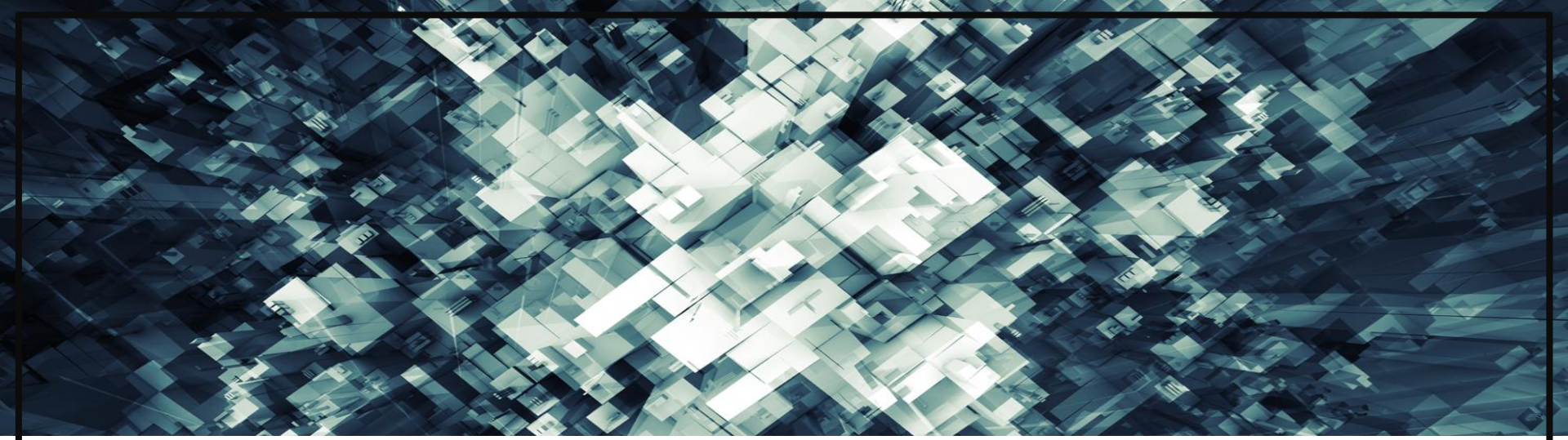

Potential-Induced Degradation within Perovskite Solar Cells

Robbe Breugelmans

IMO-IMOMEC
UHASSELT
imec
Energy Ville
fwo

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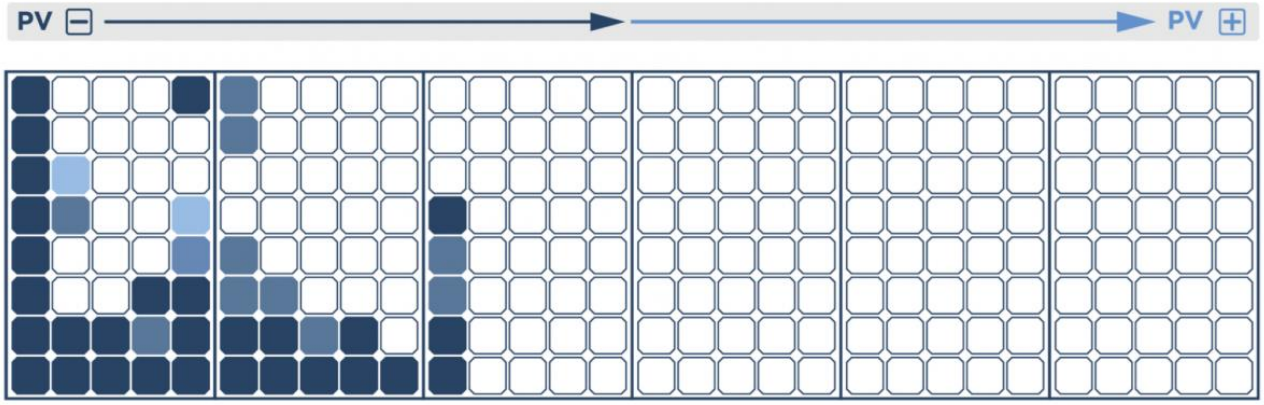
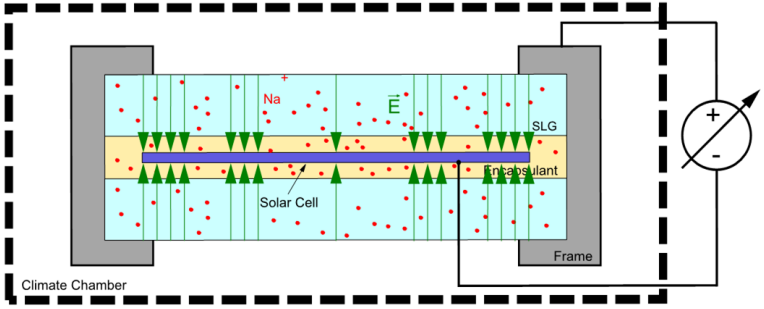
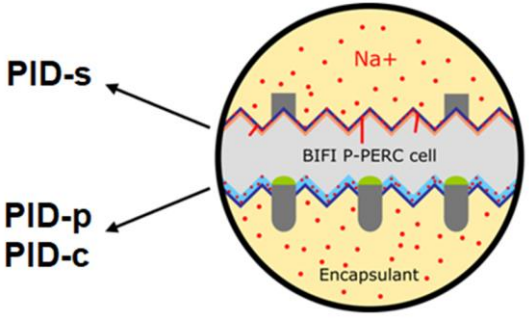
Potential-Induced Degradation (Silicon)







[1] https://www.energyville.be/en/press/expert-talk-potential-induced-degradation-photovoltaic-modules
[2] J. Carolus, Sol. Energy Mater. Sol. Cells, vol. 200, Sep. 2019

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- Potential-Induced Degradation
- **Current state of the art in literature**
- PID experiment and results
- Conclusion and outlook

Current state of the art in literature (perovskite)

- 3 publications available

Reference	Year	Perovskite structure	Stress duration	Voltage difference	Condition	Efficiency loss
[3]	2019	n-i-p	18 hours	1000 V	60°C / <60% RH	95%
[4]	2021	n-i-p, p-i-n	18 hours	1000 V	60°C / <60% RH	65.3% / 72%
[5]	2021	p-i-n	5000 hours	1000 V / 500 V	25°C / 20% RH	±90%

- Recovery investigated
- Sensitive to moisture, light, and thermal stress
- **Challenging to isolate the PID mechanism**

[3] J. Carolus et al., Sol. RRL, vol.3, no. 10, p. 1900226, Oct. 2019
[4] Z. Purohit et al., Sol. RRL, vol. 5, no. 9, p. 2100349, Sep. 2021
[5] K. Brecl et al., Sol. RRL, p. 2100815, Dec. 2021

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- Potential-Induced Degradation
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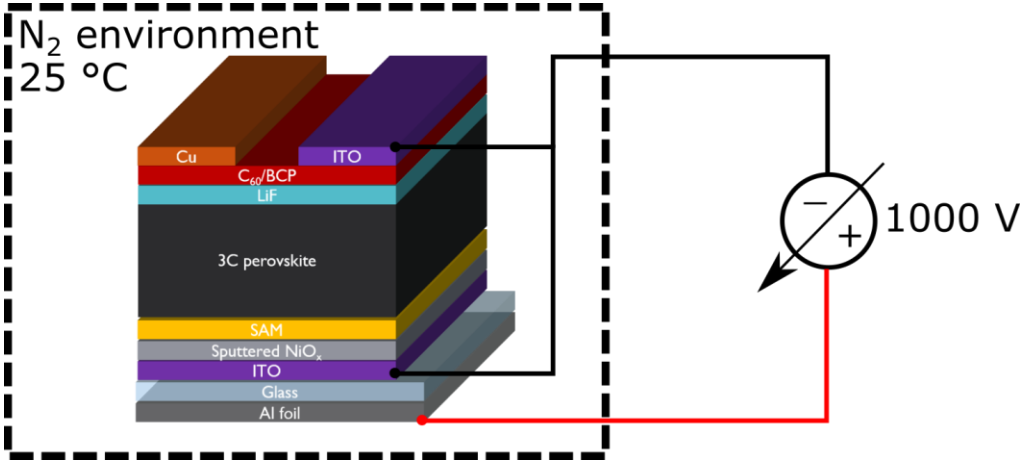
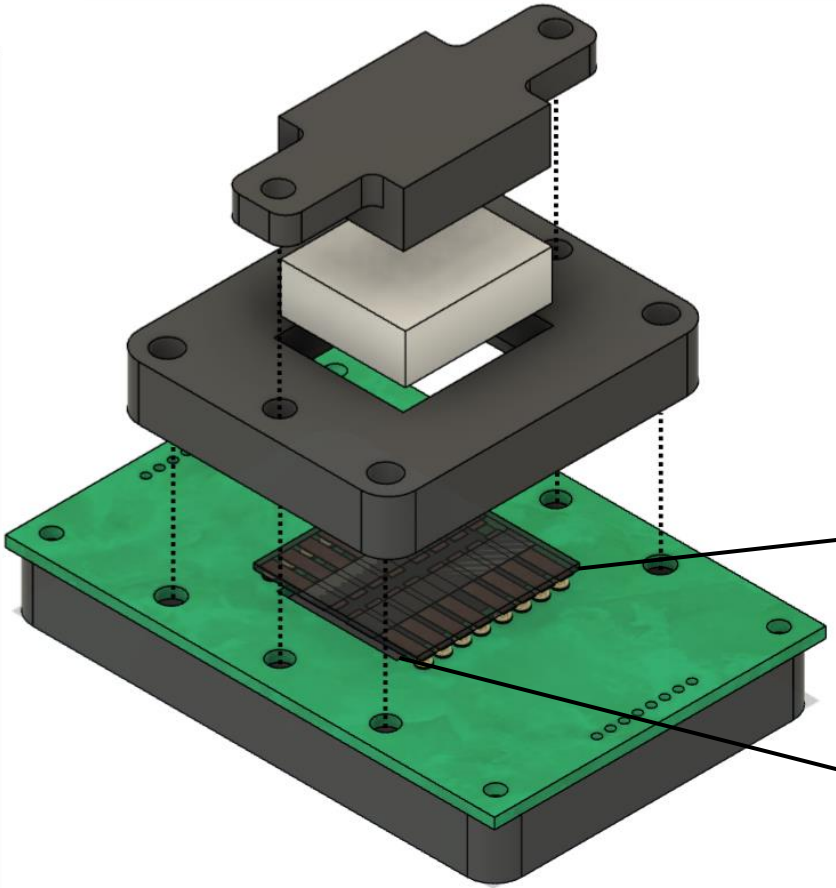
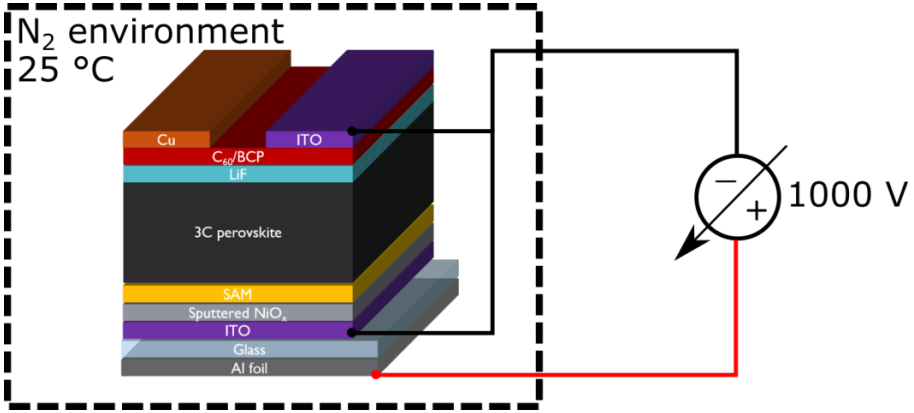
PID experiment and results

- Retrieving accurate insights in PID mechanism
- **Controlled N_2 environment at ambient temperature**
  - Exclusion moisture influence
  - Exclusion thermal influence
- Comparison PID sensitivity Cu-and ITO-contacted samples
- 3C p-i-n perovskite
  - $Cs_{0.05}FA_{0.85}MA_{0.1}PbI_{2.9}Br_{0.1}$



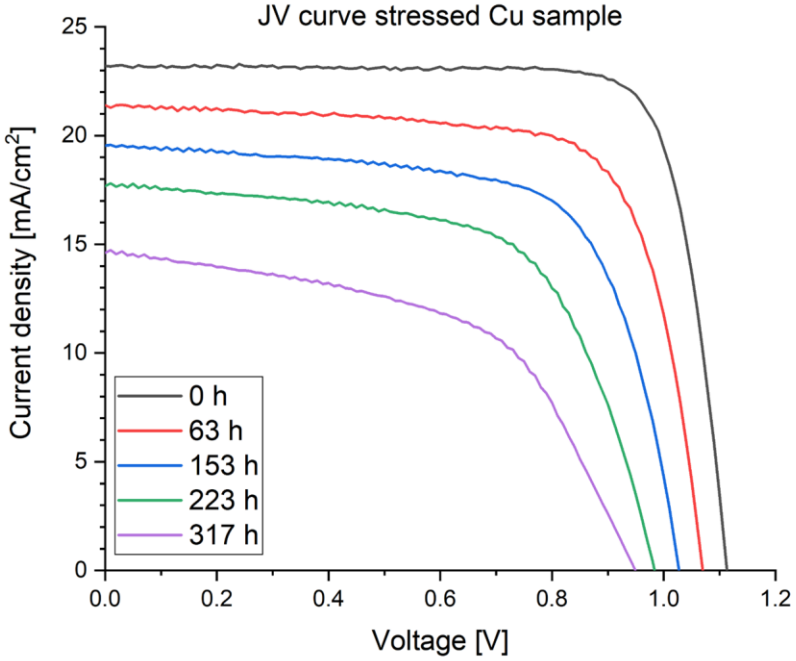
PID experiment and results: Setup

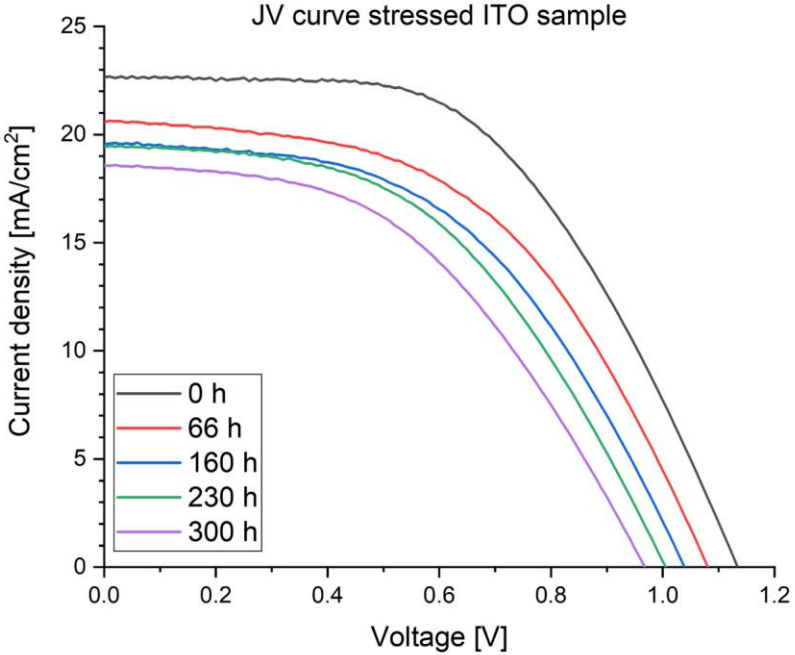




PID experiment and results: JV

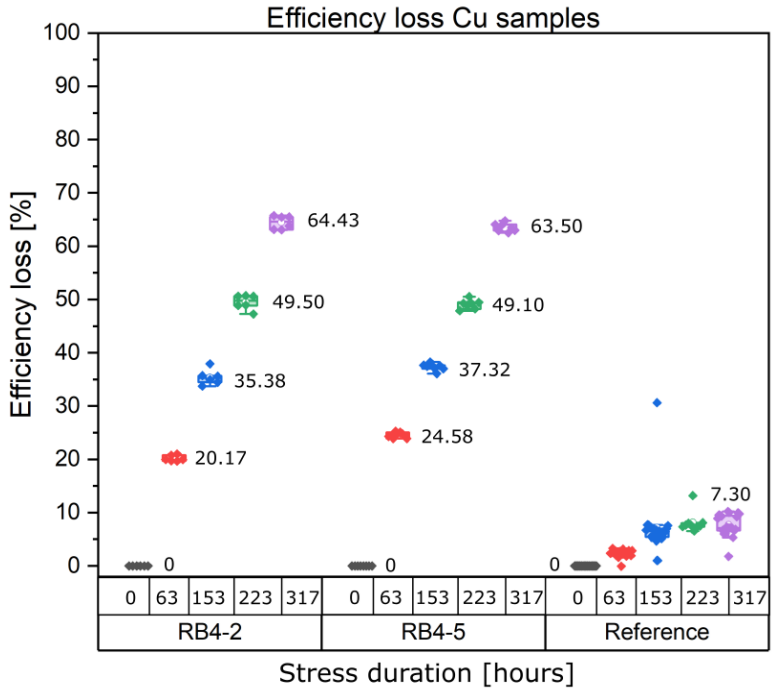
- 1000V potential difference, 25°C, ±300 hours

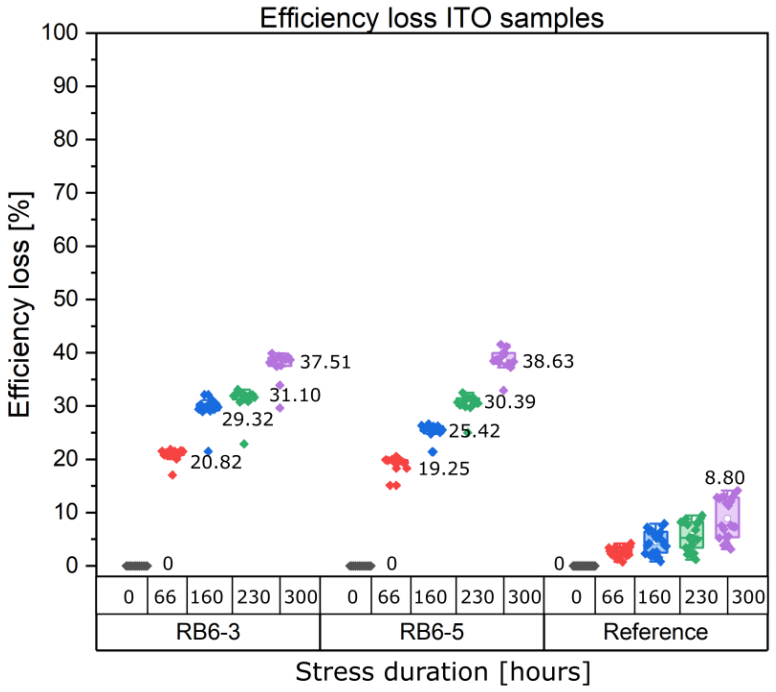




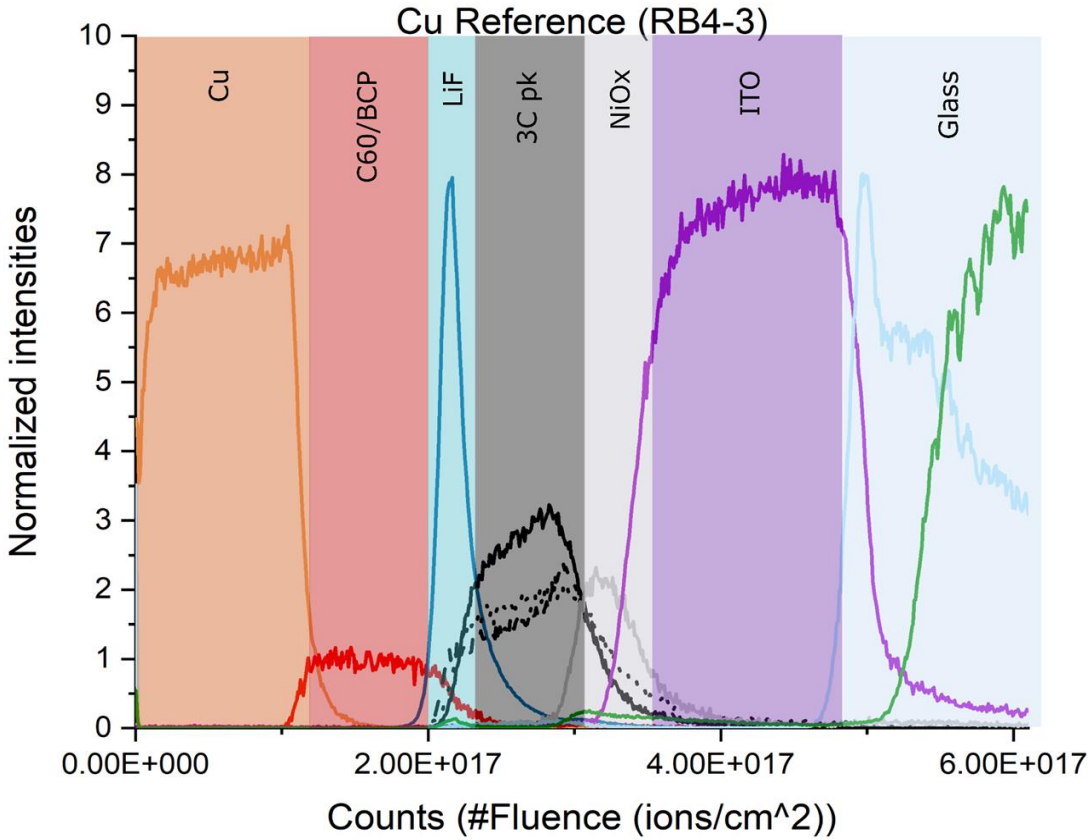
PID experiment and results

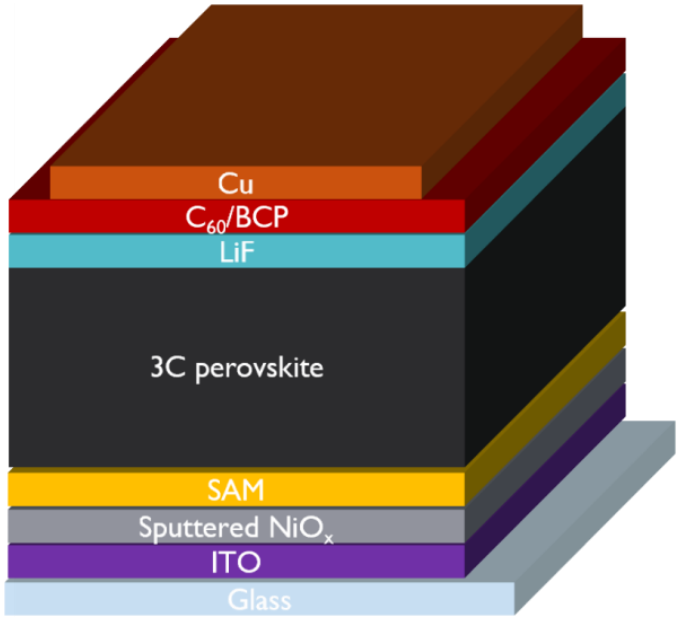
- 1000V potential difference, 25°C, ±300 hours



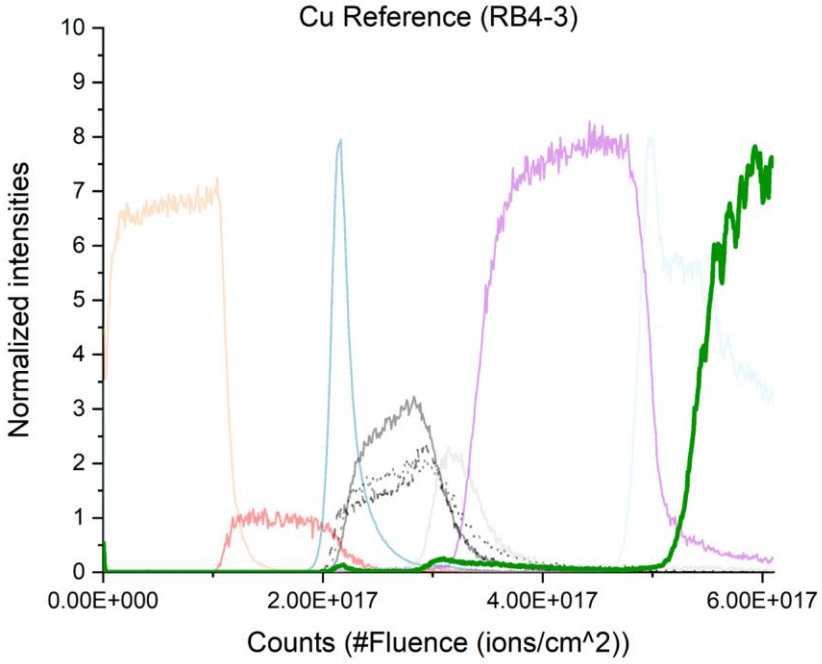


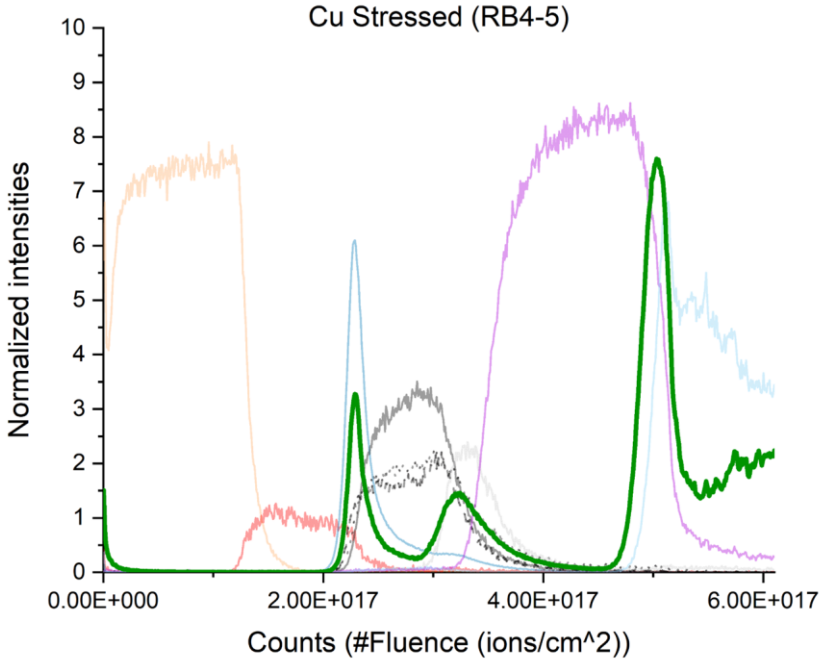
PID experiment and results: ToF-SIMS



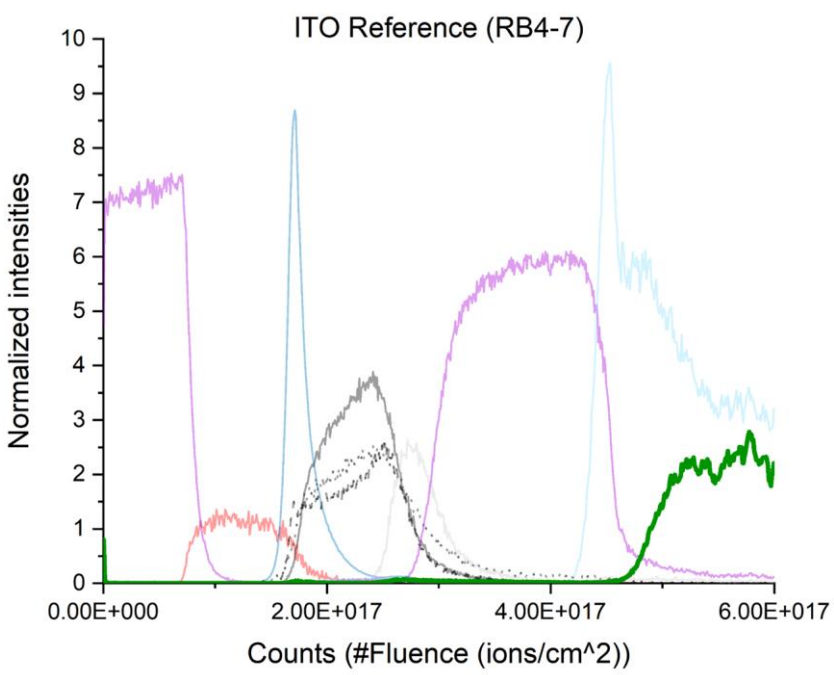


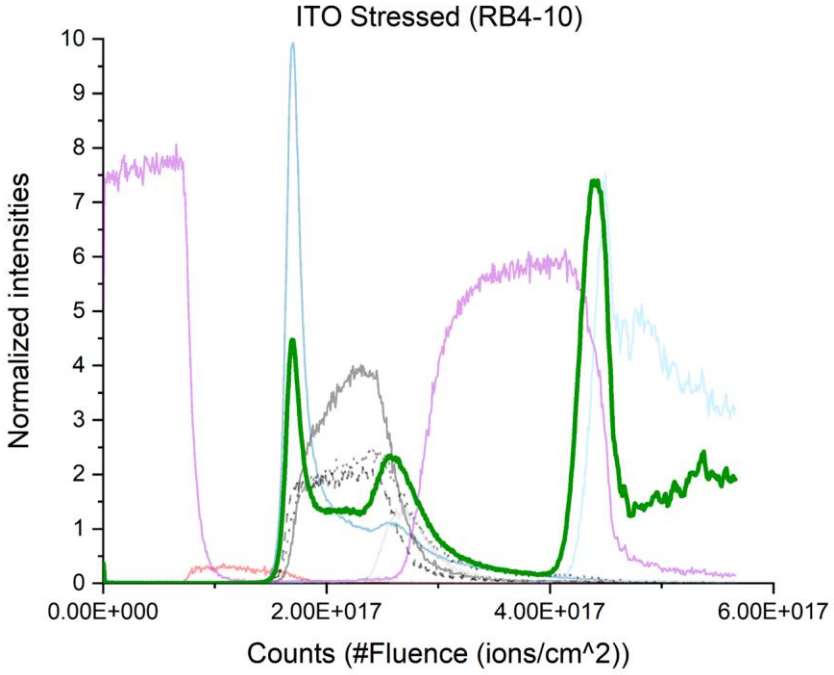
PID experiment and results: ToF-SIMS





PID experiment and results: ToF-SIMS





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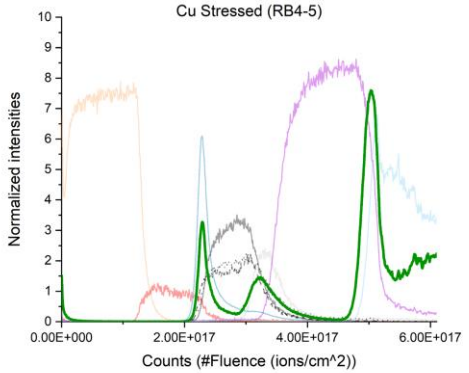
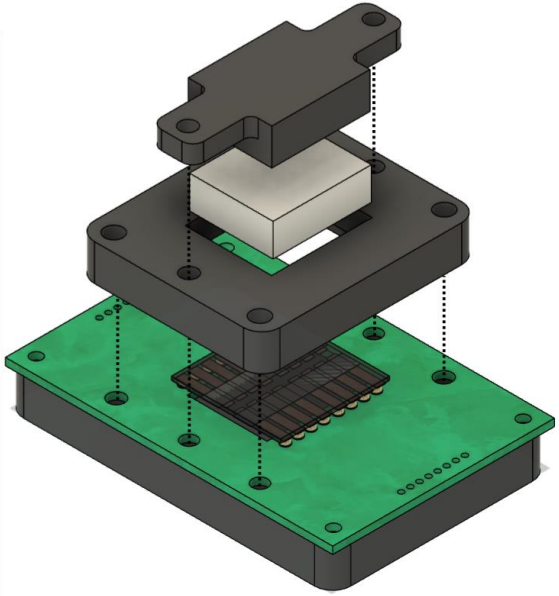
Conclusion and outlook

- **Influence of H_2O excluded by N_2 environment**
- **Na^+ migration is the main cause of PID**
- **Cu samples more PID-prone than ITO**
  - Twofold effect: Metal-induced degradation + PID?



- Further comparisons
  - 2C vs 3C
  - 2D vs 3D
  - Dependencies of other layers
- Voltage and temperature dependency
- Influence on module level
- Recovery
- Prevention



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