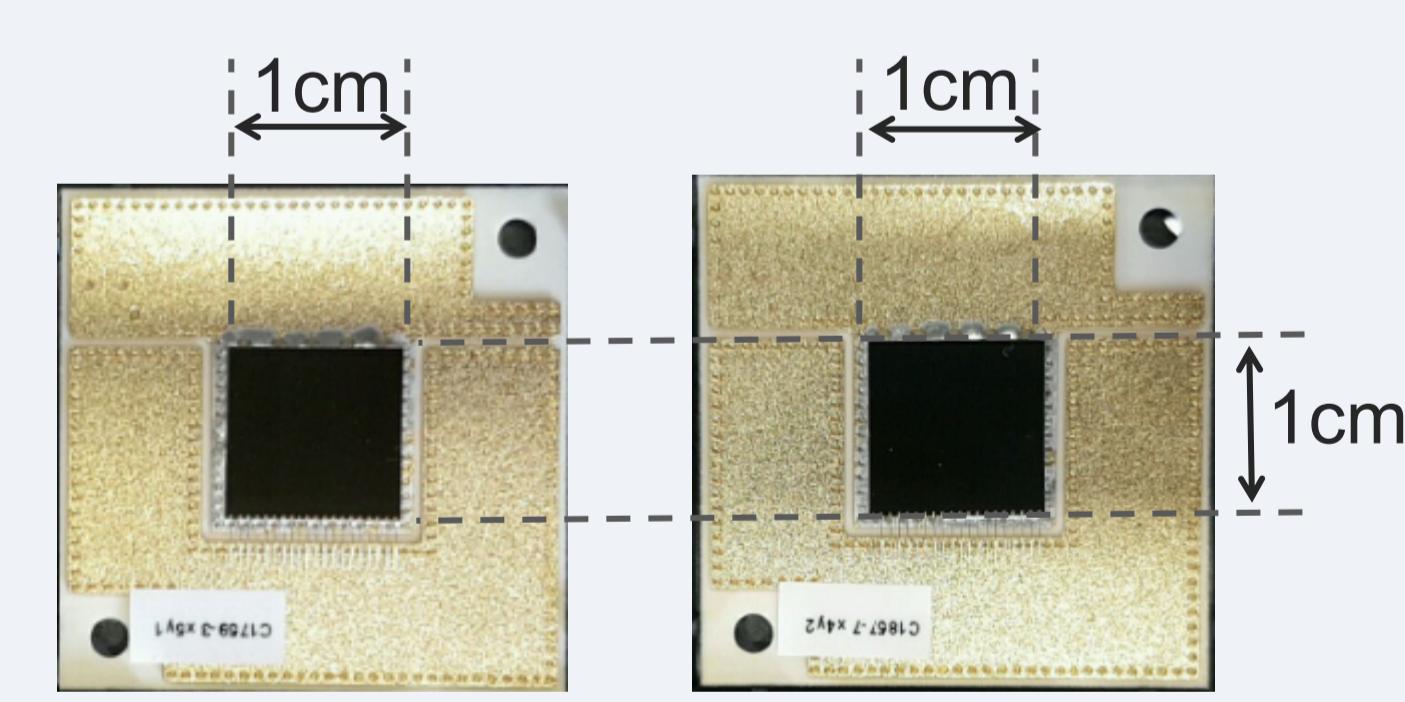
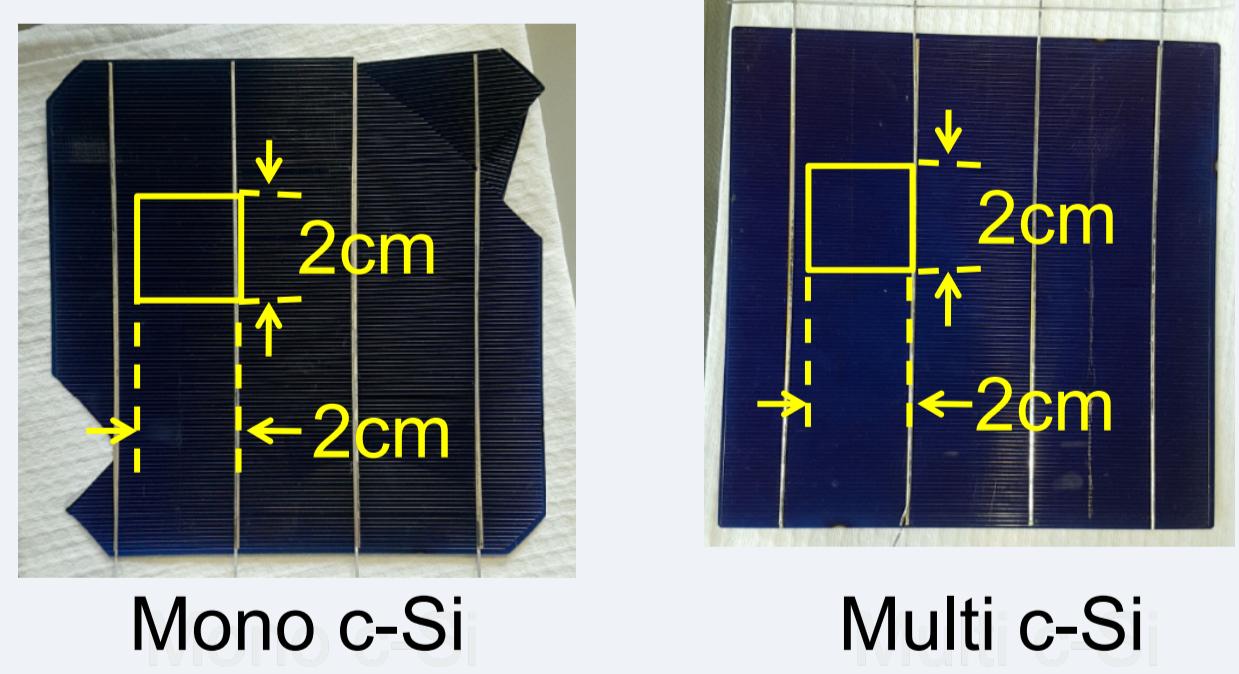
$$\frac{dV_{oc}}{dT} = \frac{V_{oc} - V_{G0}}{T} - \gamma \frac{k}{q}$$



Source: Arno Smets. MOOC Solar Energy. Delft University of Technology. <https://courses.edx.org>. Consulted in July 17, 2019.

Experimental Methods

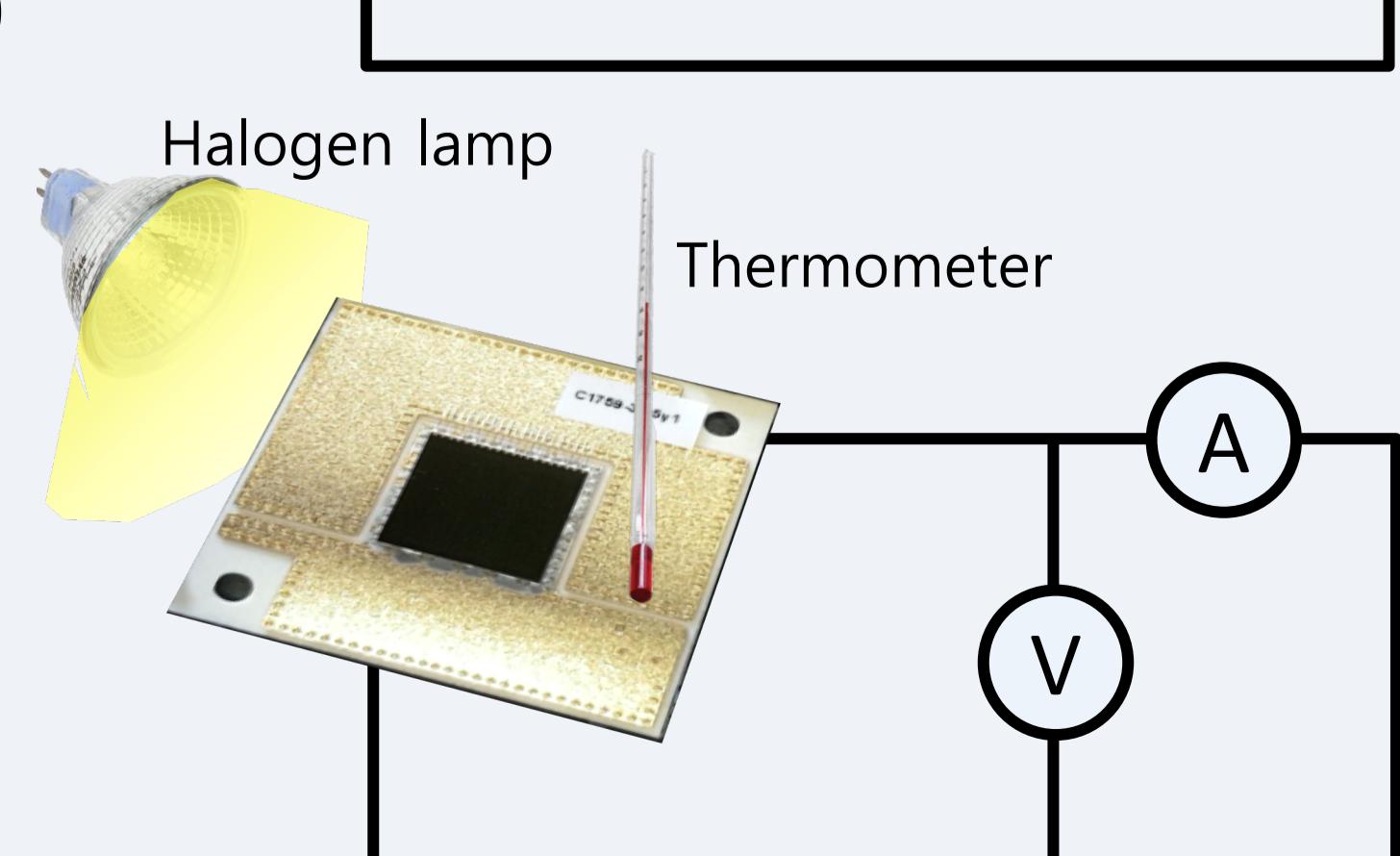
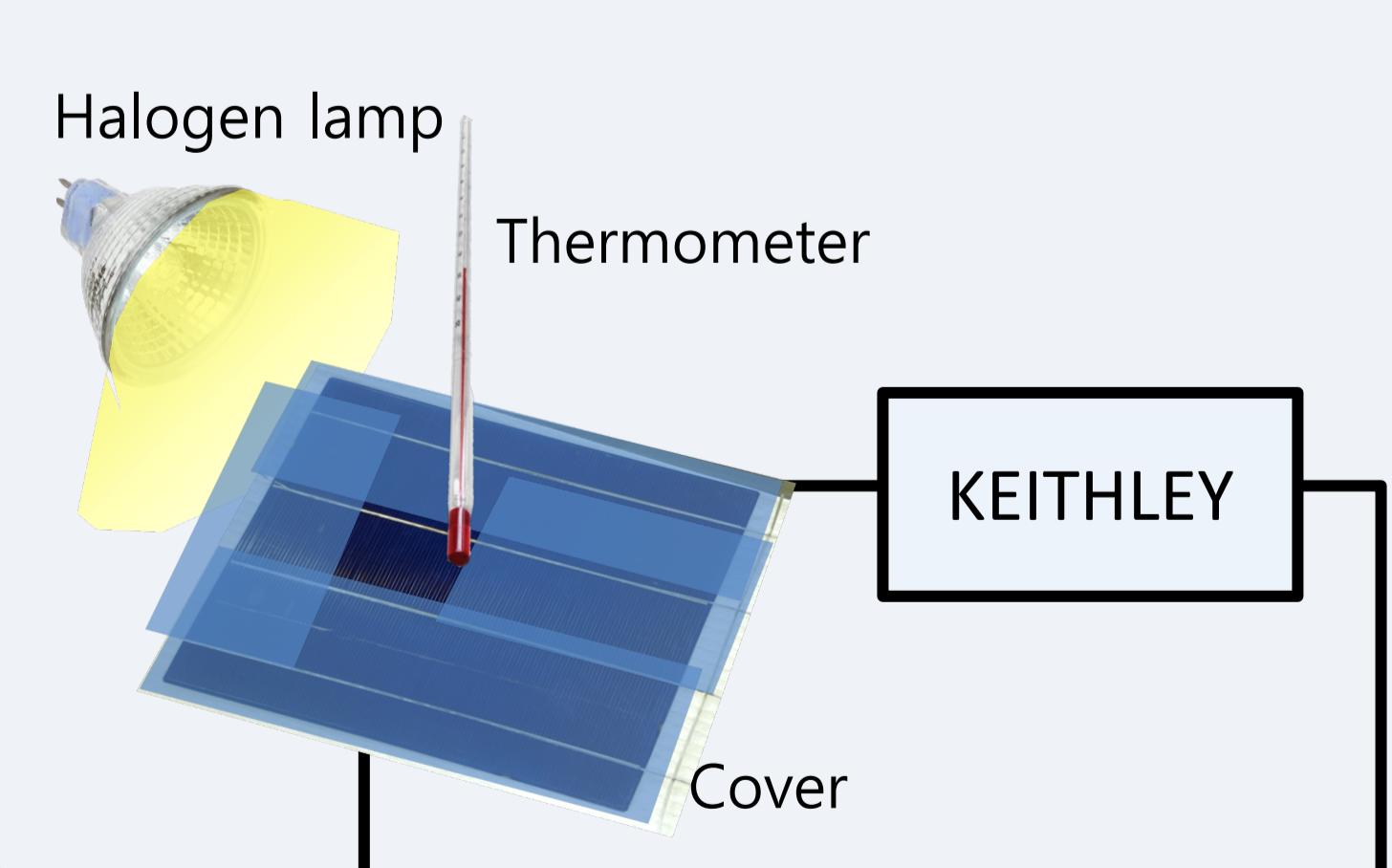
- Samples



- Experimental method

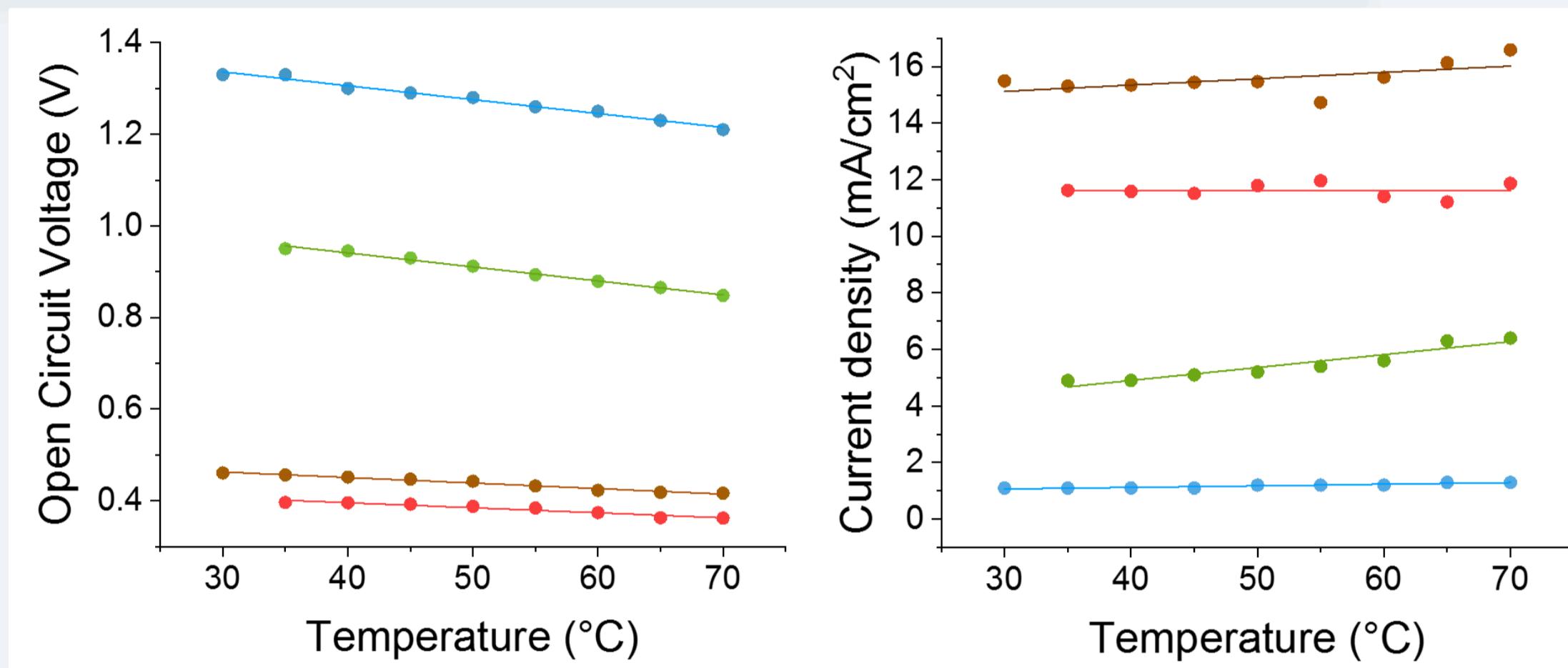
- Measuring V and I response to T increase
- T is controlled by additional halogen lamp
- V_{oc} - T , J_{sc} - T curve:
 30 °C to 70 °C (every 5 °C)
- I - V curve:
 35 °C, 50 °C, 70 °C

- Data processing
- Remove outliers

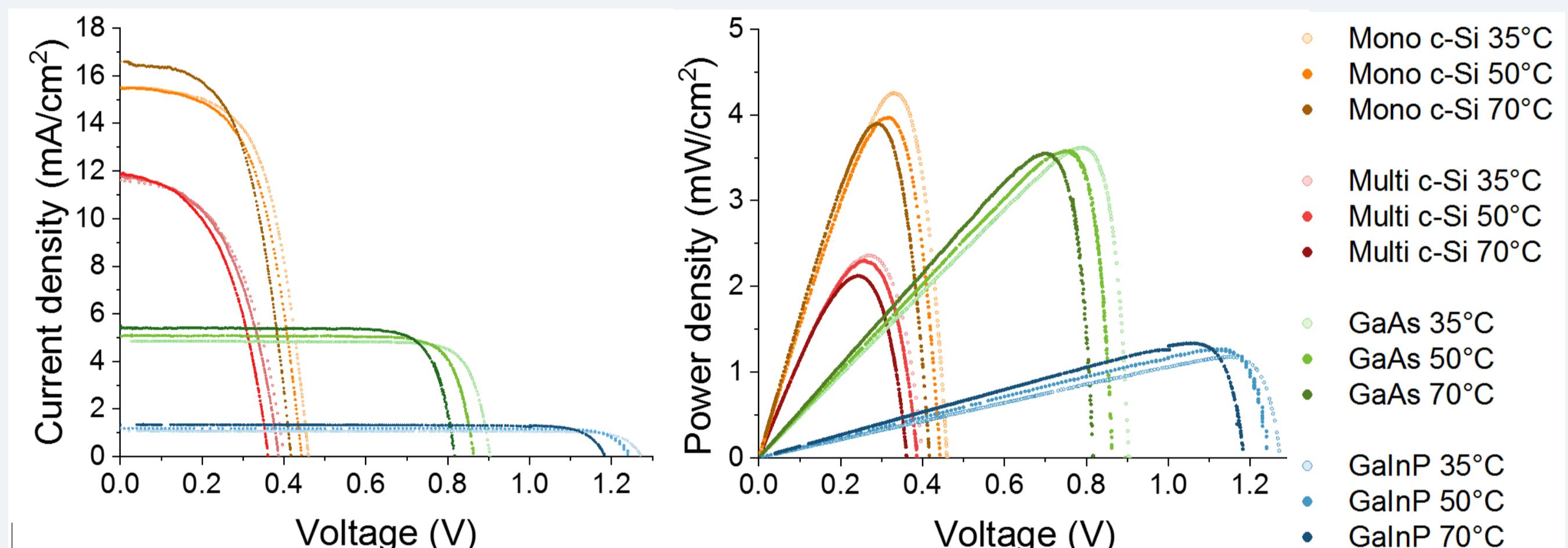


Results and Analysis

- V_{oc} and J_{sc} dependence on temperature



- I - V curve and PV Curve



- Comparison of temperature coefficients of Power (%/°C)

| Solar Cell | Measurement | Literature |
|------------|-------------|--------------------|
| GaInP | +0.39 | -0.18 ¹ |
| GaAs | -0.06 | -0.21 ¹ |
| Mono-c-Si | -0.24 | -0.45 ² |
| Multi-c-Si | -0.28 | -0.39 ² |

¹ Geoffrey A. Landis, et al. High-Temperature Solar Cell Development. NASA. 2018.

² P. kumar. NC Gupta. Effect of Temperature on Power Output from Different Commercially available Photovoltaic Modules. India. 2015

Discussion

- $\uparrow T \rightarrow \downarrow\downarrow V_{oc}$, No clear pattern for J_{sc}
 It seems the error is much bigger than effect of temperature.
- $Eg_{GaInP} > Eg_{GaAs} > Eg_{Mono\ cSi} > Eg_{Multi\ cSi}$
 The Temperature sensitivity of a solar cell depends on V_{oc} . Higher voltage solar cells are less affected by temperature.
- $P_{max,GaInP} \rightarrow$ Increasing
 It seems because of the spectrum of the halogen lamp.
- Possible error causes:
 - The temperature was not stably maintained while measure.
 - Smokes from cover papers caused by high temperature.

Conclusion

- GaAs and GaInP solar cells have less dependence on temperature compared to silicon solar cells.
- GaAs and GaInP solar cells are suitable for concentration technology and space applications.