CNATS

Centro de Nanociencia y Tecnologías Sostenibles

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

Group of Energy Conversion Materials and Devices

Current activities of the Group

LEDMOF laboratory, Triple Stack Perovskite Modules & DSSC for Indoor PV

Paul Pistor, Juan A. Anta, G. Oskam

ppis@upo.es

07/11/2025, Toledo

2nd neXtP\Vnet Meeting

Energy Conversion Nanomaterials & Devices Group

https://www.upo.es/investiga/ccs/

Senior members:

Juan A. Anta

Professor for Physical Chemistry

- Dye-sensitized solar cells
- Hybrid perovskite solar cells
- Small-signal perturbation methods
- Modeling & simulation

Gerko Oskam

Profesor (BG) at UPO.

- Dye-sensitized solar cells
- Hybrid perovskite solar cells
- Nanomaterials synthesis
- Photoelectrochemistry
- Solar fuels (H_2)

Paul Pistor

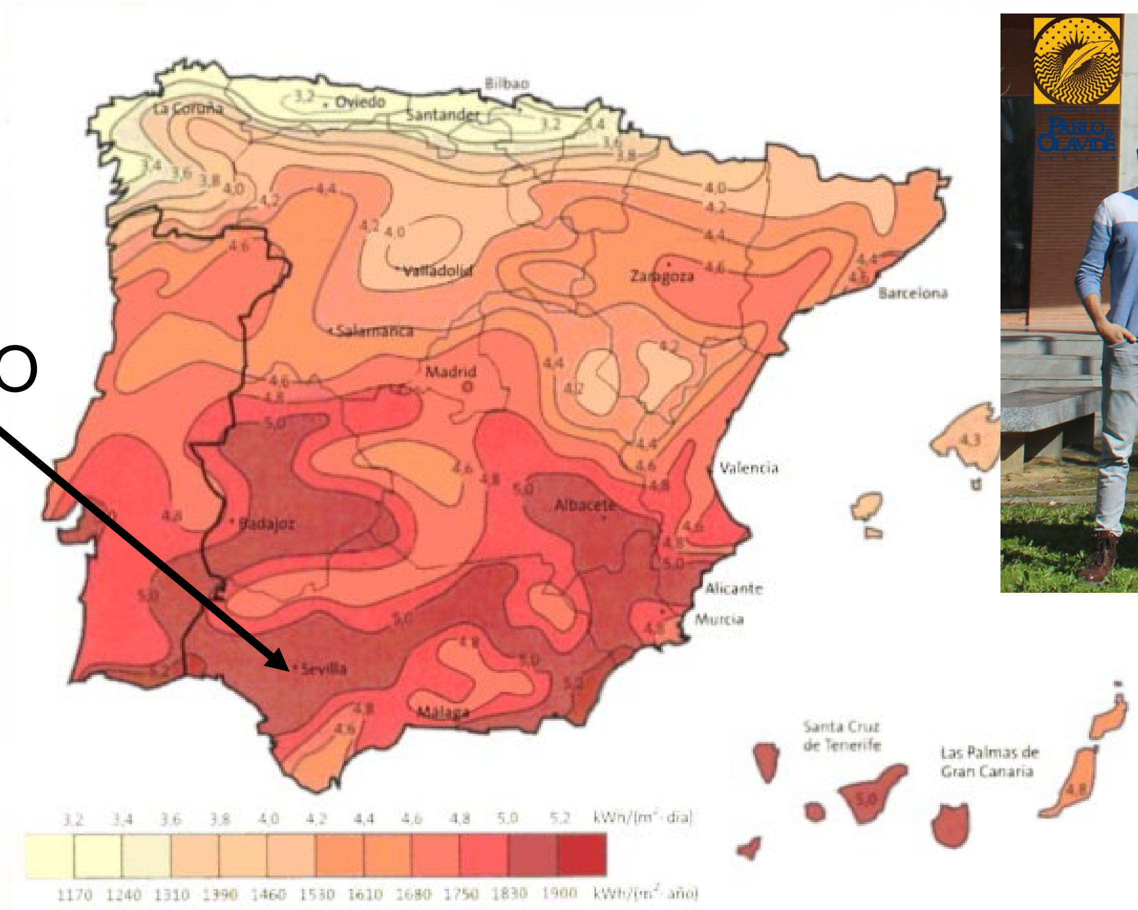
Profesor Titular (BG) at UPO.

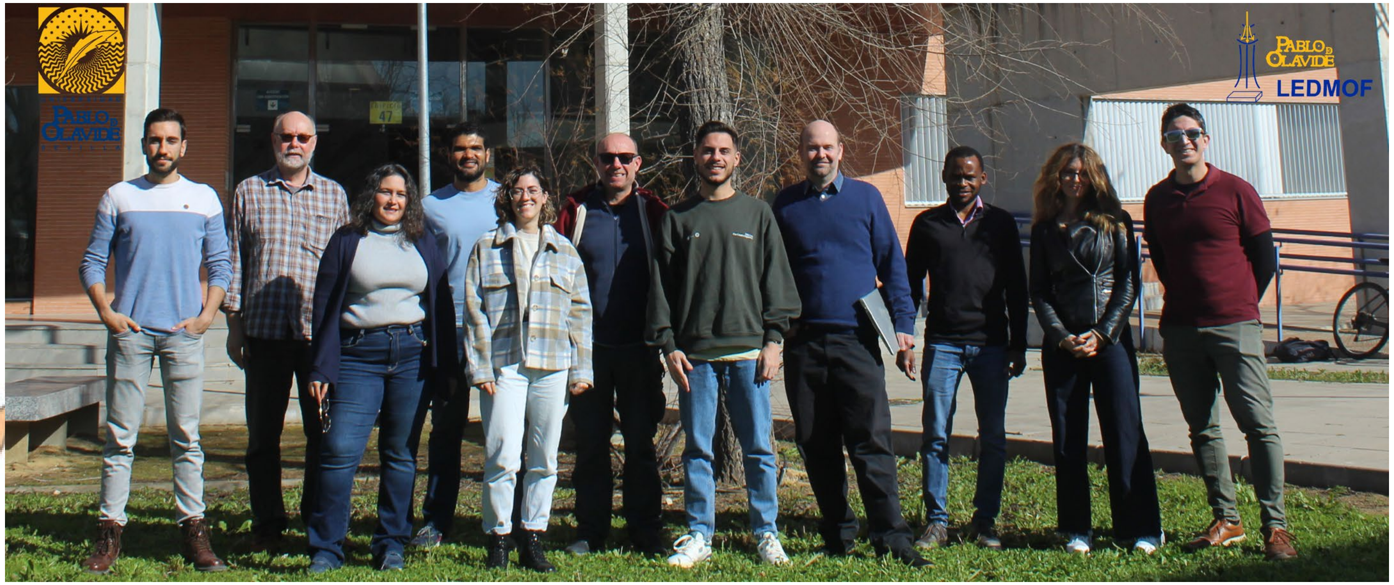
- Kesterite solar cells
- Hybrid perovskite solar cells
- Physical device fabrication methods
- Scale-up & device testing

Energy Conversion Materials & Devices Group

Previously: Nanostructured Solar Cells Group

UPO





PIs:

Juan Anta
Paul Pistor
Gerko Oskam

Postdocs:

Renán Escalante
Clara Aranda
Valid Mwalukuku

PhD students:

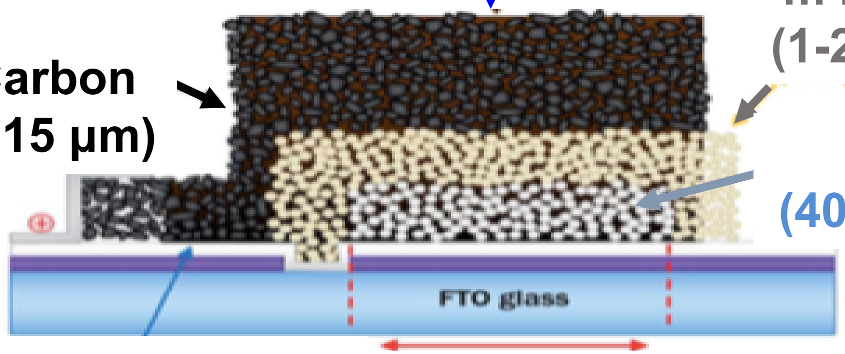
Juan Carlos Expósito
Patricia Sánchez
Mahmoud Nabil
Beatriz Heredia

Research topics

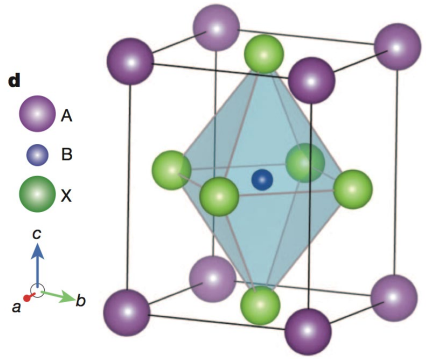
- Perovskite solar cells (PSC)
- Dye-sensitized solar cells (DSC): indoor applications
- Metal oxides for TCOs and photoelectrochemical water splitting
- Optoelectronic characterization of light conversion systems: impedance spectroscopy, IMPS/IMVS, etc.
- Device modelling: drift-diffusion numerical simulation of PSC and DSC devices
- Atomistic simulation of materials for energy: DFT, classical molecular dynamics

I. Triple Stack Carbon Perovskite Solar Cells

Perovskite infiltrated throughout stack



J. Baker et al., *J. Mater. Chem. A*, **2017**, 5, 18643–18650



"Perovskita": $CaTiO_3$

ABX_3

MAPI: $(H_3C\text{-}NH_3)PbI_3$

$E_G = 1.56$ eV

In collaboration with:

- Trystan Watson, Swansea University, Wales, UK
- Geonel Rodríguez, Cinvestav-Mérida, Yuc., México

Characteristics:

- ✧ All printed
- ✧ No organic hole conductor
- ✧ No gold top contact
- ✧ Best stability
- ✧ Scaleable processing

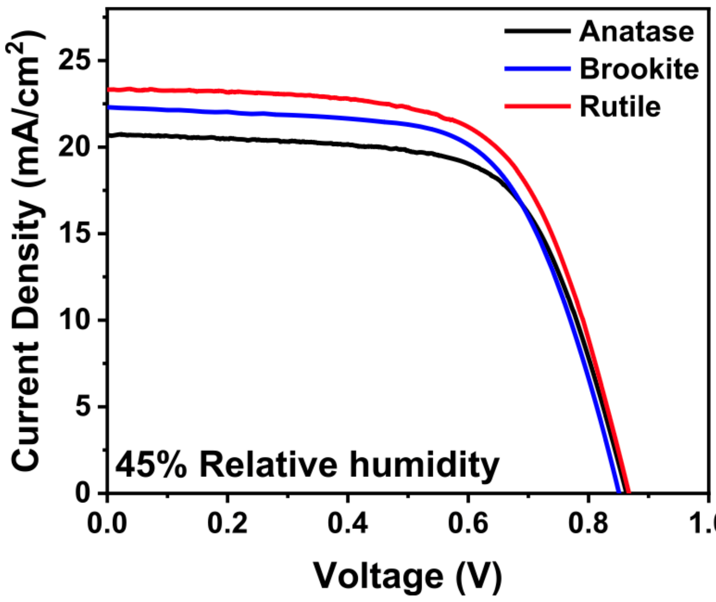
Important fabrication advantage:

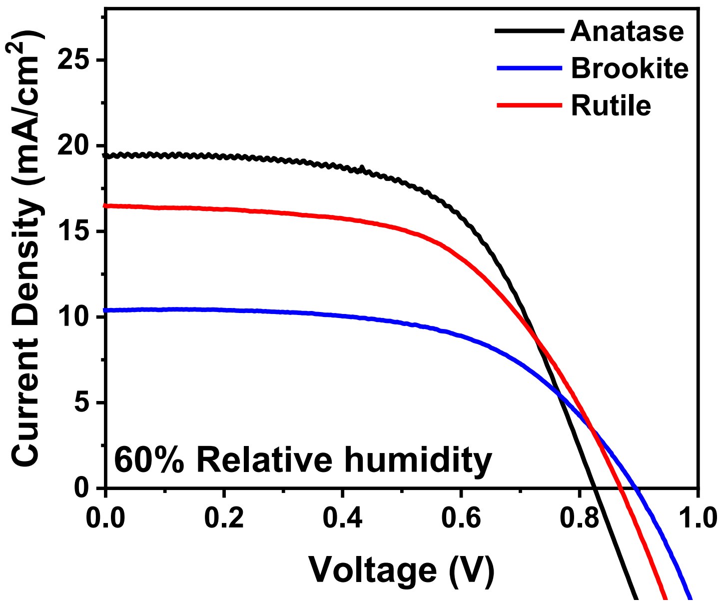
- **The entire printed architecture can be fabricated in ambient conditions.**
- **Only the infiltration step needs to be done in controlled environment.**

I. Triple Stack Carbon Perovskite Solar Cells

Strategy: Improve the extraction of electrons by modifying the morphology and structure of the TiO_2 layer.

Bety Heredia





At relatively low humidity during infiltration, rutile performs best:

- ➢ larger perovskite crystallite size, and good electronic properties of both rutile and the hybrid perovskite.

At relatively high humidity during infiltration, anatase performs best:

- ➢ better wetting properties promotes crystallization, while avoiding perovskite degradation.

B. E. Heredia-Cervera, M. Nabil et al.; APL Energy ***3****, (2025).*
DOI: *10.1063/5.0278702*

Laboratory LEDMOF

Laboratory for Testing and Diagnostics of Photovoltaic Cells and Sub-modules

(Laboratorio de ensayo y diagnóstico de sub-módulos fotovoltaicos)

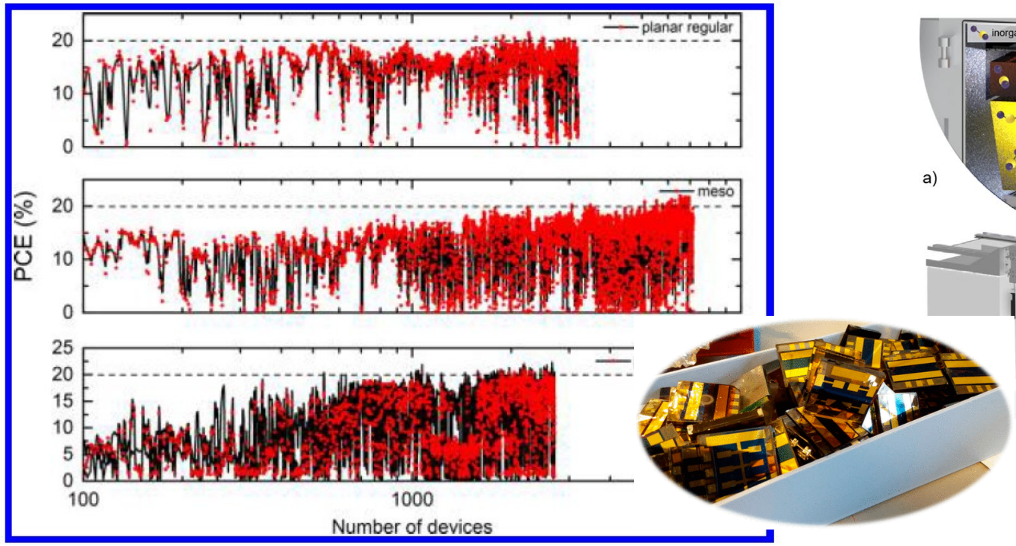
Laboratory for Testing and Diagnostics of Photovoltaic Cells and Sub-modules

Main Objective

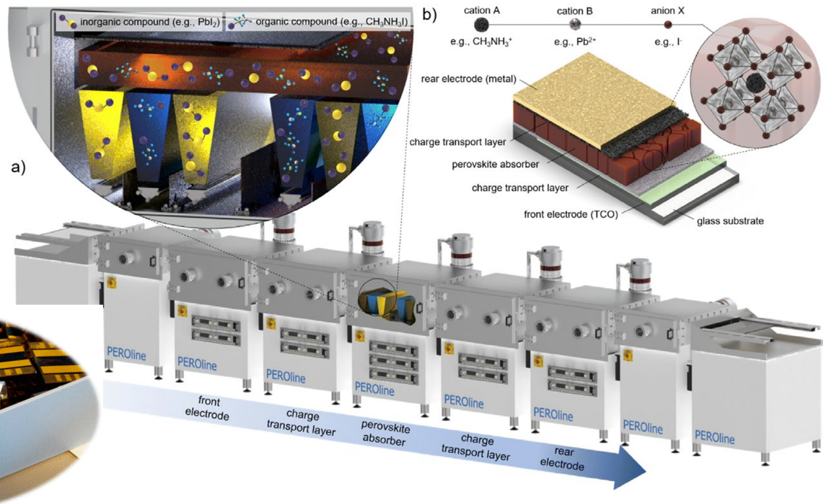
To provide the infrastructure and techno-scientific services necessary for the upscaling of emerging PV technologies, namely for the processing, testing and the diagnosis of devices from lab scale up to pre-industrial submodules.

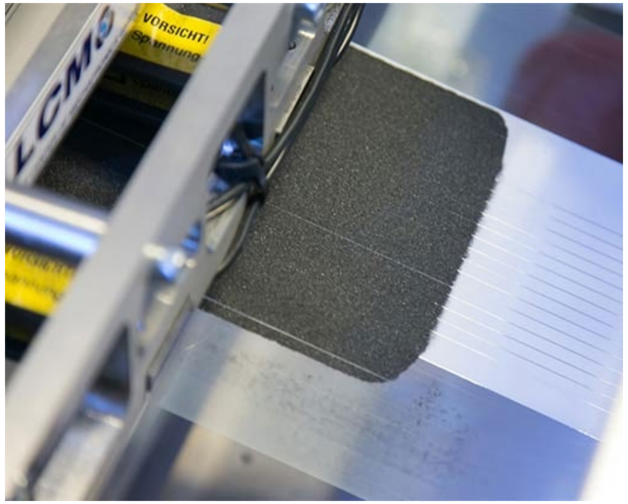
Challenges to upscaling and commercialisation

Reproducibility and cycle time

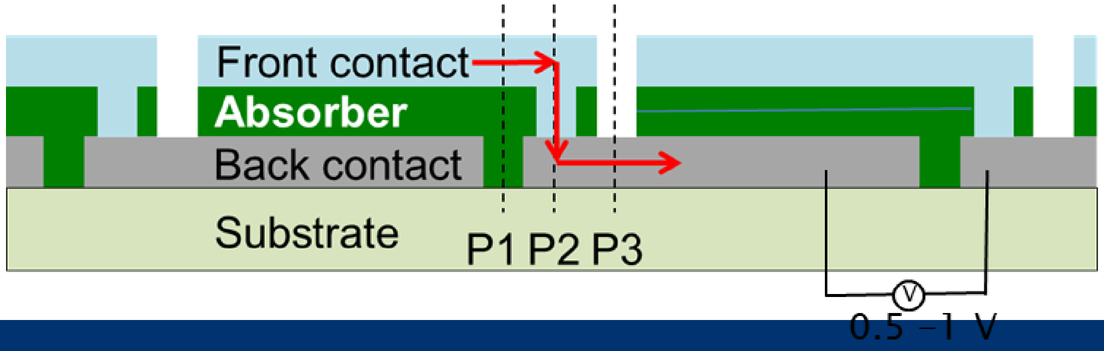


Homogeneity and process scaling

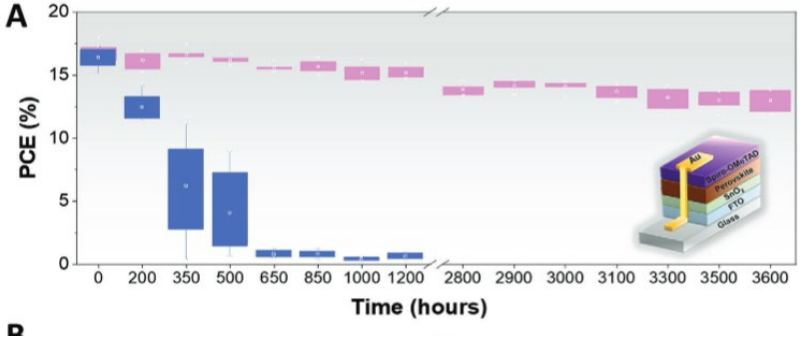




Contacts and Interconnects



Stability



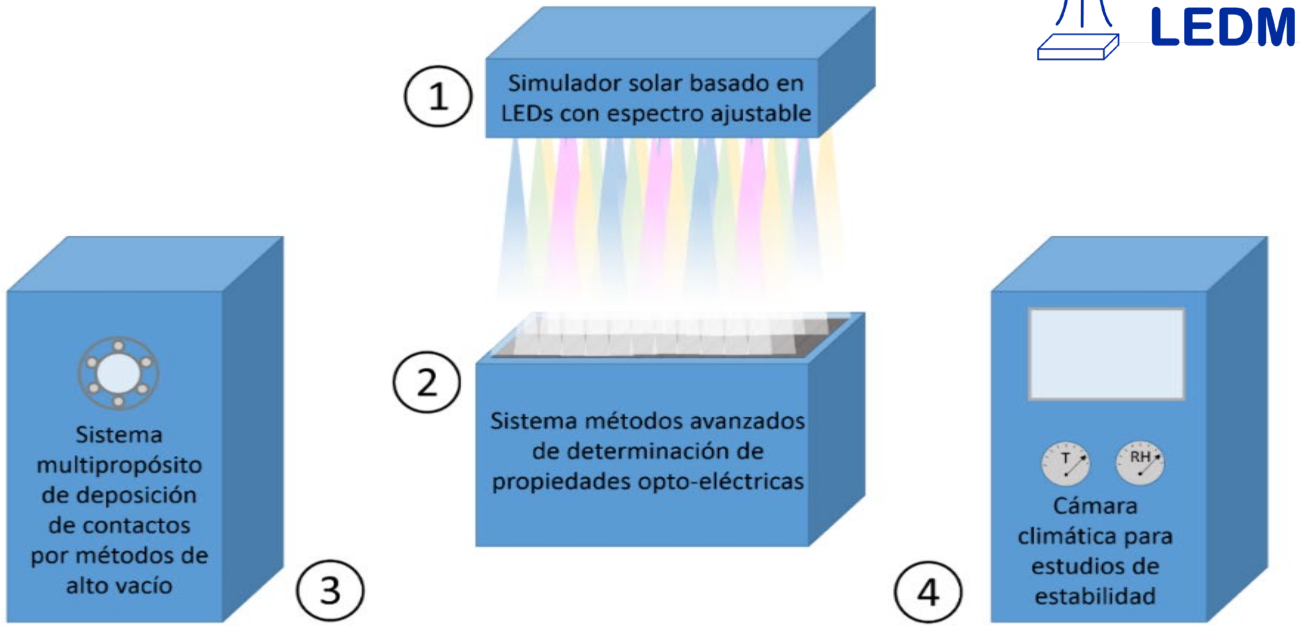
Laboratory for Testing and Diagnostics of Photovoltaic Cells and Sub-modules

Main Objective

To provide the infrastructure and techno-scientific services necessary for the upscaling of emerging PV technologies, namely for the processing, testing and the diagnosis of devices from lab scale up to pre-industrial submodules.

Analysis of :

- Efficiency losses during the transition from cells to modules.
- Inhomogeneities during scaling.
- Process reproducibility.
- Device stability and degradation.



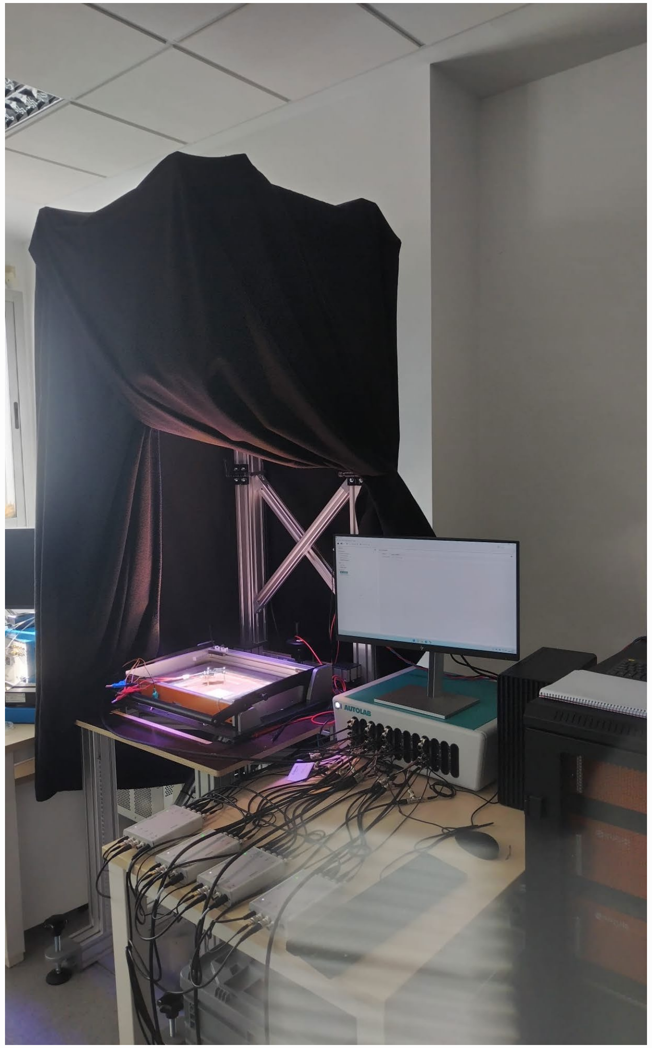
Laboratory LEDMOF

(1) LED-based solar simulator from **WAVELABS**: Testing of photovoltaic devices up to 22 x 22 cm2 size under calibrated standard conditions (AM1.5) as well as various non-standard conditions (spectral, intensity, temperature variations).

(2) Advanced opto-electronic characterization setup enables the profound fundamental characterization of series of opto-electronic devices using small pertubation techniques (Impedance, IMVS, IMPS, DLTS, …) (PAIOS from **FLUXIM**).

(3) A multi-deposition tool from **KORVUS**, capable of depositing different contact and charge extraction layers via sputtering, thermal evaporation or spin-coating, all of these in vacuum or inert gas atmosphere (N2-filled glovebox and vacuum chamber).

(4) Climate chamber for the controlled exposure to defined humidity and temperatura conditions allowing a detailed degradation analysis of devices.



Laboratory LEDMOF

(1) **LED-based solar simulator** from **WAVELABS**: Testing of photovoltaic devices up to 25 x 25 cm2 size under calibrated standard conditions (AM1.5) as well as various non-standard conditions (spectral, intensity, temperature variations).

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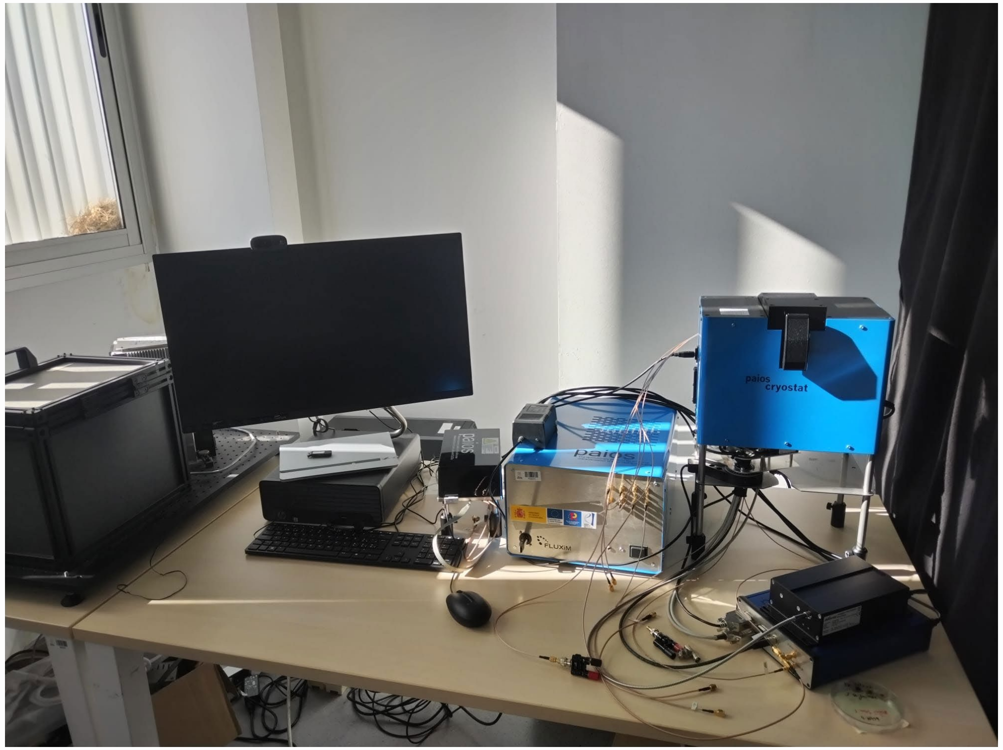

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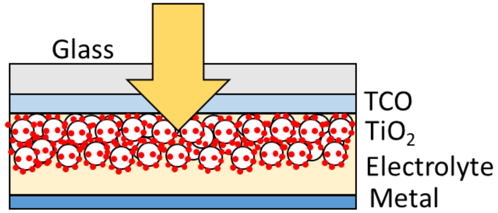
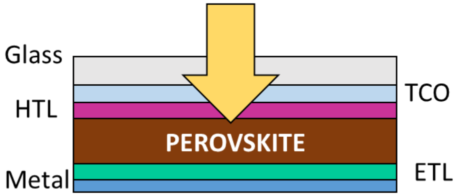
Internal Samples

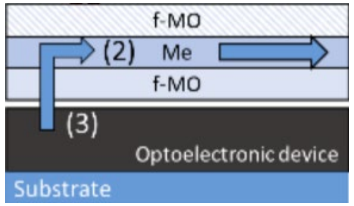
DSSC



Perovskite



Metal oxide contacts
(TiO_2, SnO_2, ZnO, mixtures)



EMERSCALE
Escalamiento de tecnologías fotovoltaicas emergentes

Triple Stack Perovskite Solar Modules

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

External samples – collaborations with academia and industry

HZB Helmholtz Zentrum Berlin

sunplugged

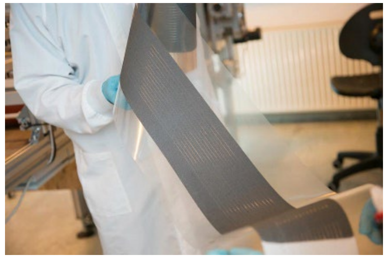
IREC Shaping Energy for a Sustainable Future

Cinvestav

ZSW

imec

SAULE TECHNOLOGIES



EMERSCALE
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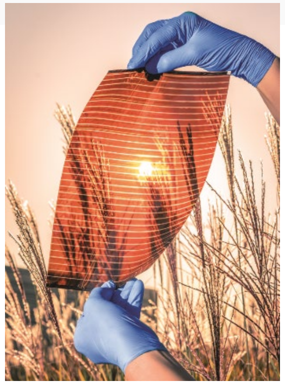


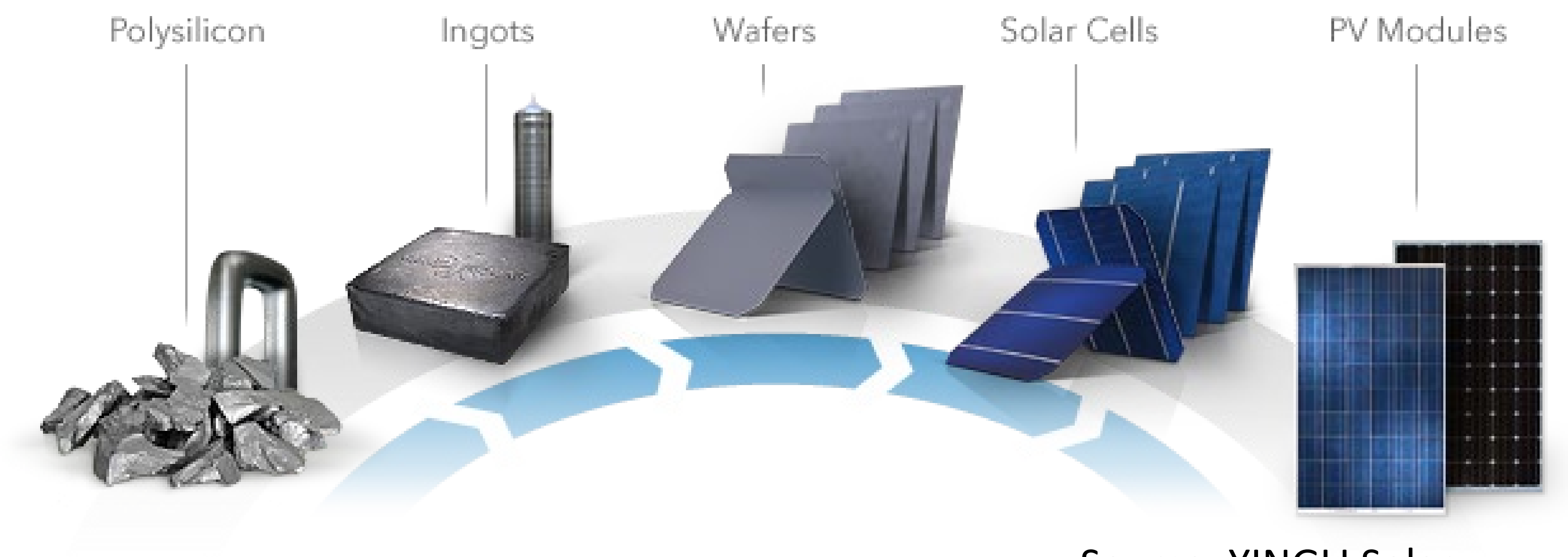
Platform-ZERO

Lograr una producción sin defectos para la industría fotovoltaica

Co-funded by the European Union

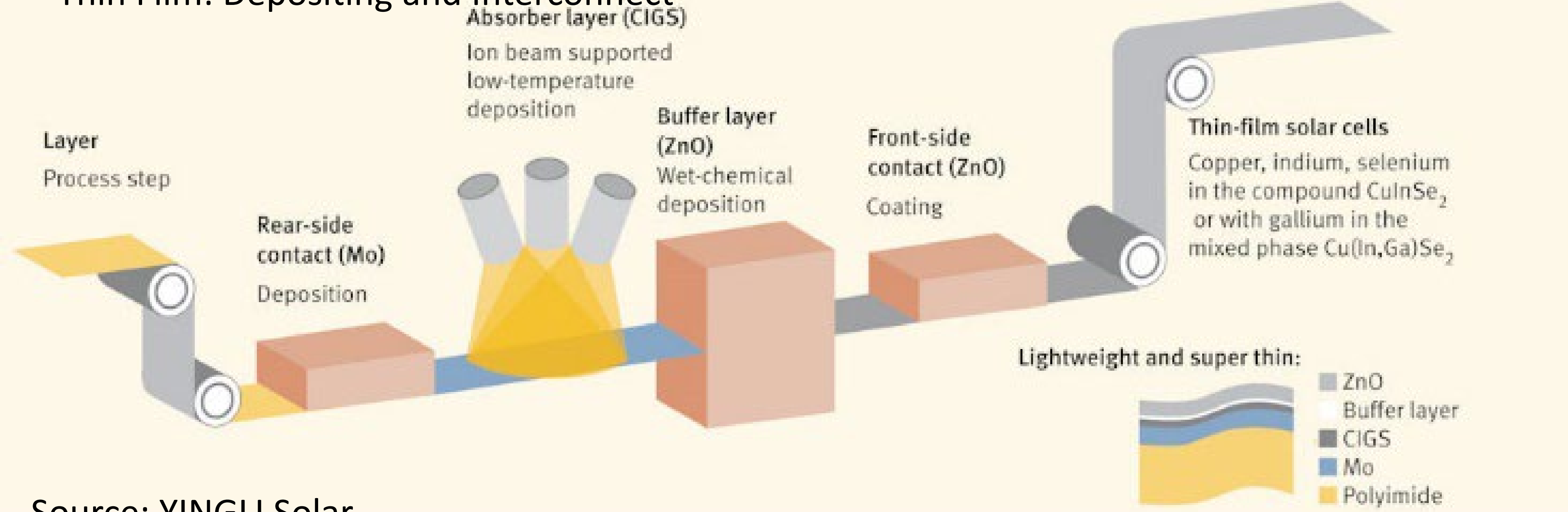
Grant agreement ID: 101058459

Wafer-based: Purification, Casting, Sawing, Processing, Connection and Module assembly



Source: YINGLI Solar

Thin Film: Depositing and Interconnect



Source: YINGLI Solar

Platform Zero: Concepto

Retos en la producción de tecnologías fotovoltaicas emergentes:

➔ **Pequeñas desviaciones** del proceso de fabricación lleva a defectos críticos en la producción de los módulos, resultando en dispositivos defectuosos.

➔ **Evaluación de los productos** hoy día normalmente al final.

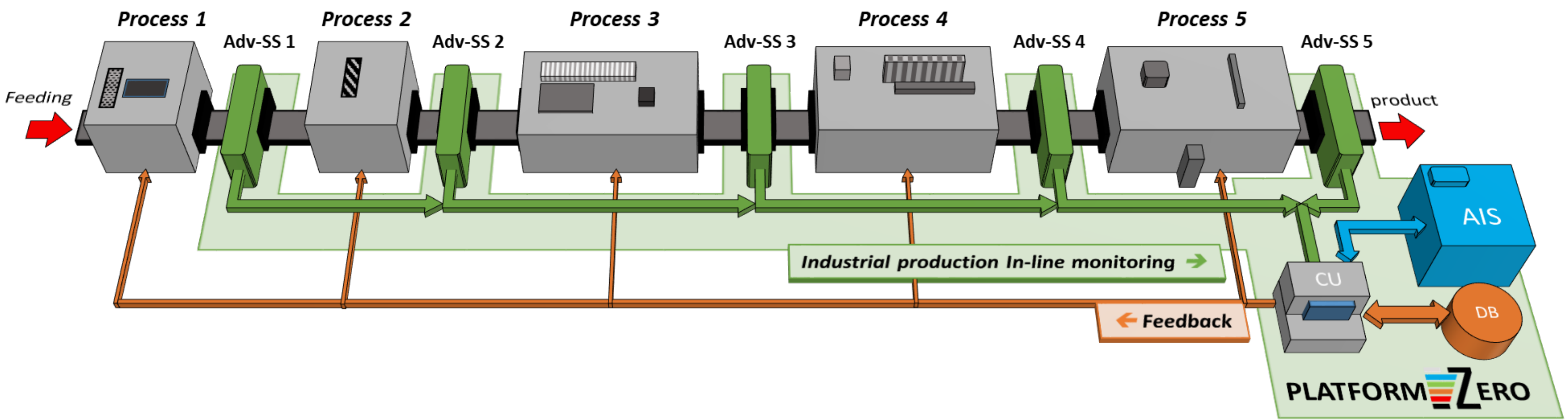
➔ **Desperdicio de materiales** de alto valor por productos defectuosos.

Platform-Zero objetivo principal:

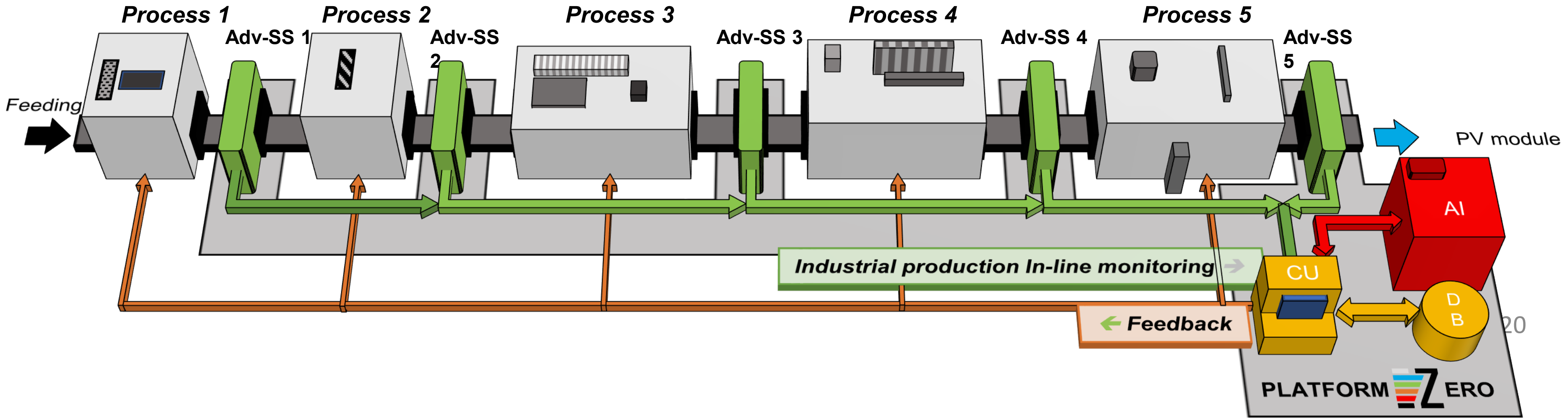
Reducir los productos defectuosos en la fabricación fotovoltaica.

Desarrollo de una plataforma de monitorización de procesos en línea que proporcione una evaluación de la producción in situ.

Métodos de inspección no destructivos y herramientas basadas en inteligencia artificial (IA), para permitir la detección, corrección y/o prevención temprana de fallos de la producción.



Testeo de prototipo en líneas de fabricación industrial



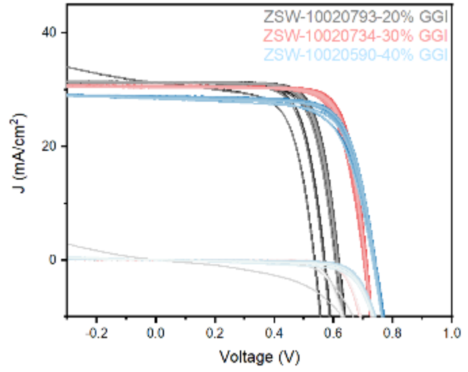
Contribución UPO: Sensor Optoelectrónico (IV, EQE, IMP)

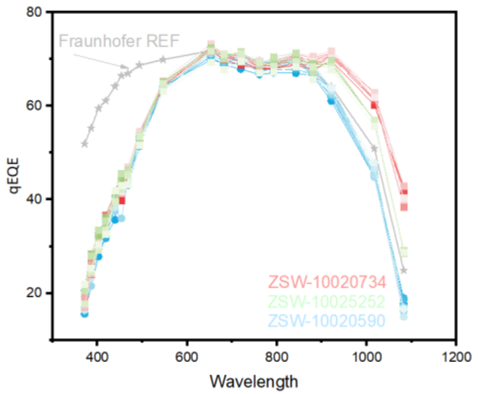
Tareas:

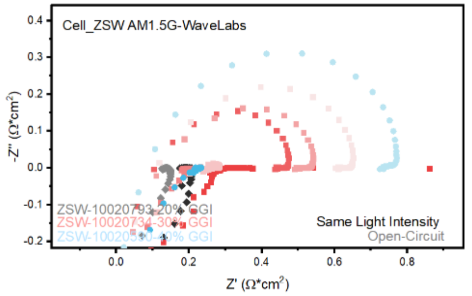
- Desarollo una estación sensorial optoelectrónica.
- Medidas optoelectrónicas de sets de referencias de los diferentes partners industriales para establecer la metodología.
- Diseño de formatos de datos y alimentar la base de datos
- Prototipaje en la UPO e implementación en las líneas de producción.

Medidas y extracción de KPIs (Key Performance Indicators):

- Curvas IV (η, FF, V_{OC}, j_{SC}, R_S)
- Quasi EQE (bandgap, max, buffer thickness)
- Impedance/Admittance (RS, MaxFreq, Rrec, doping)







Thank you.

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