



HAL
open science

A lateral heterojunction device as a tool to study perovskite-based solar cells

Davide Regaldo, Pilar Lopez-Varo, Nitin Mallik, Javid Hajhemati, Vincent Dufoulon, Guillaume Vidon, Stefania Cacovich, J Alvarez, Jean Baptiste Puel, Philip Schulz, et al.

► To cite this version:

Davide Regaldo, Pilar Lopez-Varo, Nitin Mallik, Javid Hajhemati, Vincent Dufoulon, et al.. A lateral heterojunction device as a tool to study perovskite-based solar cells. 40th European Photovoltaic Solar Energy Conference and Exhibition (EU-PVSEC), Sep 2023, Lisbon, Portugal. hal-04296790

HAL Id: hal-04296790

<https://centralesupelec.hal.science/hal-04296790>

Submitted on 29 Aug 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



Davide Regaldo, Pilar Lopez-Varo, Mathieu Fregnaud, Nitin Mallik, Javid Hajhemati, Vincent Dufoulon, Jean-Baptiste Puel, José Alvarez, Philip Schulz, Jean-Paul Kleider

IPVF, Institut Photovoltaïque d'Ile-de-France, 18, Boulevard Thomas Gobert, 91120 Palaiseau, France.

Université Paris-Saclay, CentraleSupélec, CNRS, Lab. de Génie Électrique et Électronique de Paris, 91192, Gif-sur-Yvette, France.

Sorbonne Université, CNRS, Lab. de Génie Électrique et Électronique de Paris, 75252, Paris, France.

Institut Lavoisier de Versailles, Université de Versailles Saint-Quentin-en-Yvelines, Université Paris-Saclay, CNRS, UMR 8180, 45 avenue des Etats-Unis, 78035 Versailles Cedex, France⁷

A Lateral Heterojunction Device as a Tool to Study Perovskite-Based Solar Cells

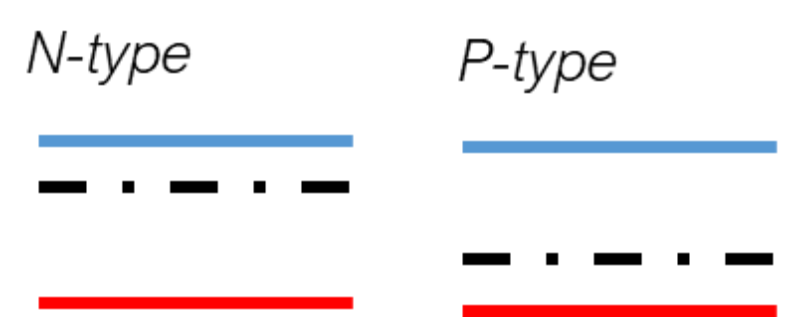
Scope of the work

Study the perovskite (PSK) properties on top of different substrates:

- Surface work function (WF);
- Defect and ion properties;

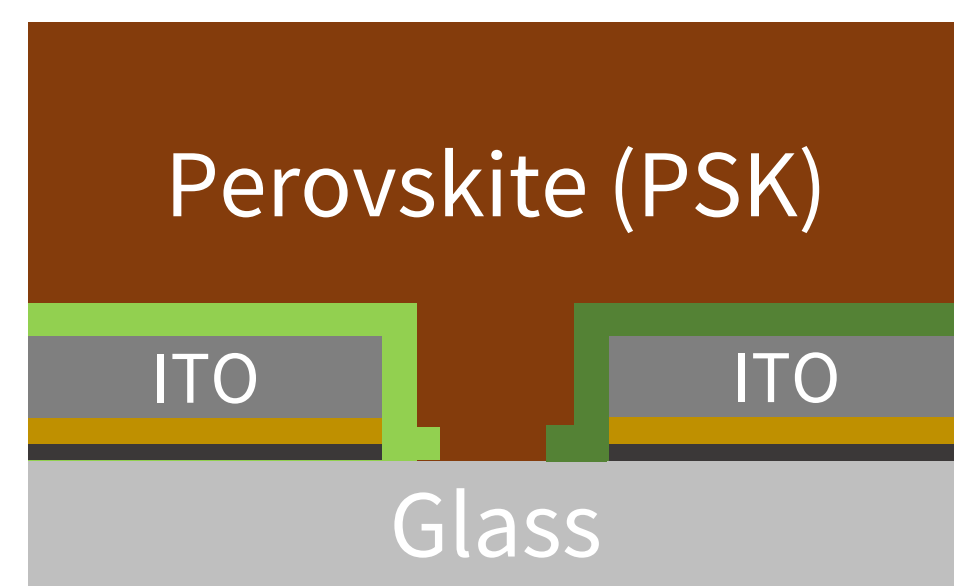
Previous knowledge:

Perovskite WF dependence on the substrate WF



ACS Energy Lett. 2019, 4, 1-7
 S. P. Dunfield et al., (2021).

Cross section view



Previous device allowed to fix an upper limit of the doping density in the PSK layer:

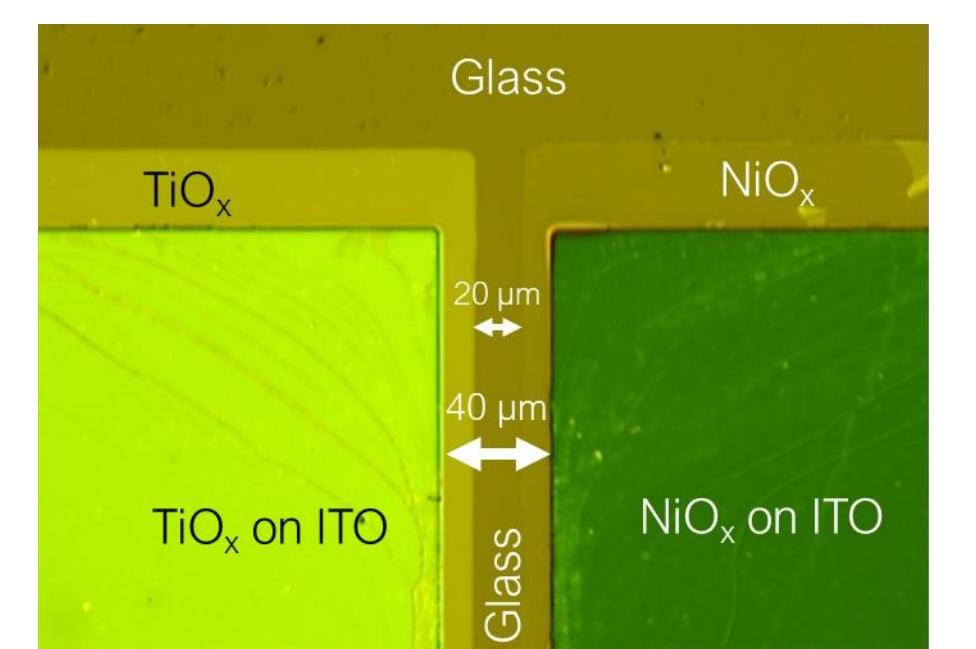
$$N_{\text{dop}} \leq 10^{12} \text{ cm}^{-3}$$

LHJ structure and fabrication

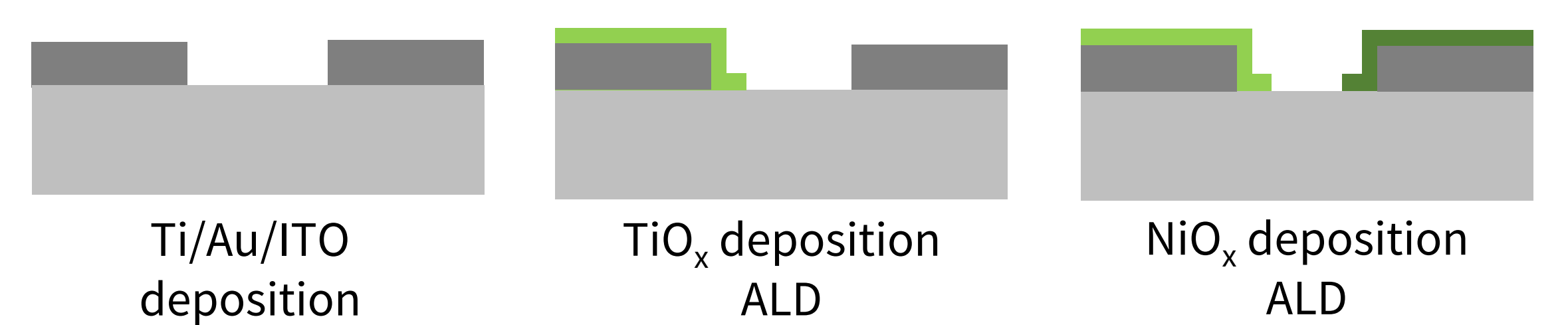
3 photolithography steps to deposit:

- Contact layer: Ti (adhesion to glass) / Au (high conductivity) / ITO (PSK protection);
- Electron transport layer: TiO_x ;
- Hole transport layer: NiO_x .

Top view (optical microscope image)

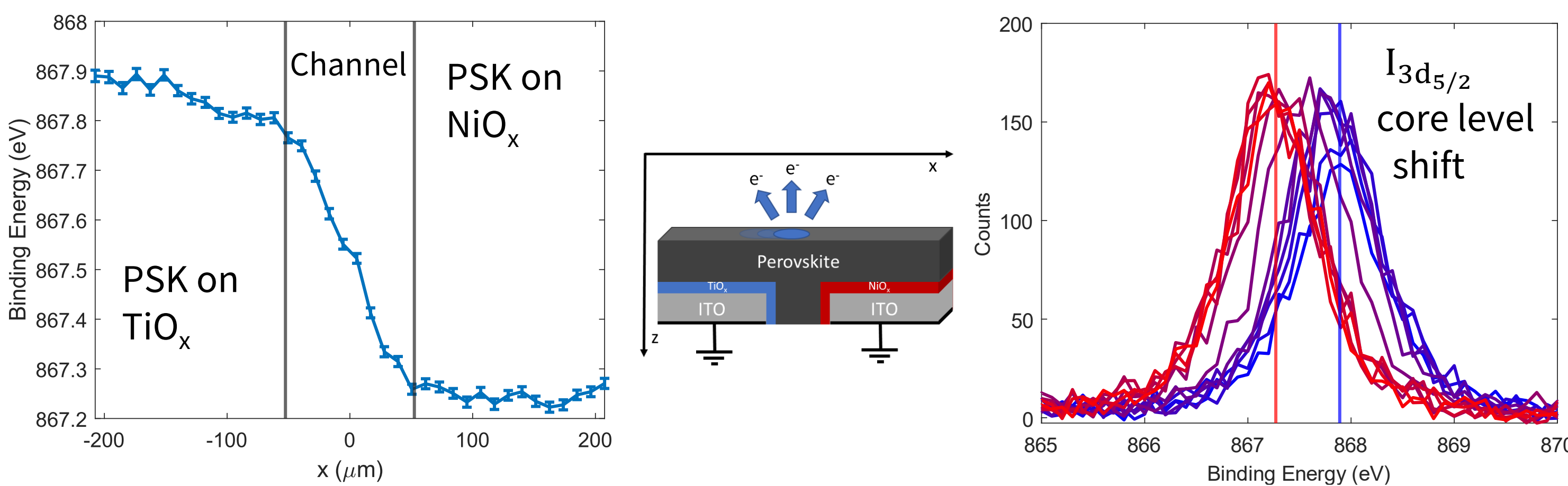


Cross section view



XPS equilibrium characterization

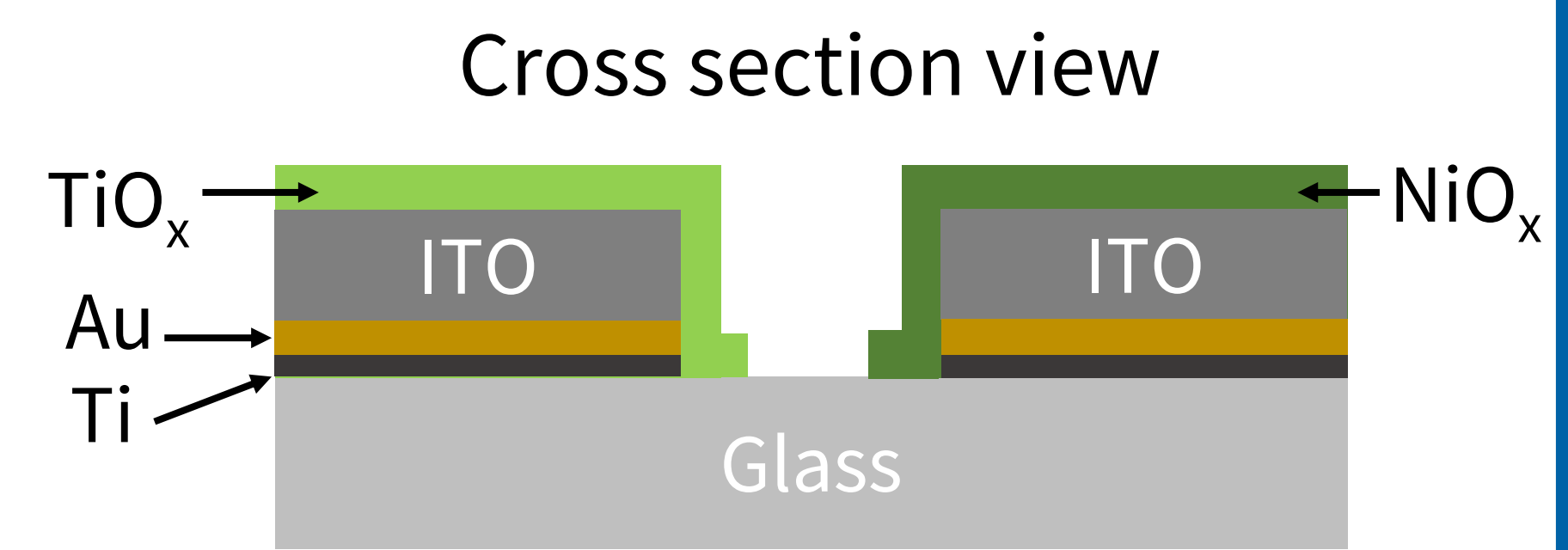
The scan of the X-ray electron collection area (with 10 μm diameter) along the PSK surface, from the TiO_x to the NiO_x side revealed an iodine core level shift of 650 meV, in agreement with the WF difference between the TiO_x and the NiO_x surface.



KPFM substrate characterization

Work functions (KPFM)

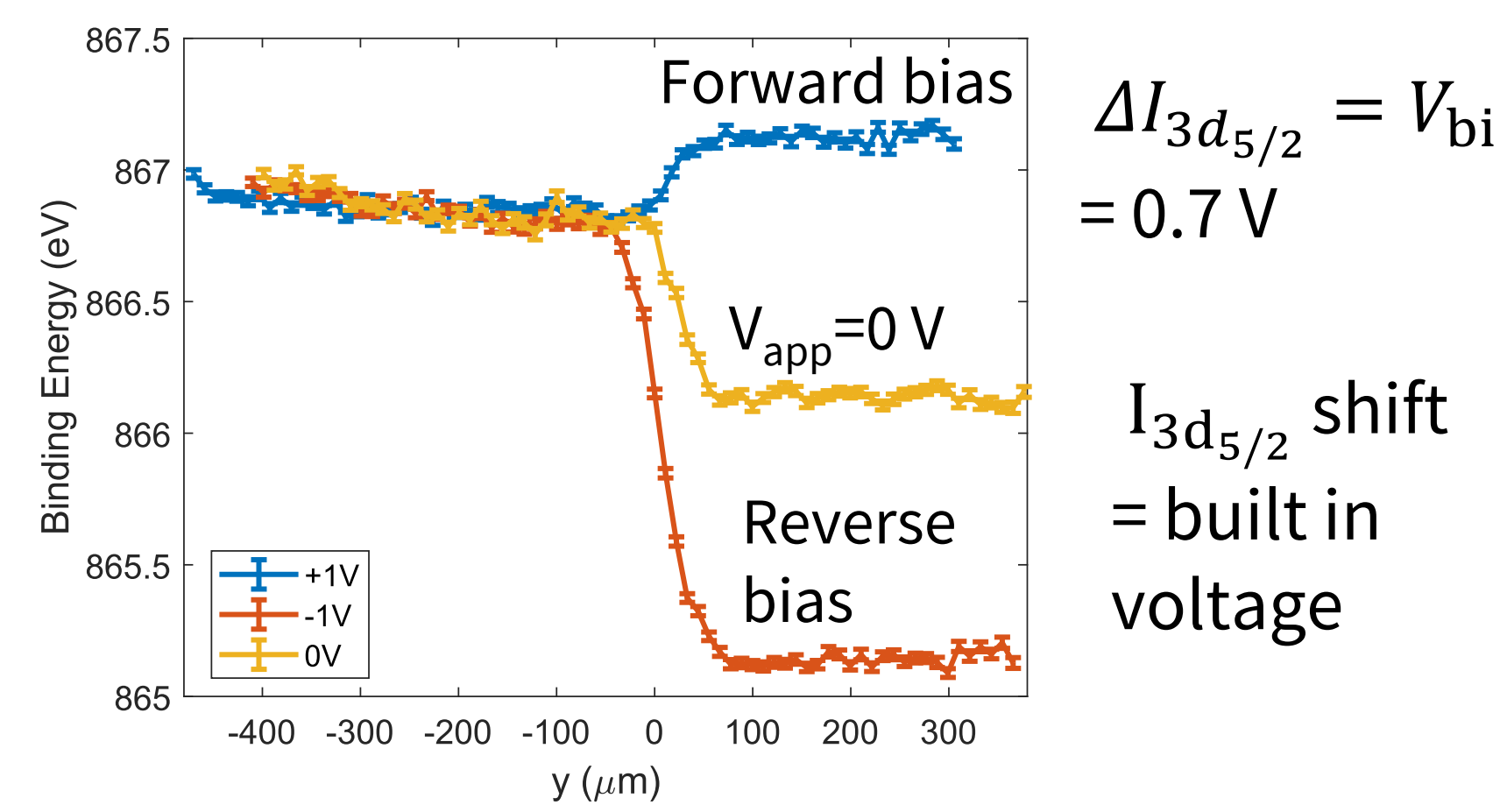
| | |
|----------------|----------------|
| ITO | 4.95 eV |
| NiO_x | ≥ 5.10 eV |
| TiO_x | ≤ 4.50 eV |



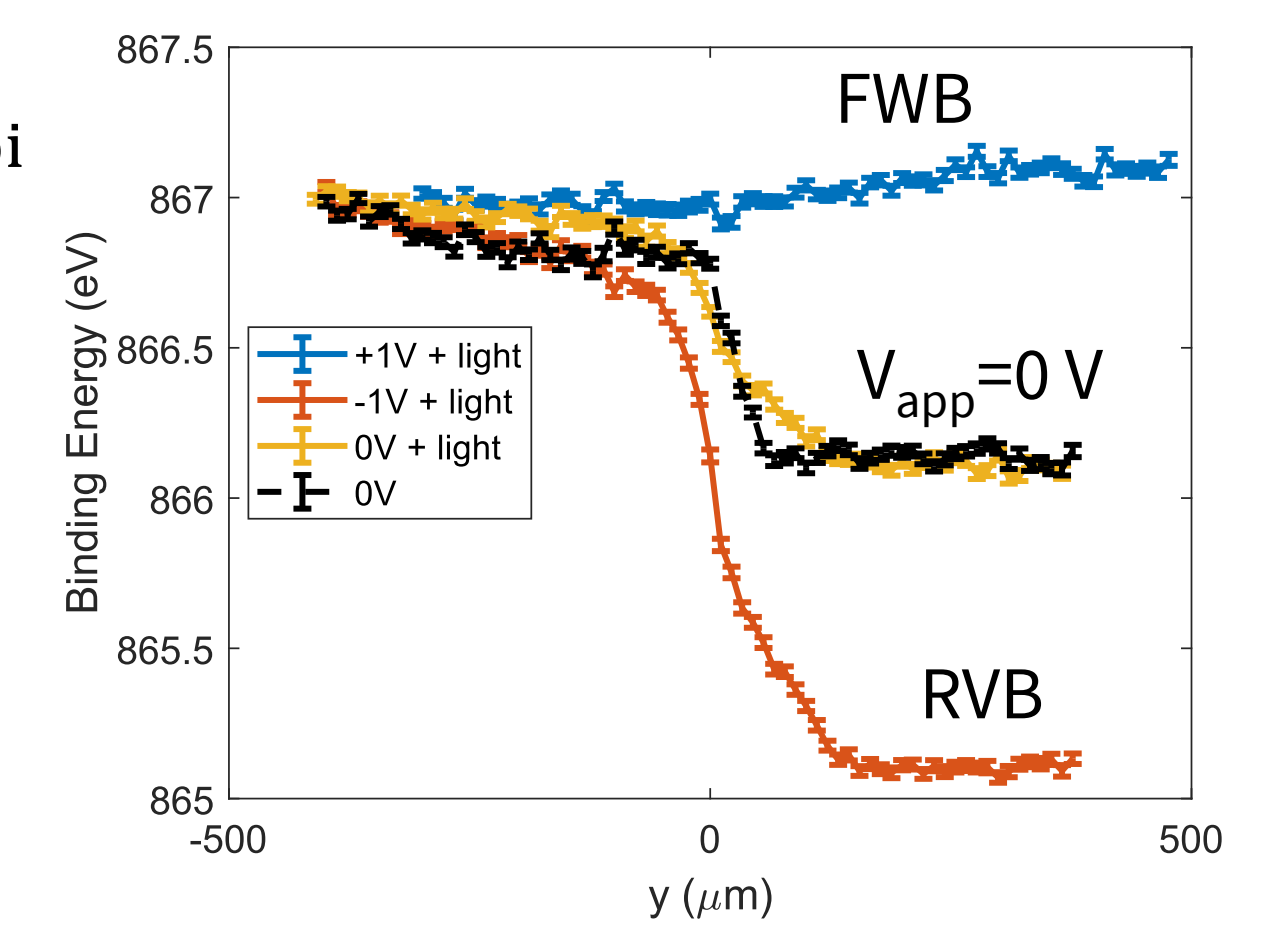
$$\Delta_{WF} = WF_{\text{NiO}_x} - WF_{\text{TiO}_x} \geq 0.6 \text{ eV}$$

XPS under Light and Voltage bias

Scan in the « dark »



Scan under illumination

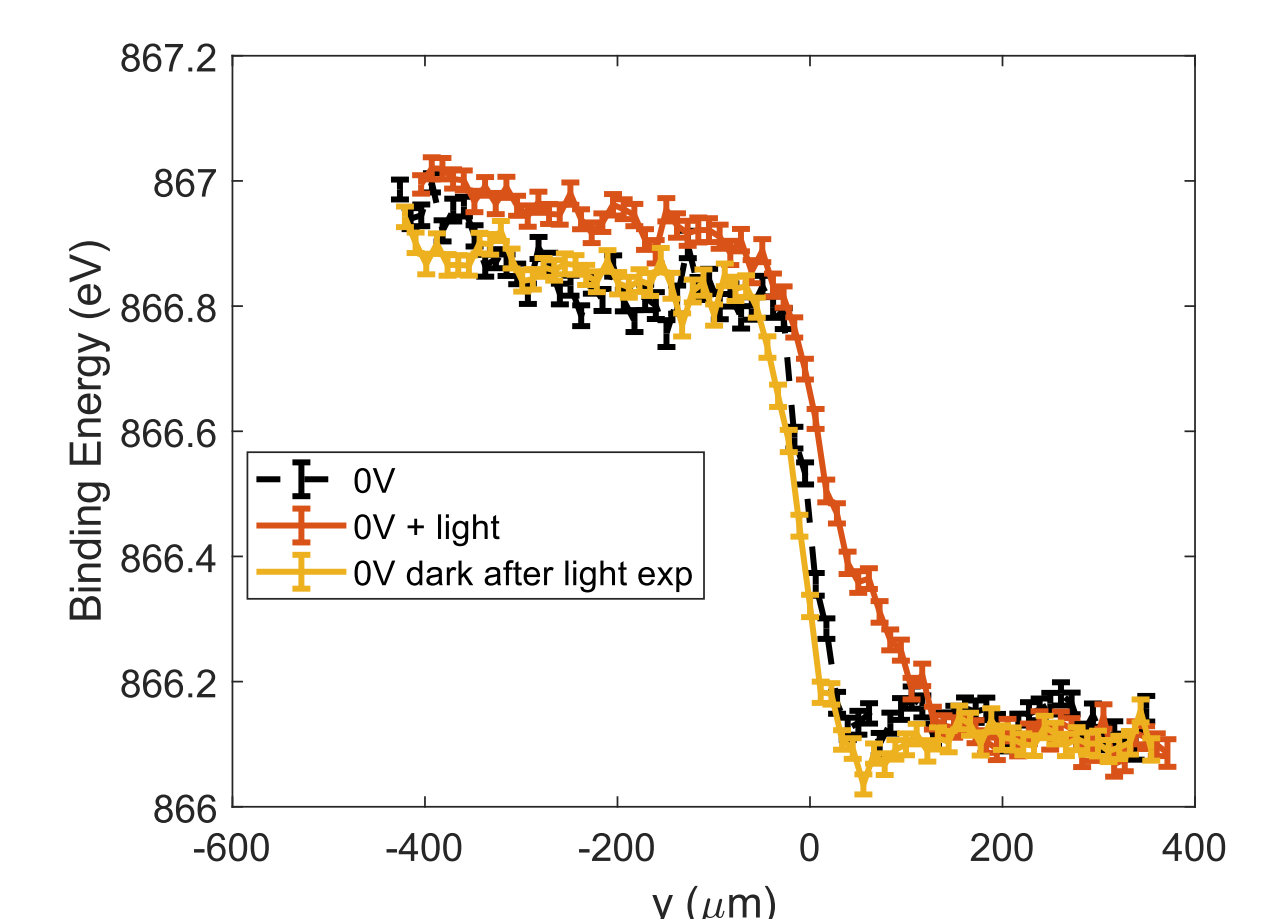
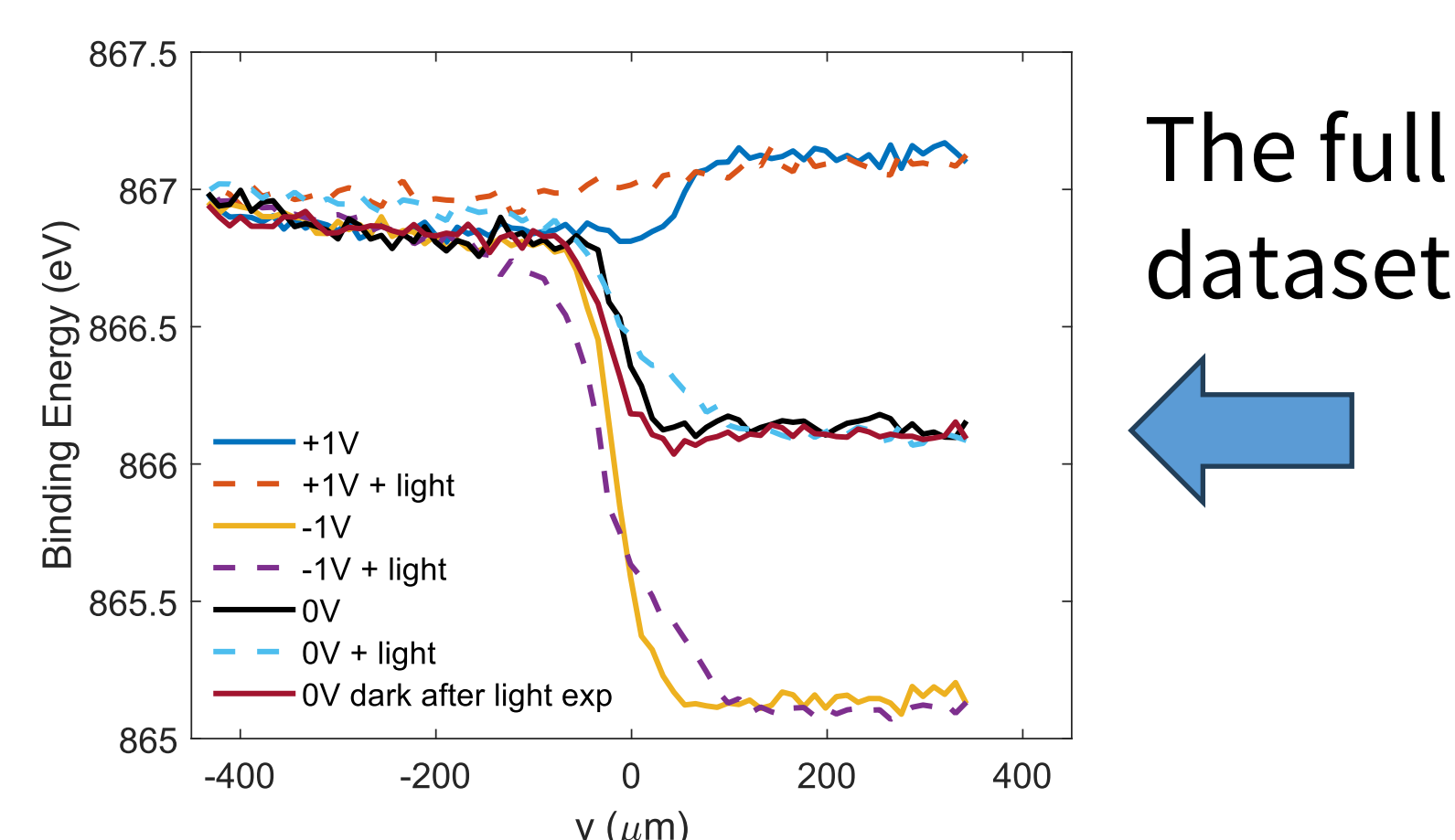


The applied voltage modifies V_{bi} :

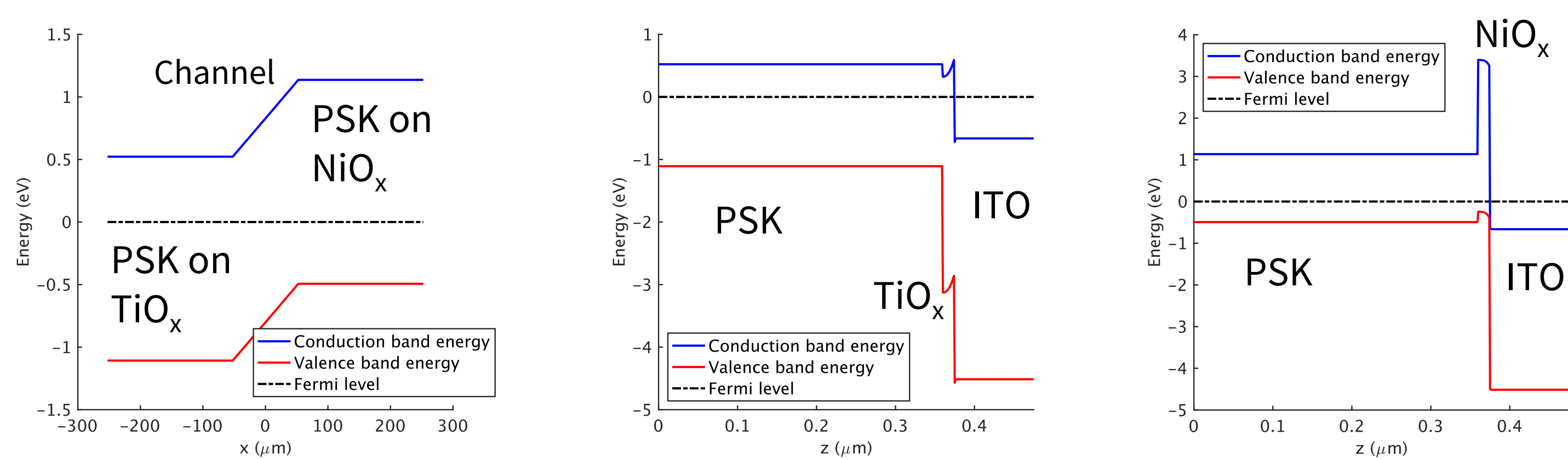
$$\text{RV B: } V_{bi} - V_{app} = 0.7 + 1 = 1.7 \text{ V}$$

$$\text{FW B: } V_{bi} - V_{app} = 0.7 - 1 = -0.3 \text{ V}$$

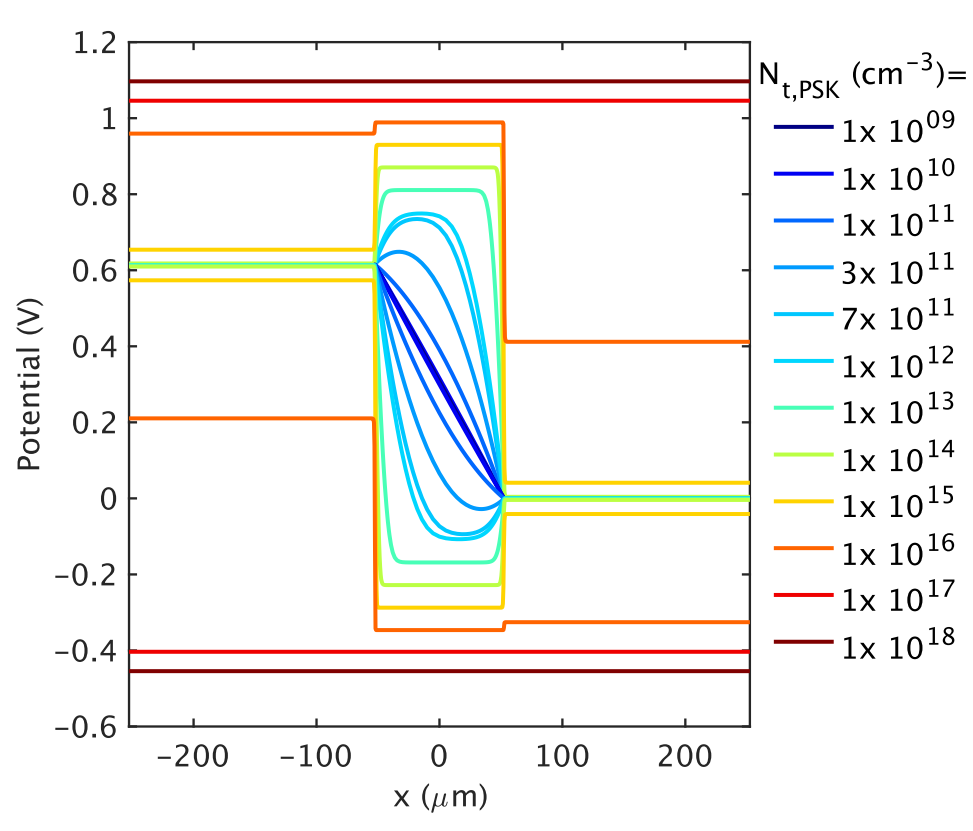
No hysteresis in the dark 0 V scan, after applying light.



Drift-Diffusion model: band diagrams for intrinsic perovskite



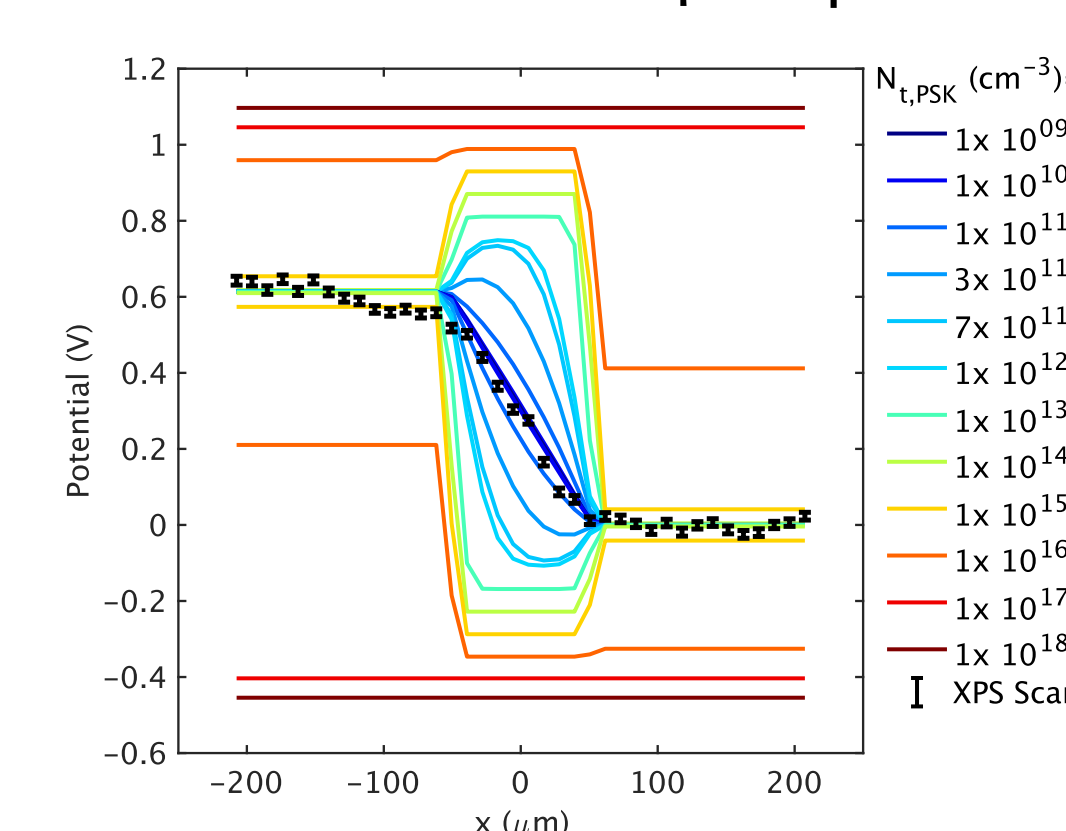
Actual Potential



Surface Potential as a function of PSK doping density

Conclusion:
 $N_{\text{dop}} \leq 10^{11} \text{ cm}^{-3}$

Convolution with 10 μm spot size



CONCLUSIONS

NiO_x and TiO_x - based LHJ device: various PSK channels created between the two contacts (lengths ranging from 10 to 100 μm). Double cation perovskite spin coated on the LHJ: the selective contacts under the PSK determine the potential drop in the PSK (V_{bi}) which can be modulated by an applied bias. PSK doping density measured $\leq 10^{11} \text{ cm}^{-3}$.

Dunfield et al., **Carrier gradients and the role of charge selective contacts in lateral heterojunction all back contact perovskite solar cells**, Cell Reports Physical Science 2, 100520.

Regaldo, D et al, **On the equilibrium electrostatic potential and light-induced charge redistribution in halide perovskite structures**. Prog Photovolt Res Appl. 2022; 1- 9.