

# Impact of potential-induced degradation (PID) on PV parameters

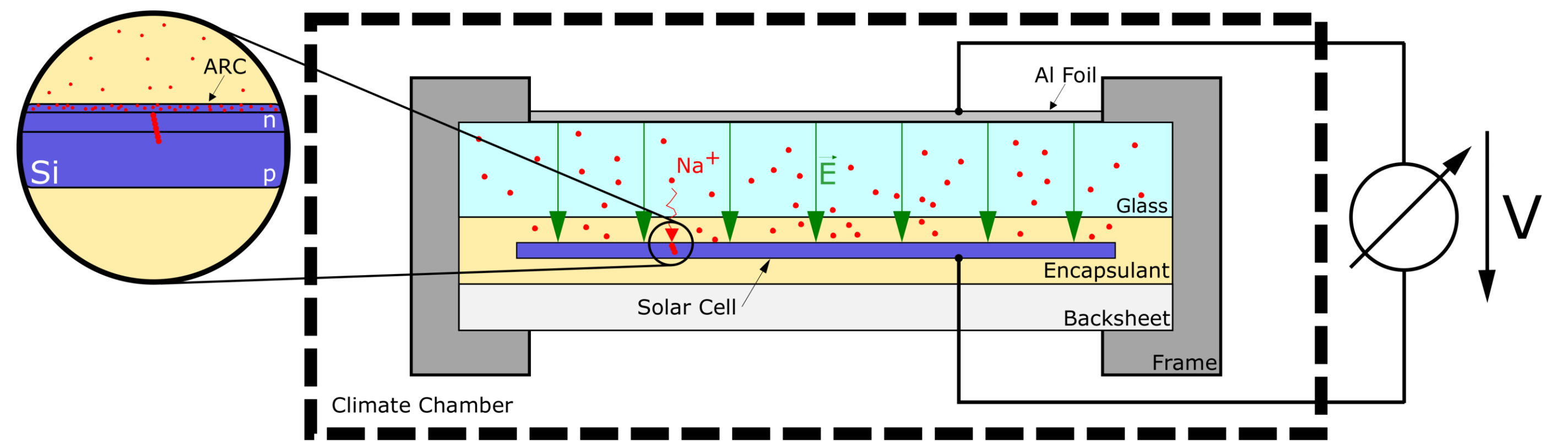
J. Carolus<sup>1,2</sup>, J. Govaerts<sup>2</sup>, E. Voroshazi<sup>2</sup>, W. De Ceuninck<sup>1,2</sup>, and M. Daenen<sup>1,2</sup>

<sup>1</sup>Hasselt University, Martelarenlaan 42, 3500 Hasselt, Belgium

<sup>2</sup>imec, Kapeldreef 75, 3000 Leuven, Belgium

## Introduction

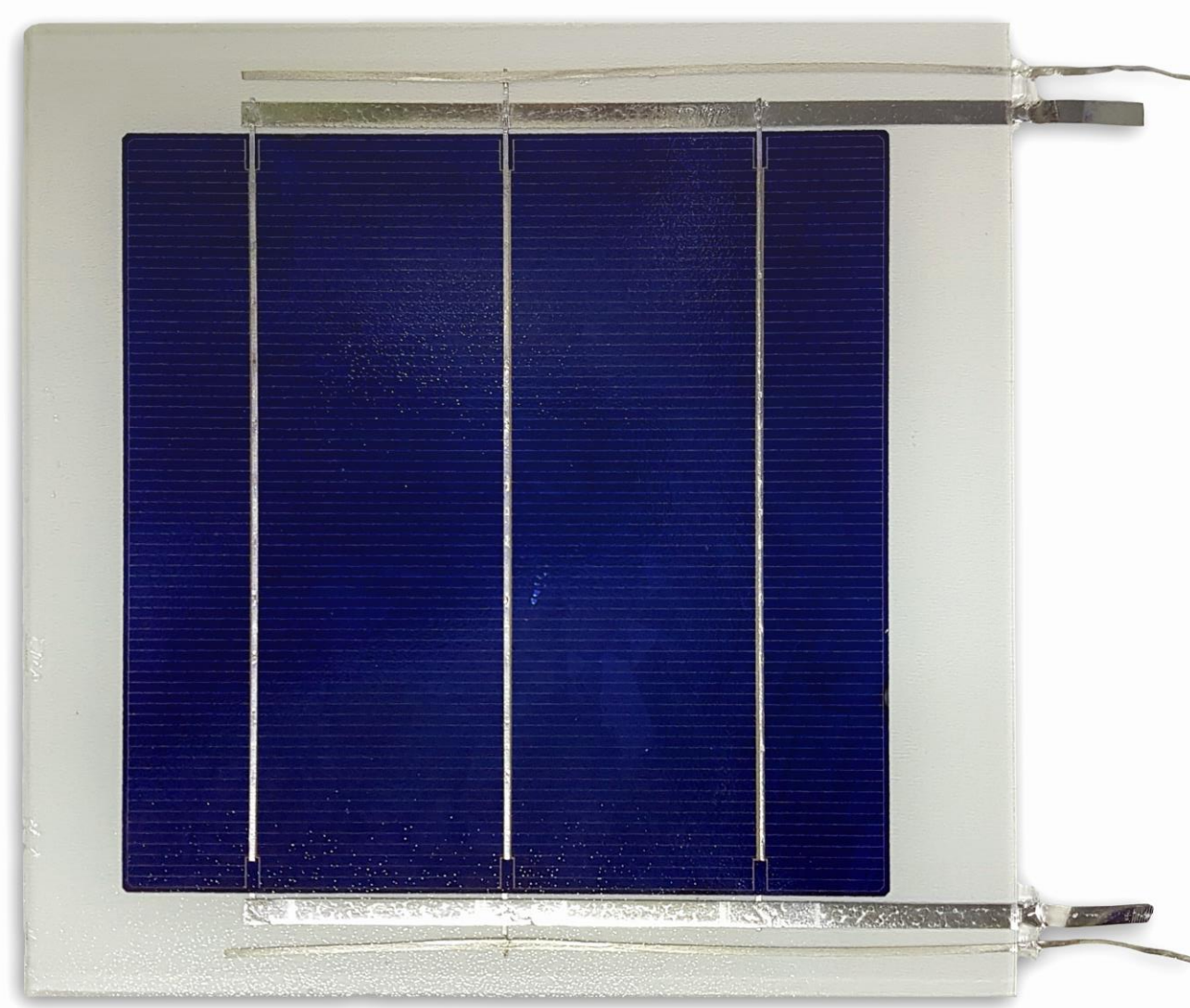
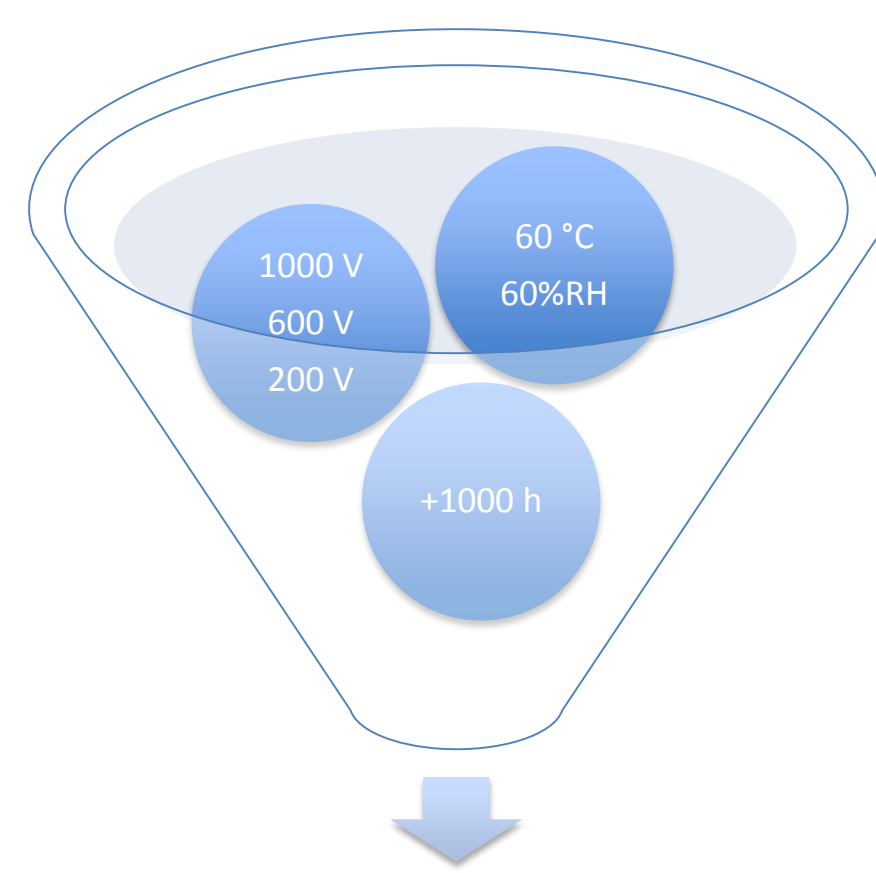
Potential-induced degradation (PID) is known as a severe degradation phenomenon. PID was first noticed in large photovoltaic (PV) plants where a significant amount of PV modules was connected in series, hence resulting in a significant voltage between the solar cells at one end of the string and the grounded frame. According to Naumann et al., the induced electrical field causes a leakage current and sodium ion ( $\text{Na}^+$ ) diffusion into stacking faults through the PN-junction of the solar cell, resulting in a substantial lowering of the shunt resistance.



## Experimental

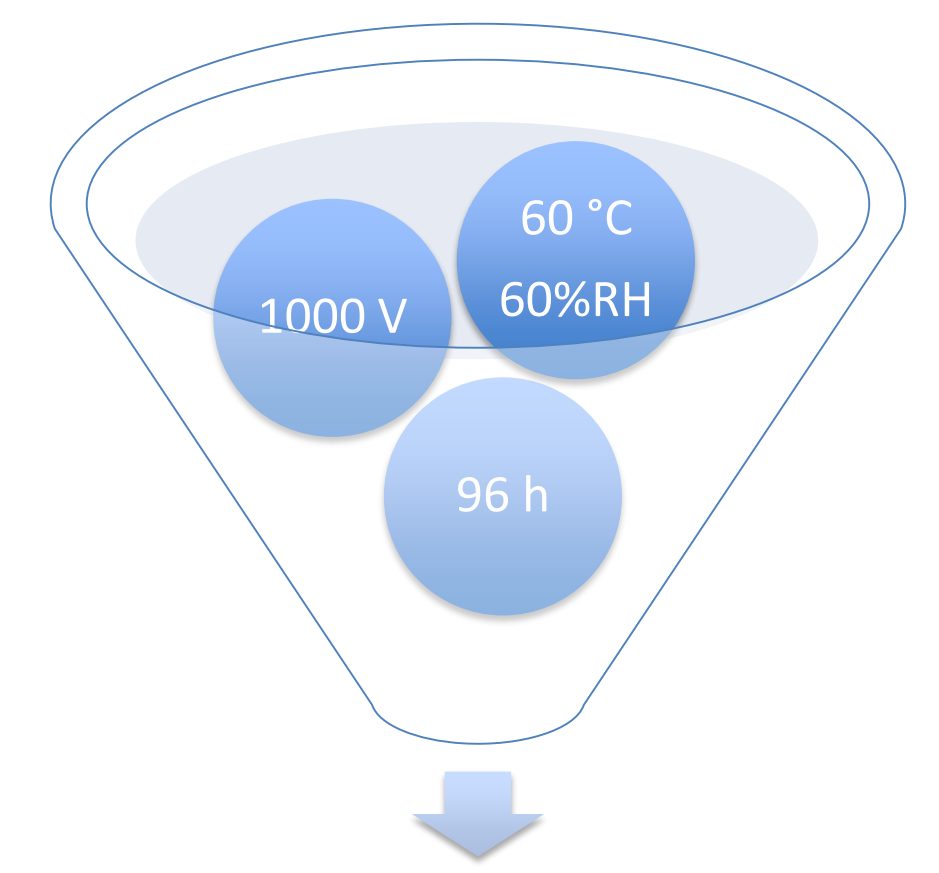
### Multi-voltage experiment

- IEC62804-1 (foil method)
- 5 single-cell laminates
  - Mono-/multi-Cr p-type wafers
  - 3.2 mm soda lime glass
  - EVA encapsulants
  - PVF back sheet

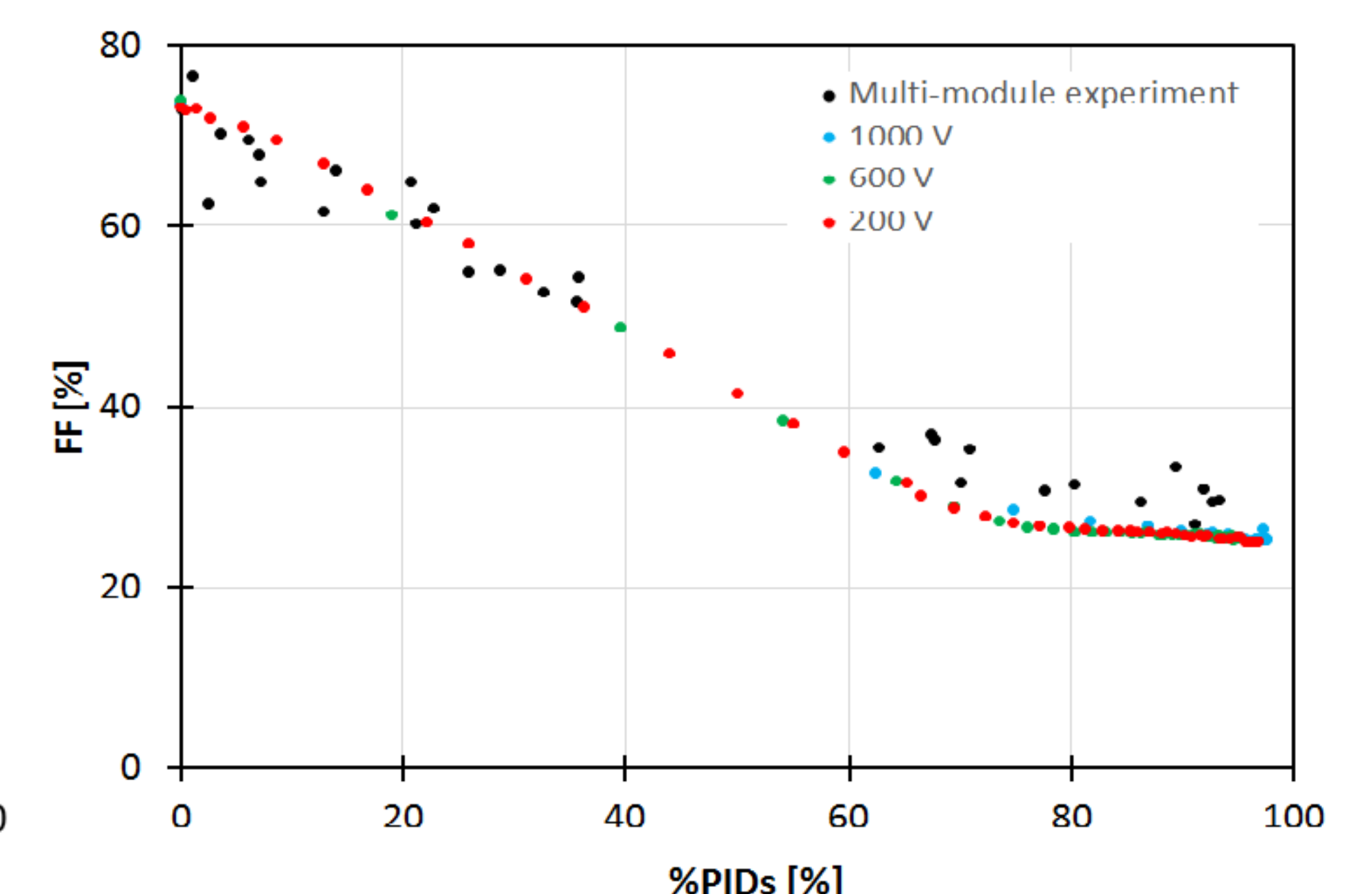
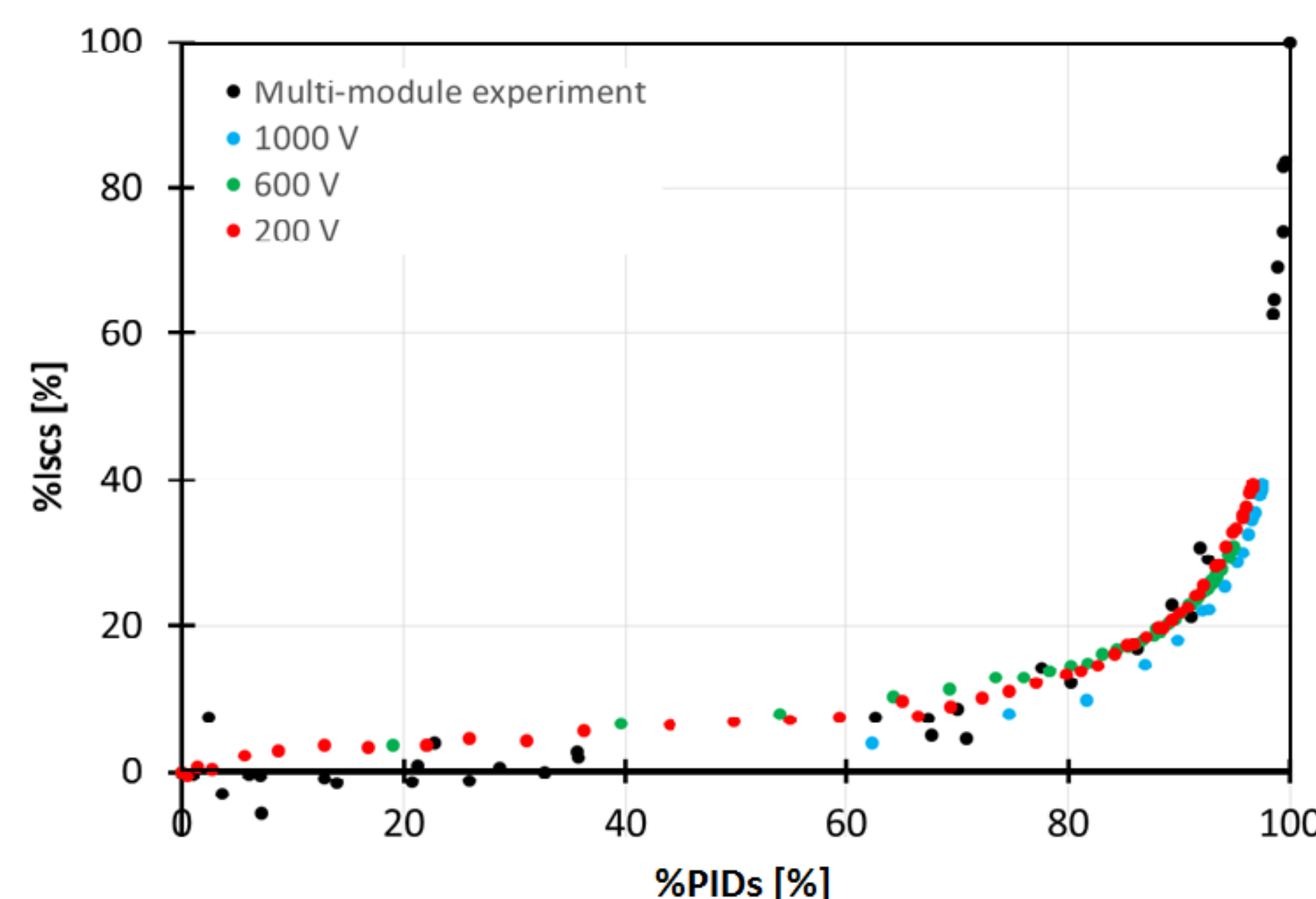
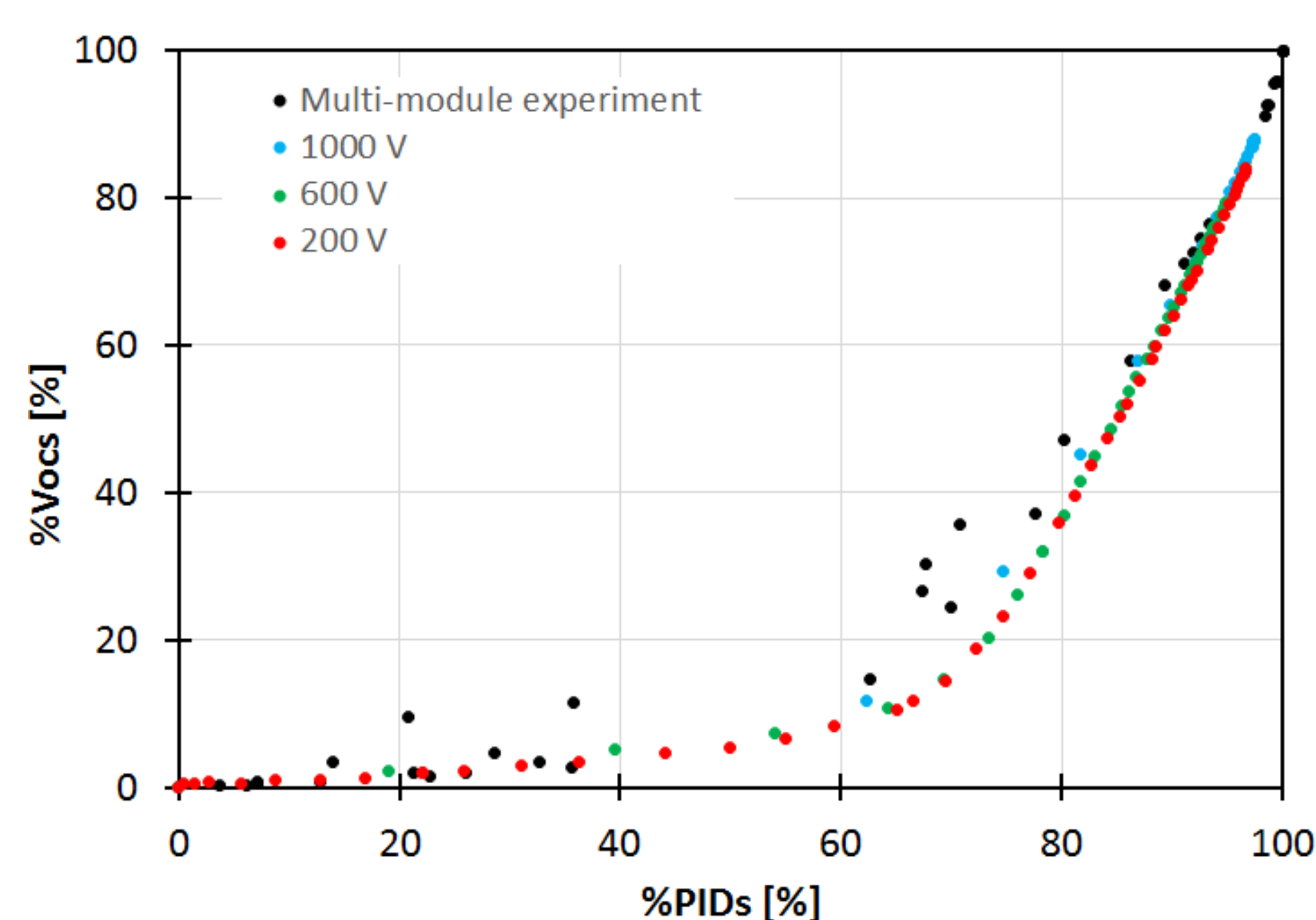


### Multi-module experiment

- IEC62804-1 (foil method)
- 49 full-size PV module
  - Mono- & multi-Cr wafers
  - New & used modules
  - Glass-glass & glass-foil
  - Framed & not-framed



## Results



## Conclusions

- Clear trends with respect to impact of PID on the PV parameters ( $V_{oc}$ ,  $I_{sc}$ , FF) were observed;
- The trends showed the same behaviour, unregarded the stress voltage (200V, 600V and 1000V) and PV module type/brand;
- These results are the basis for an easy measurement method in order to detect PID in residential-scale applications;
- The results confirm the proposed degradation mechanism by Naumann: a substantial lowering of the shunt resistance;
- At last, the results show that no secondary degradation mechanism is activated due to the higher stress voltage.

## Selected Publications

- V. Naumann et al., "Explanation of potential-induced degradation of the shunting type by Na decoration of stacking faults in Si solar cells"
- J. Carolus et al., "Irreversible damage at high levels of potential-induced degradation on photovoltaic modules: A test campaign"
- J. Carolus et al., "Voltage dependence of potential-induced degradation and recovery on photovoltaic one-cell laminates"