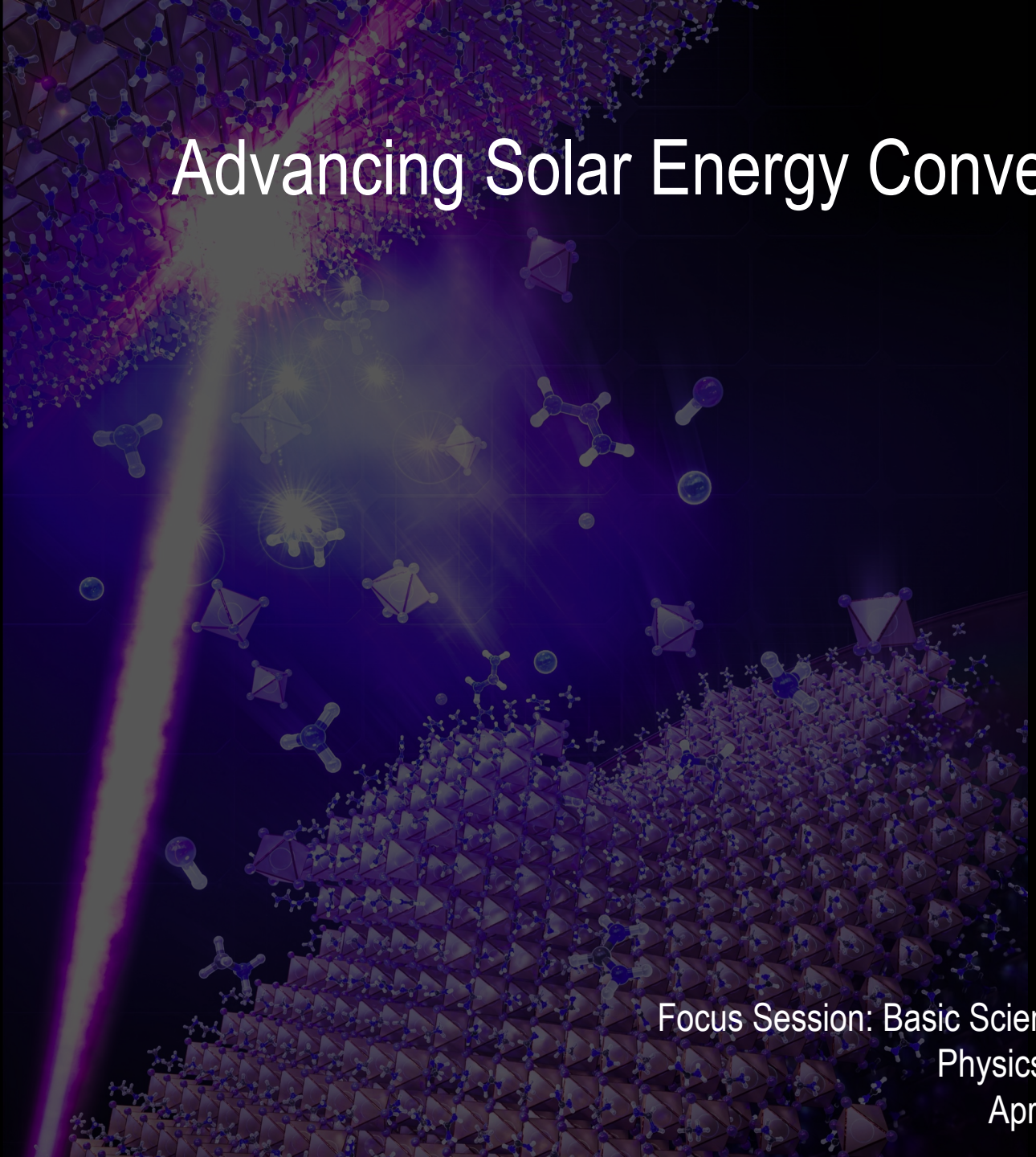


Advancing Solar Energy Conversion through Materials Science

Prof. Monica Morales-Masis
m.moralesmasis@utwente.nl

European Research Council
Established by the European Commission

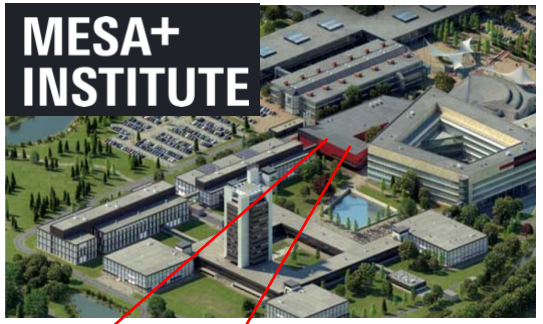
NWO

Focus Session: Basic Science for Sustainable Development
Physics@Veldhoven
April 4th 2023

MESA+ INSTITUTE FOR NANOTECHNOLOGY
UNIVERSITY OF TWENTE.

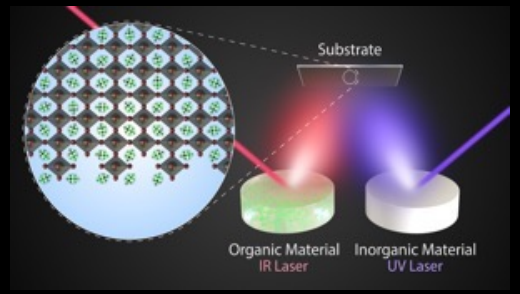
About me: a carreer in physics with a strong focus on materials science

	BSc-Physics	MSc-Physics	PhD-Physics	Postdoc	Team Leader	Professor
Education	UNIVERSIDAD DE COSTA RICA	WRIGHT STATE UNIVERSITY	Universiteit Leiden	ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE		UNIVERSITY OF TWENTE.
Visiting scientist				NIMS 独立行政法人 物質・材料研究機構 National Institute for Materials Science	BERKELEY LAB Lawrence Berkeley National Laboratory	



M³ Lab

Strong focus on controlled synthesis of materials



M^3: Making Optoelectronic Materials that Matter

M3 Lab

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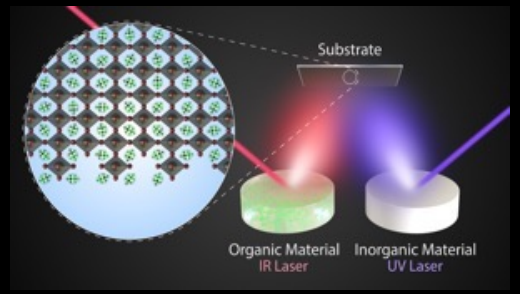
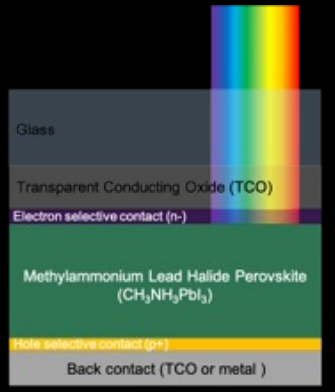
Strong focus on controlled synthesis of materials



M³: Making Optoelectronic Materials that Matter



Materials with tunable electrical and optical properties to optimize existing and enable new applications.

M³ Lab

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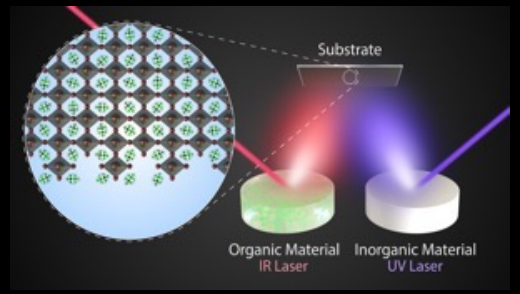
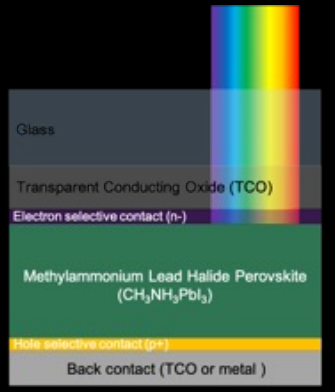
Strong focus on controlled synthesis of materials



M³: Making Optoelectronic Materials that Matter



Materials with tunable electrical and optical properties to optimize existing and enable new applications.

Enhance efficiency and functionality in emerging and stablished solar cells. Earth-abundant, Toxic-free materials

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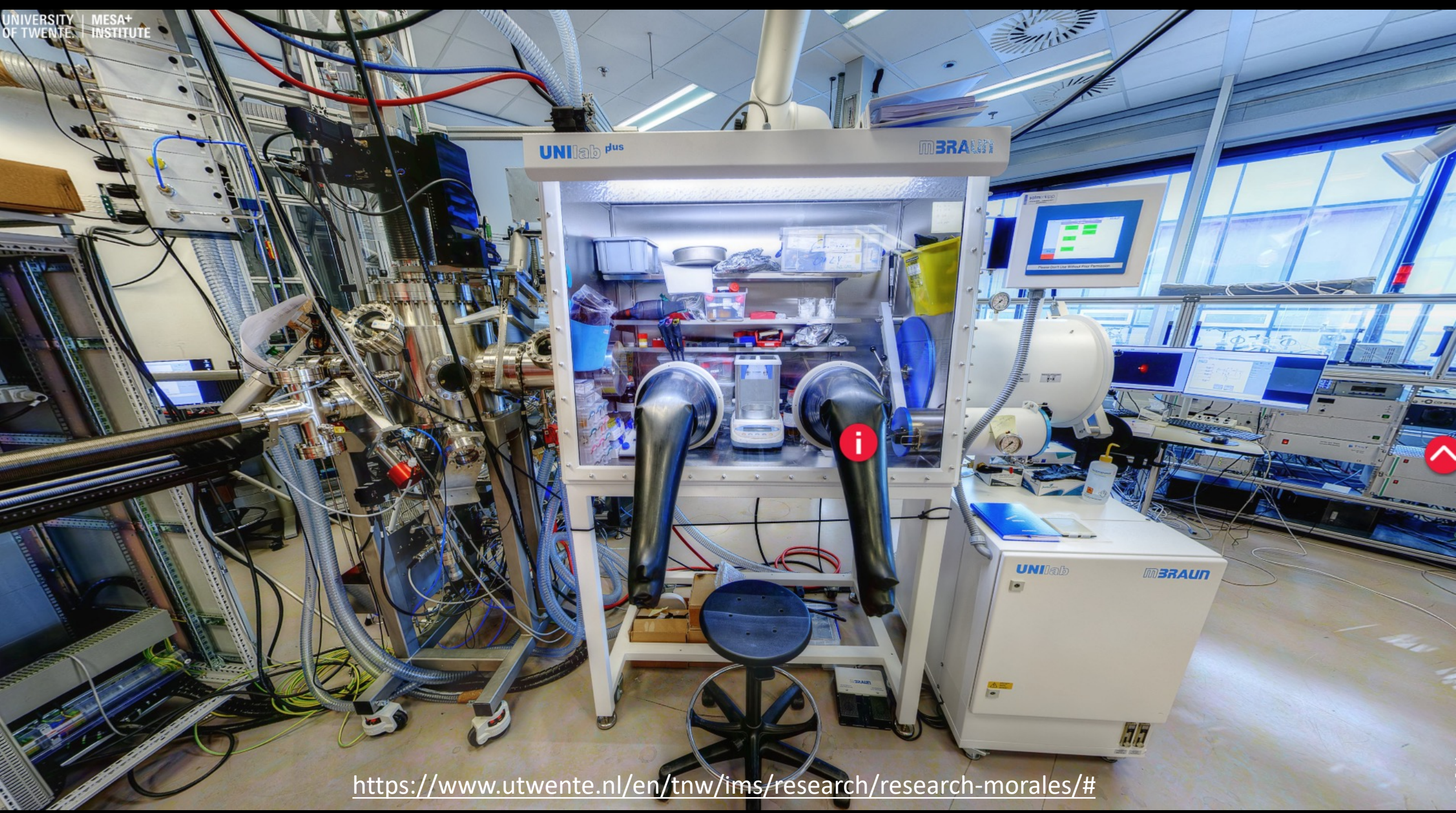
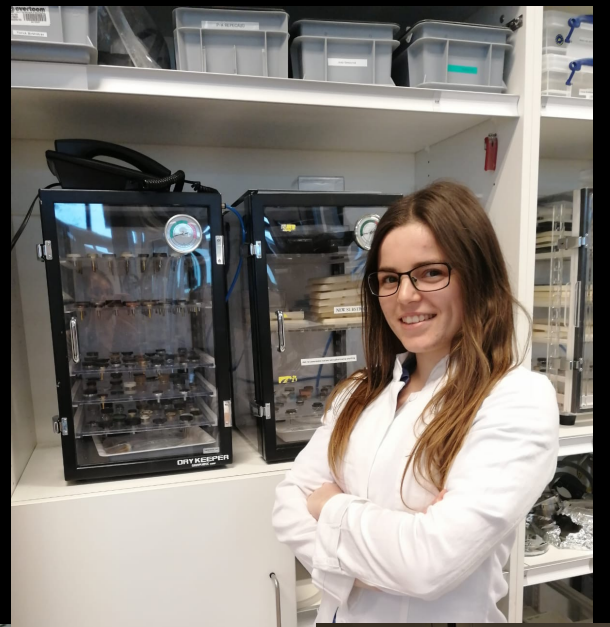
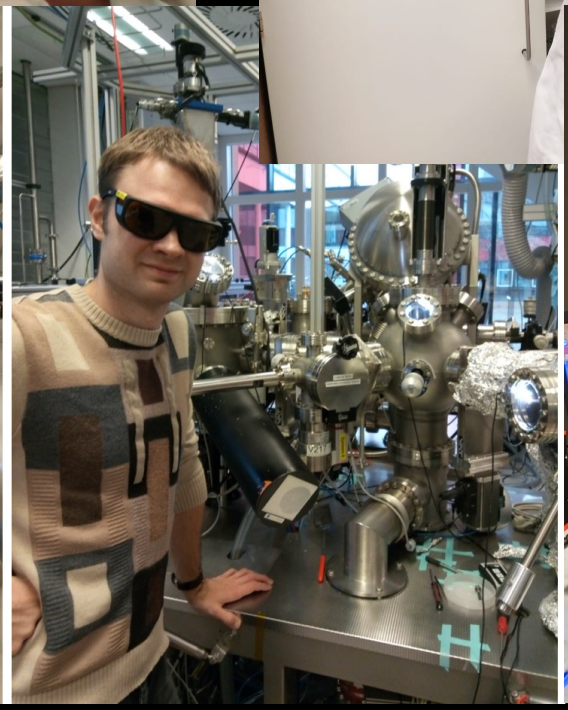
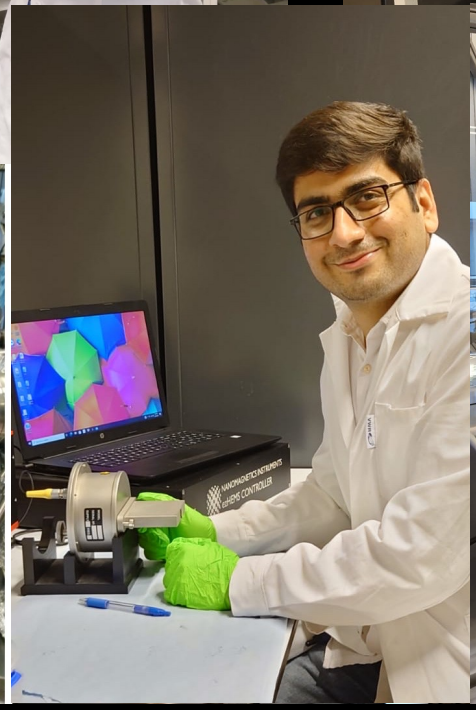
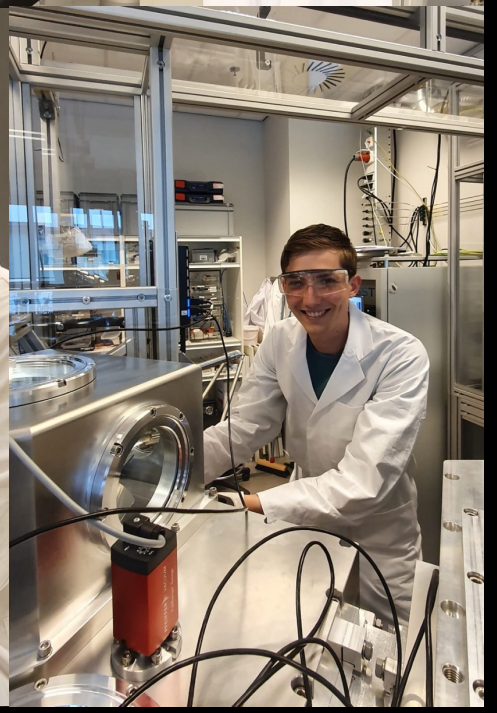


https://www.utwente.nl/en/tnw/ims/research/research-morales/#







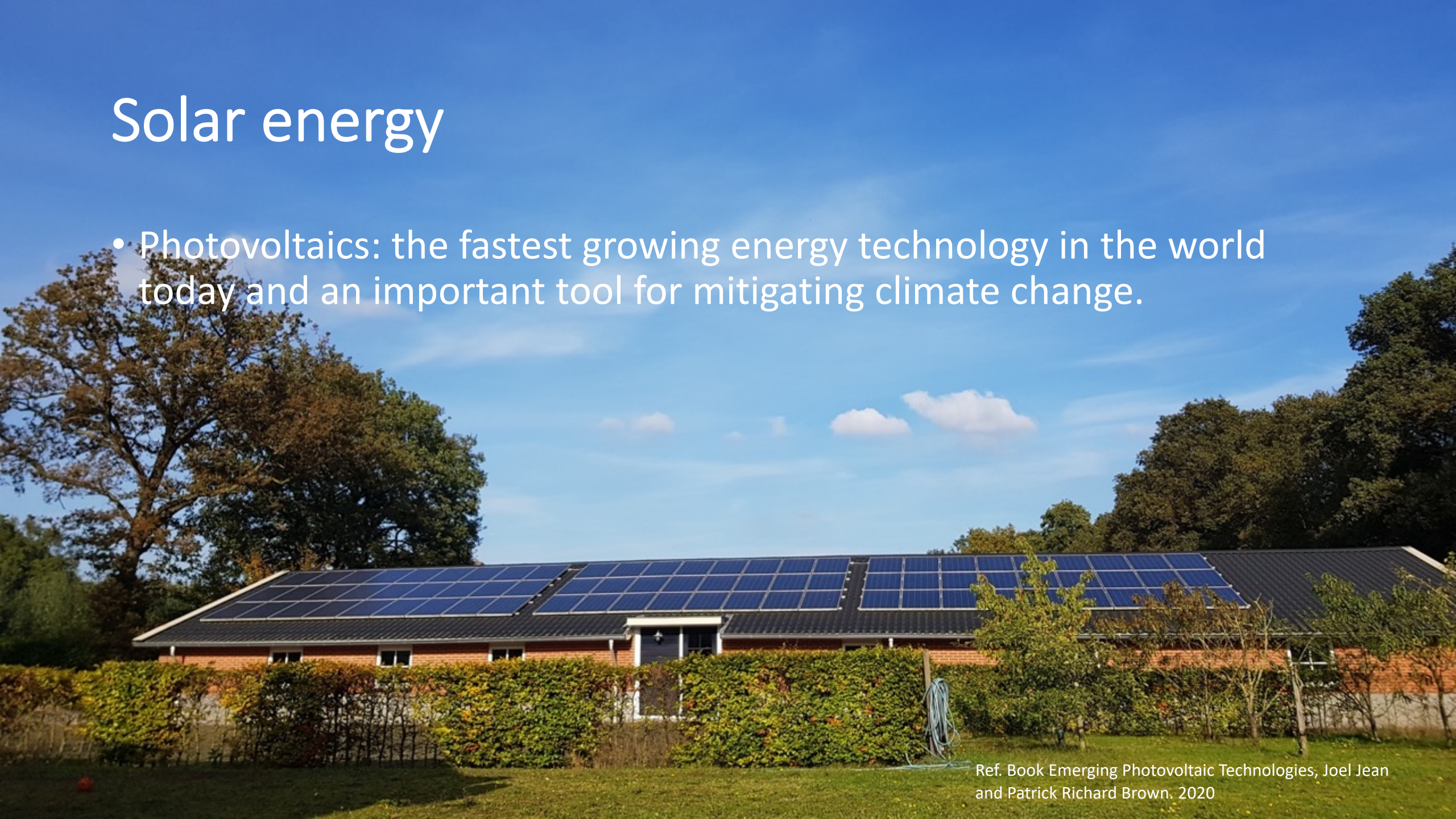


The M^3 team

Why Materials for Solar Cells?

Solar energy

- Photovoltaics: the fastest growing energy technology in the world today and an important tool for mitigating climate change.



Ref. Book Emerging Photovoltaic Technologies, Joel Jean and Patrick Richard Brown. 2020

Science Contents News Careers Journals

SHARE POLICY FORUM | RENEWABLE ENERGY

Terawatt-scale photovoltaics: Transform global energy

Nancy M. Haegel, Harry Atwater Jr., Teresa Barnes, Christian Breyer, Anthony Burrell, Yet-Ming C...

+ See all authors and affiliations

Science 31 May 2019:
Vol. 364, Issue 6443, pp. 836-838
DOI: 10.1126/science.aaw1845

Energy

Search The Guardian International edition

'Insanely cheap energy': how solar power continues to shock the world

Australian smarts and Chinese industrial might made solar power the cheapest power humanity has seen – and no one saw it coming

Royce Kurmelovs
@RoyceRk2
Sat 24 Apr 2021 21.00 BST

pv magazine Subscriptions

World has installed 1TW of solar capacity

The world has installed its first terawatt of hardware on Earth to generate electricity directly from the sun.

MARCH 15, 2022 JOHN FITZGERALD WEAVER

Global power demand ~ 20 TW

"Global installed solar PV capacity exceeded 500 GW at the end of 2018, and an additional 500 GW is projected to be installed by 2022-2023, bringing us to the era of TW-scale PV"

"…solar supplies 3% of the world's electricity. Our official forecast is that it will be 23% by 2050, but that's completely underestimated…"

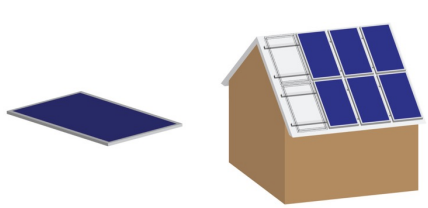
~90% of global PV installations are crystalline Silicon!

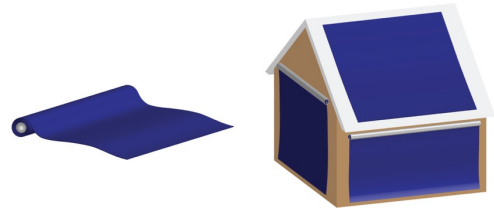
Crystalline silicon PV:
modules are now affordable, efficient, reliable and dominant in the global PV market

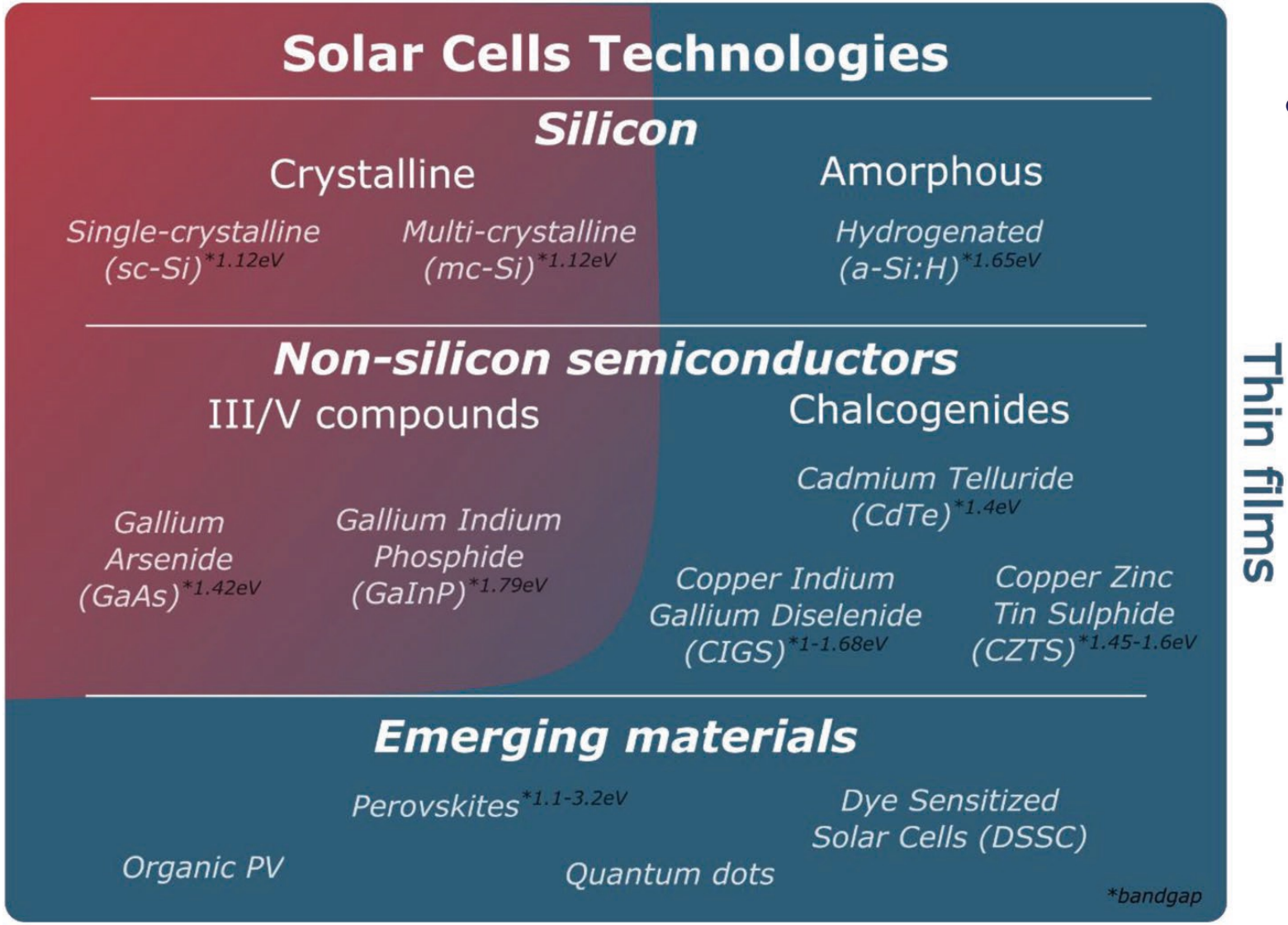
Do we actually need other PV technologies?

Sustainability! (low carbon footprint, recyclability, etc)
Efficiency (e.g. less m^2)
Seamless integration of PV everywhere (VIPV, BIPV, wearables, etc)

Main solar photovoltaic technologies…





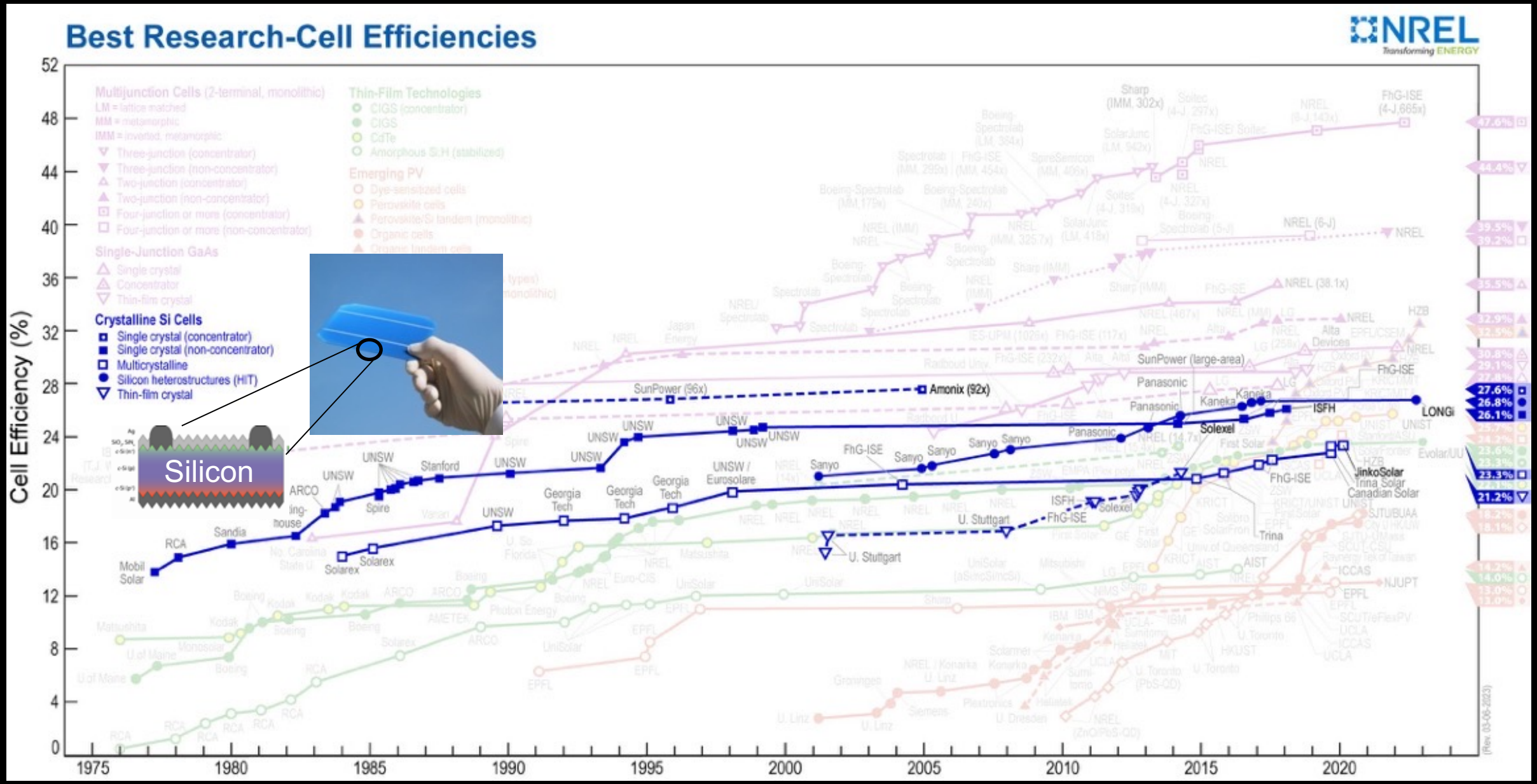


- Low CO_2 footprint
- Reduce use of materials
- Opportunities for new Earth abundant materials
- Avoid critical and toxic materials

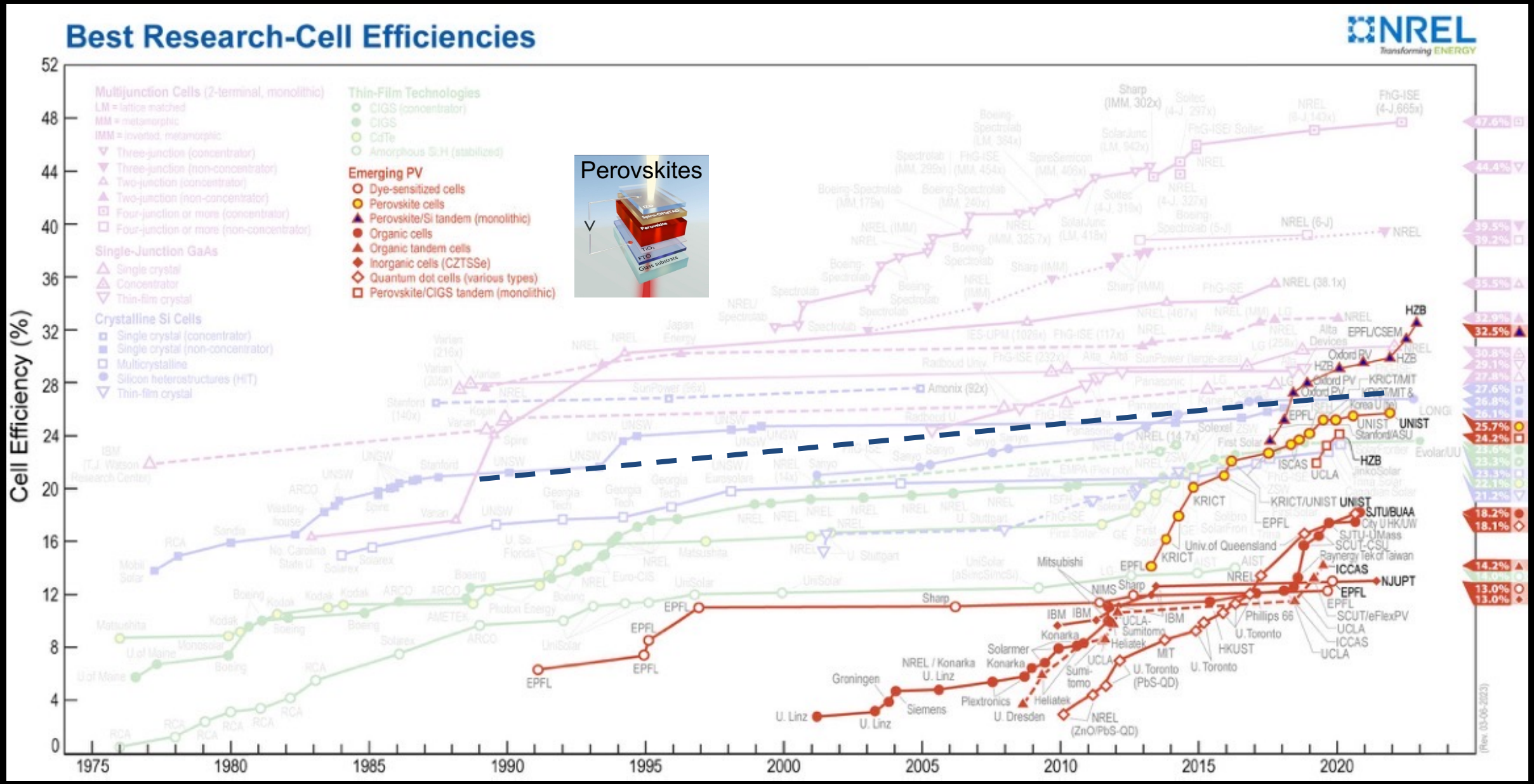
Ref. Nasti, Abate, Adv. Energy Mat. 2019. DOI: 10.1002/aenm.201902467

UNIVERSITY OF TWENTE.

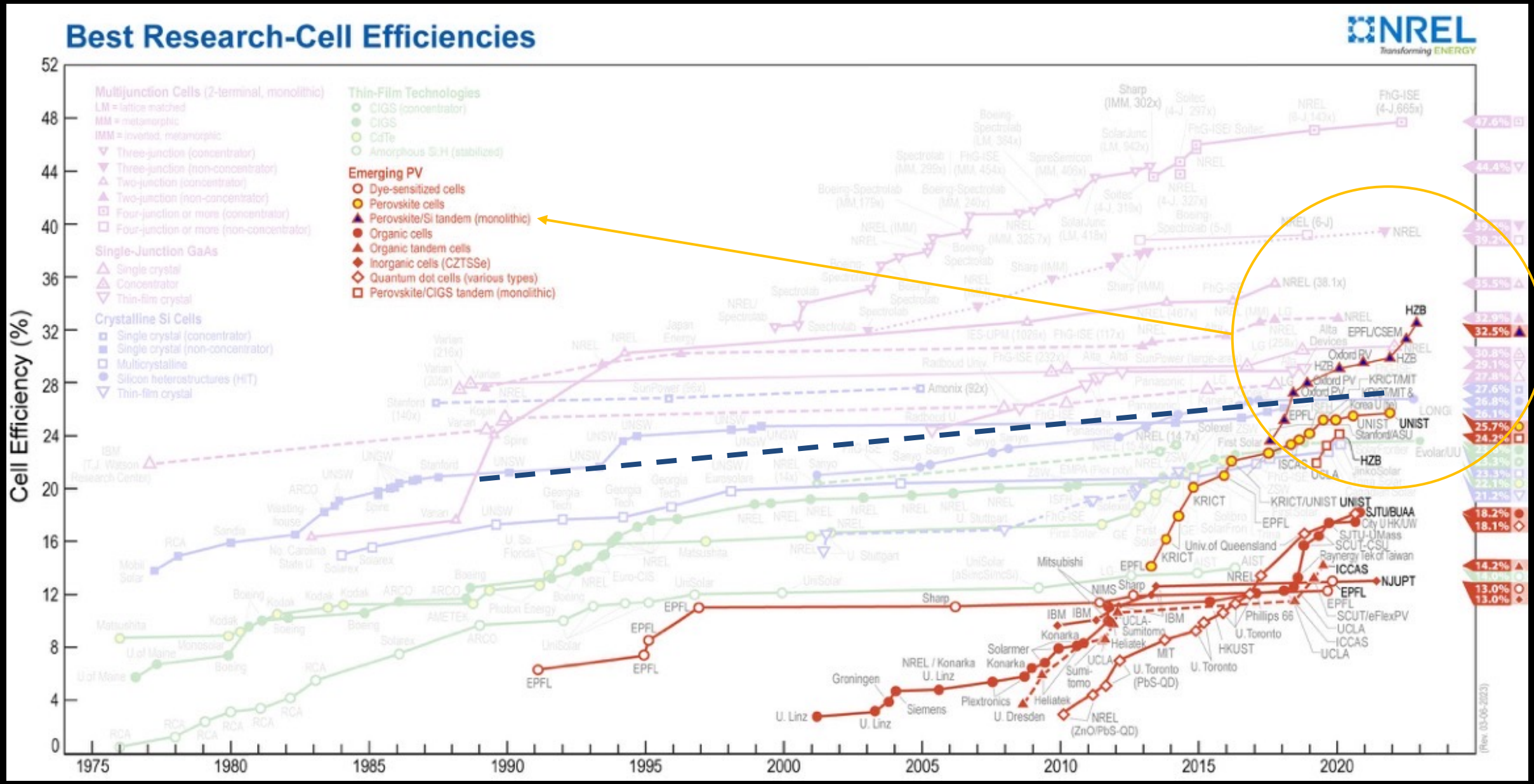
Solar Cell (certified) record efficiency chart



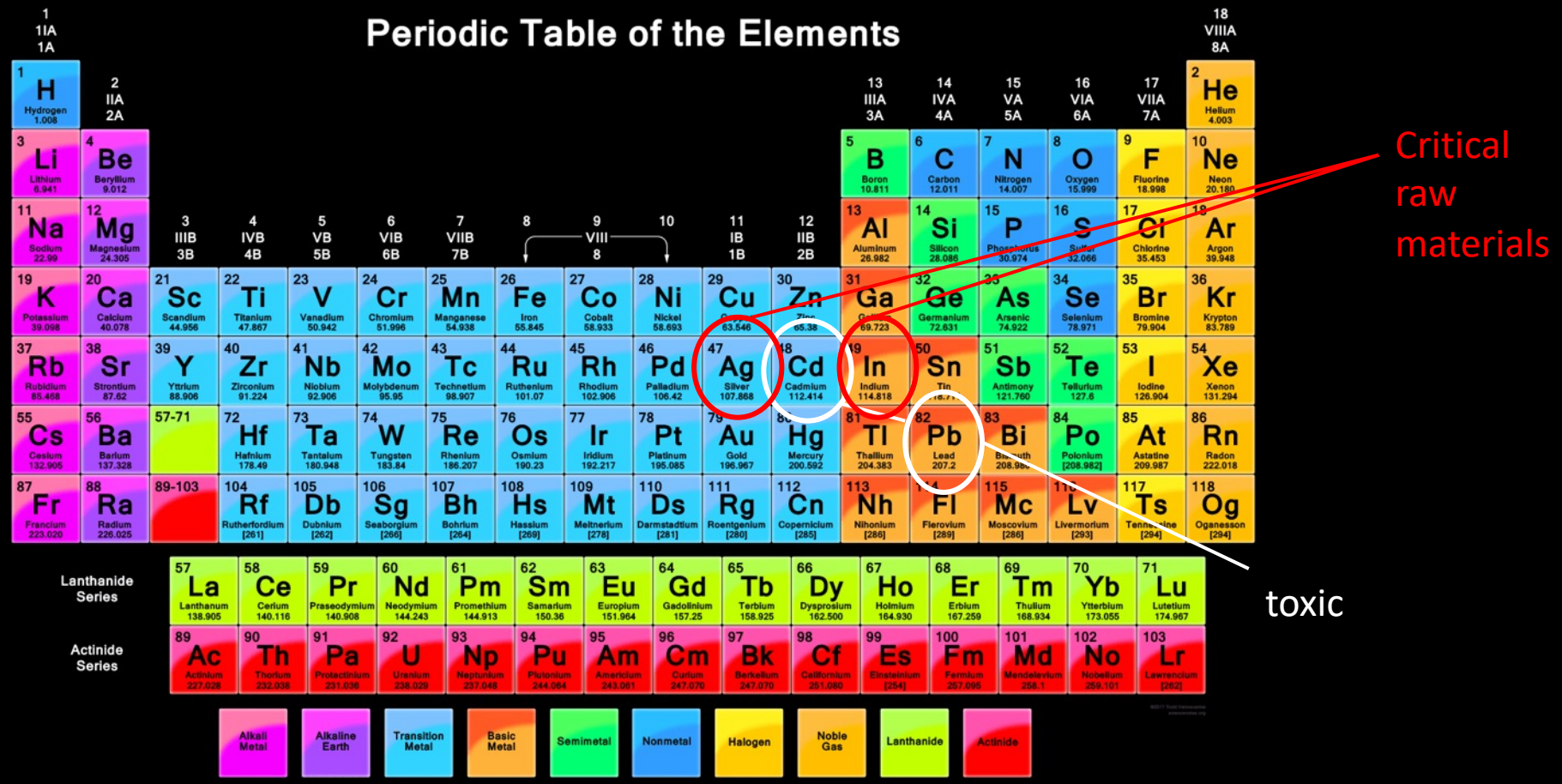
Solar Cell (certified) record efficiency chart



Solar Cell (certified) record efficiency chart



Interesting challenges for materials science:
New materials with properties on par with those used in record devices **but made of non-toxic, non-critical raw materials**



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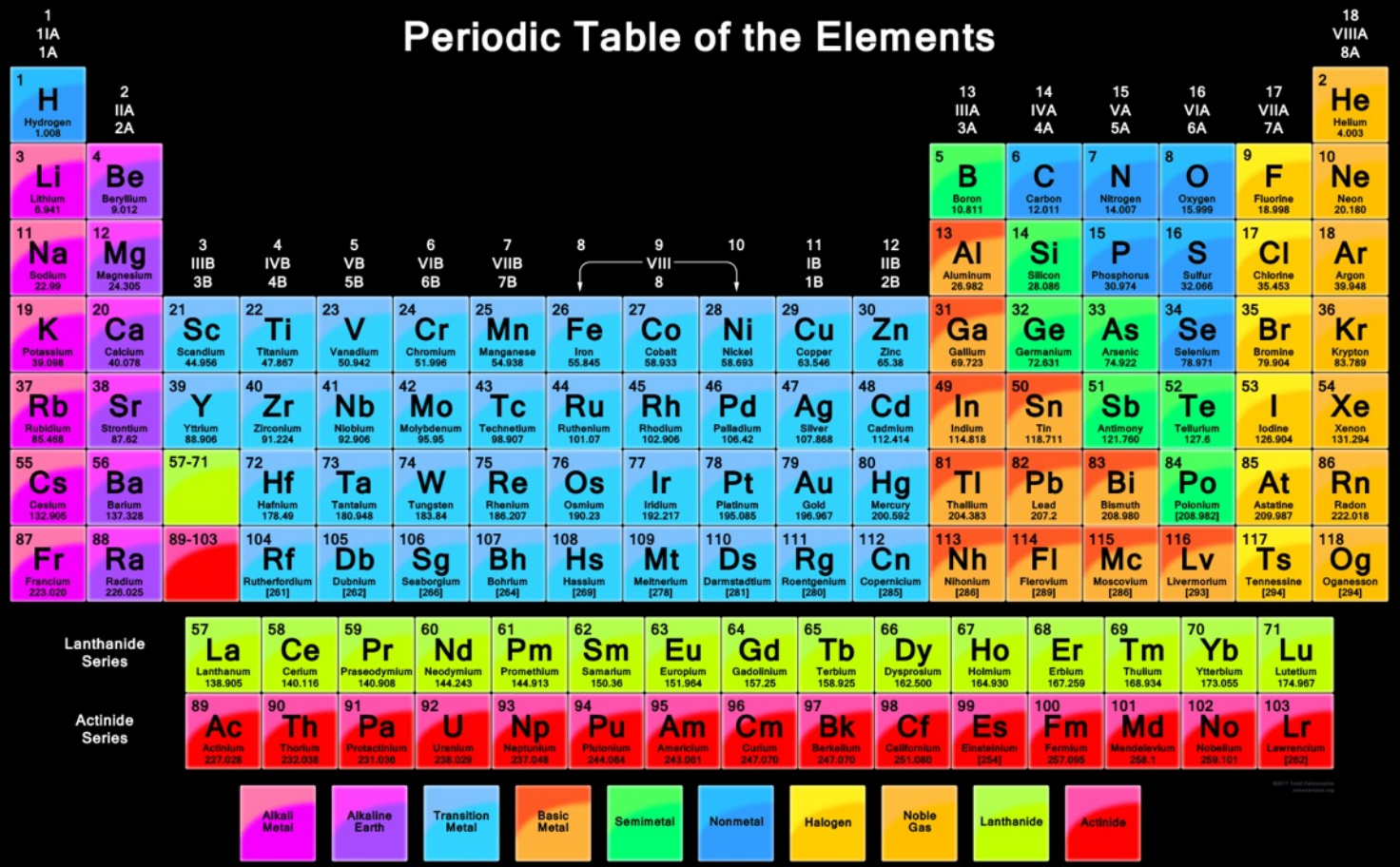
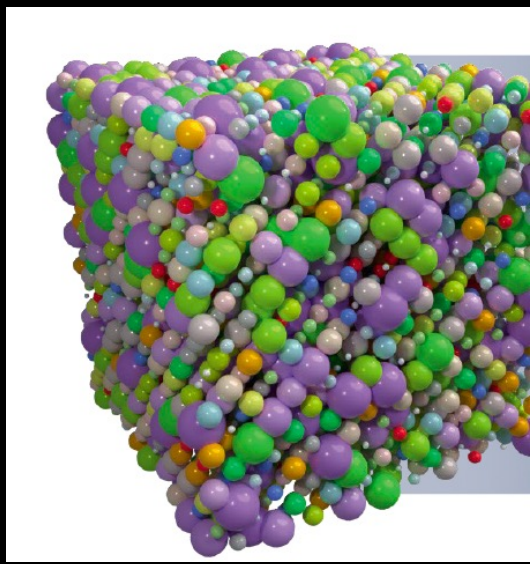
Interesting challenges for materials science:
Great opportunities for **Materials Design** joining experimental and computational efforts

Only **118 elements** on the period table, but huge number of materials combinations possible

Chemical complexity in materials therefore increasing!





https://doi.org/10.1038/s43588-023-00412-7

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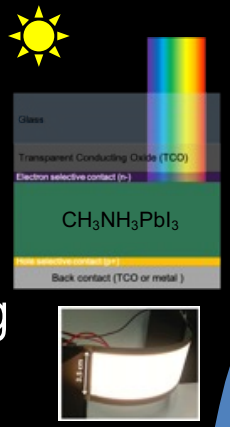
Our contribution to the field: Optoelectronic Thin Film Materials

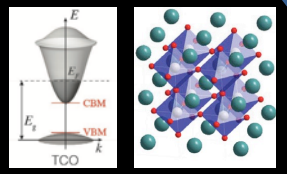
Solar cells

Photonics

Light emitting devices



Structural and defect analysis. Material modeling



Apply and enable functionalities in devices

Synthesize and fabricate

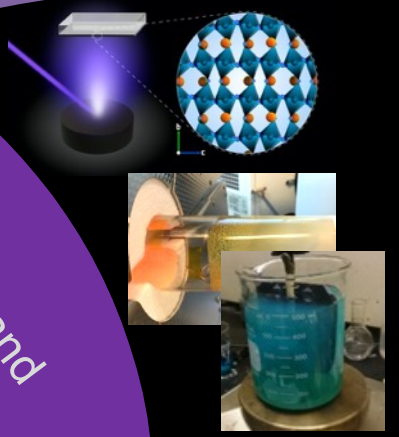
Understand and Design

Characterize and Improve

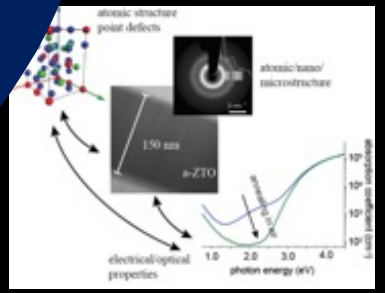
Materials

Transparent Conducting Materials (n- and p-type)

Inorganic and Hybrid Halide Perovskites



Physical & chemical deposition techniques



Structural, electrical, optical property relations

Reviews

Morales-Masis M., et al. Adv. Electron Mat. Vol.3 (2017)
Fioretti A., Morales-Masis M. J. Phot. Energy (2020)
Soto-Montero T., Soltanpoor W., M.MM. invited. APL Mat (2020)

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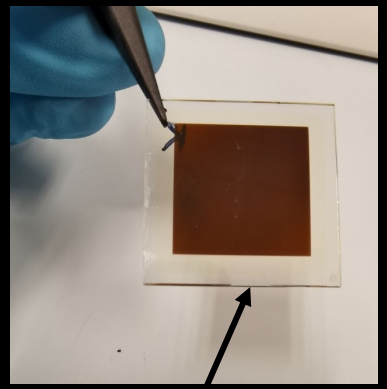
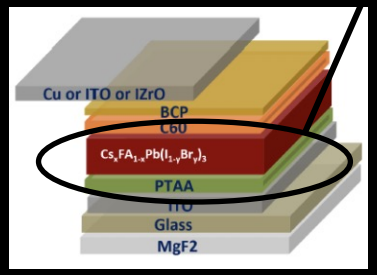
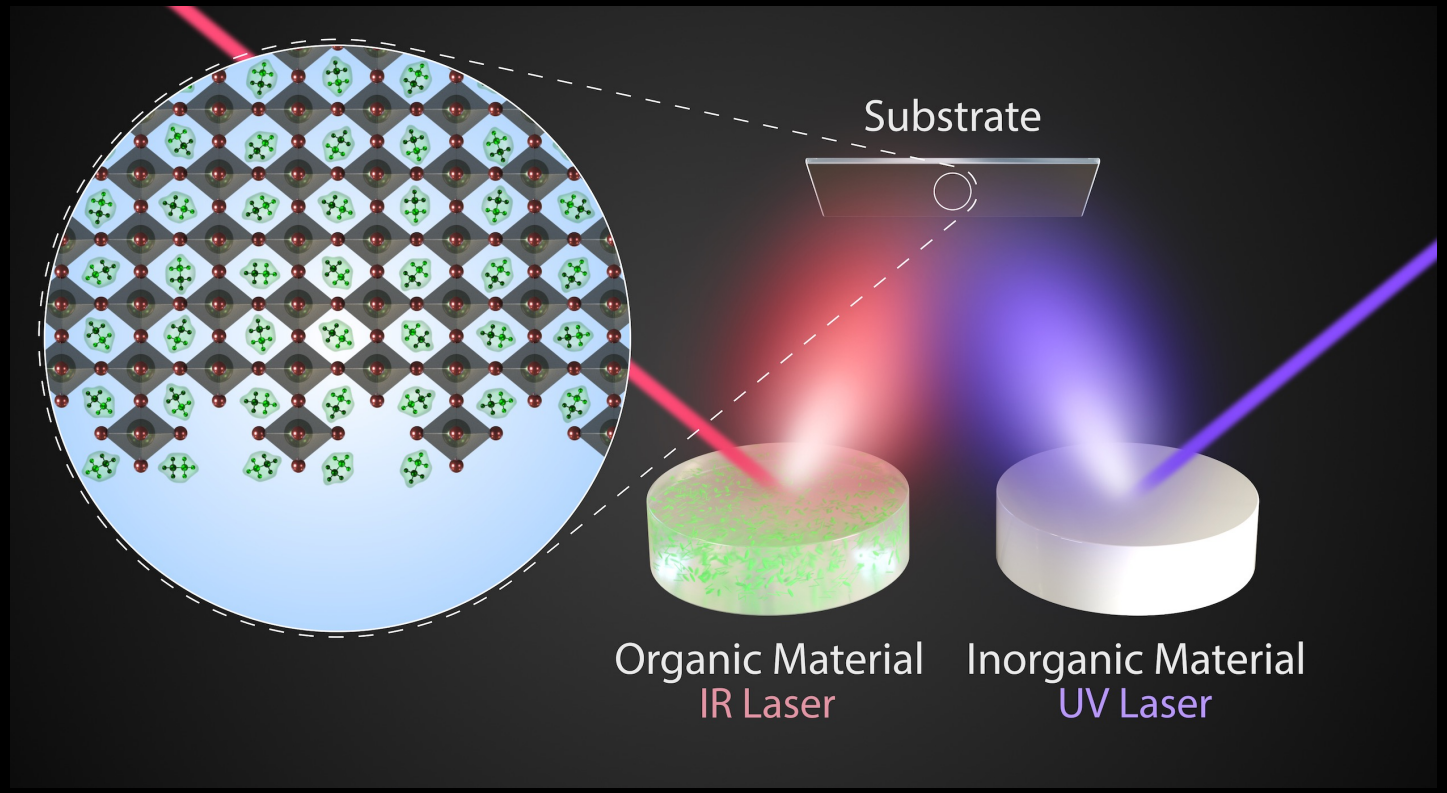
A versatile thin film deposition technique for **complex material compositions**: case of hybrid halide perovskites for solar cells





Thin film solar cell stack



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T. Soto-Montero, S. Kralj, W. Soltanpoor, J. Solomon, …Morales-Masis, ***Adv Funct. Mat****. 2023 (DOI: 10.1002/adfm.202300588)*

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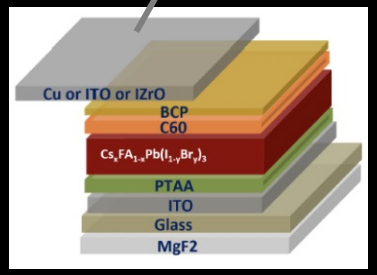
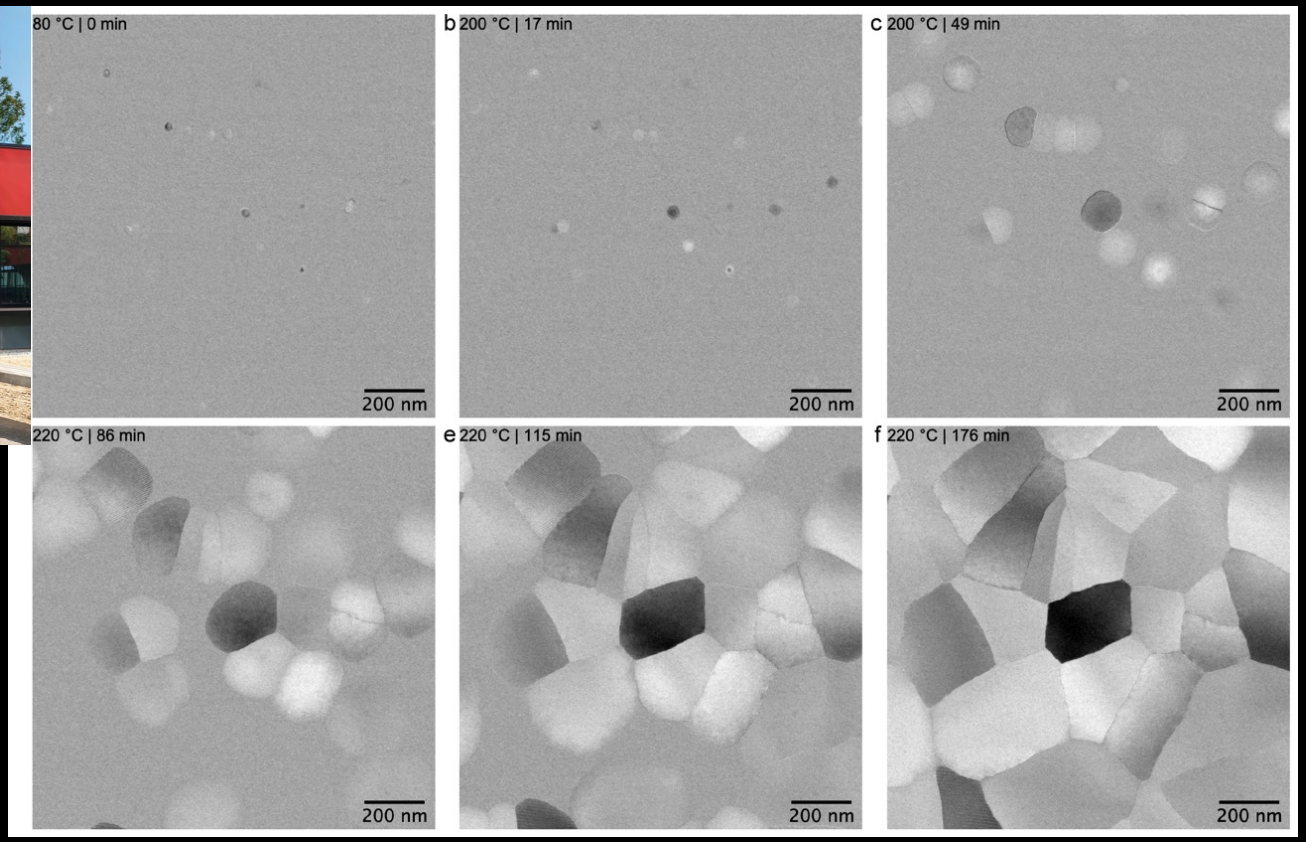
Development of transparent electrodes for solar cells





In-situ crystallization of a Zr-doped In_2O_3 transparent electrode:

Improve performance with microstructure control

Reducing thickness of the electrodes to reduce the use of indium in SCs

Dzhigaev, Smirnov,… Morales-Masis, Stuckelberger. ***Commun Mater 3, 38 (2022)***
Y. Smirnov, L. Schmengler, R. Kuik, P-A Repecaud,… Morales-Masis –**Adv. Mater. Technol. (2021)**

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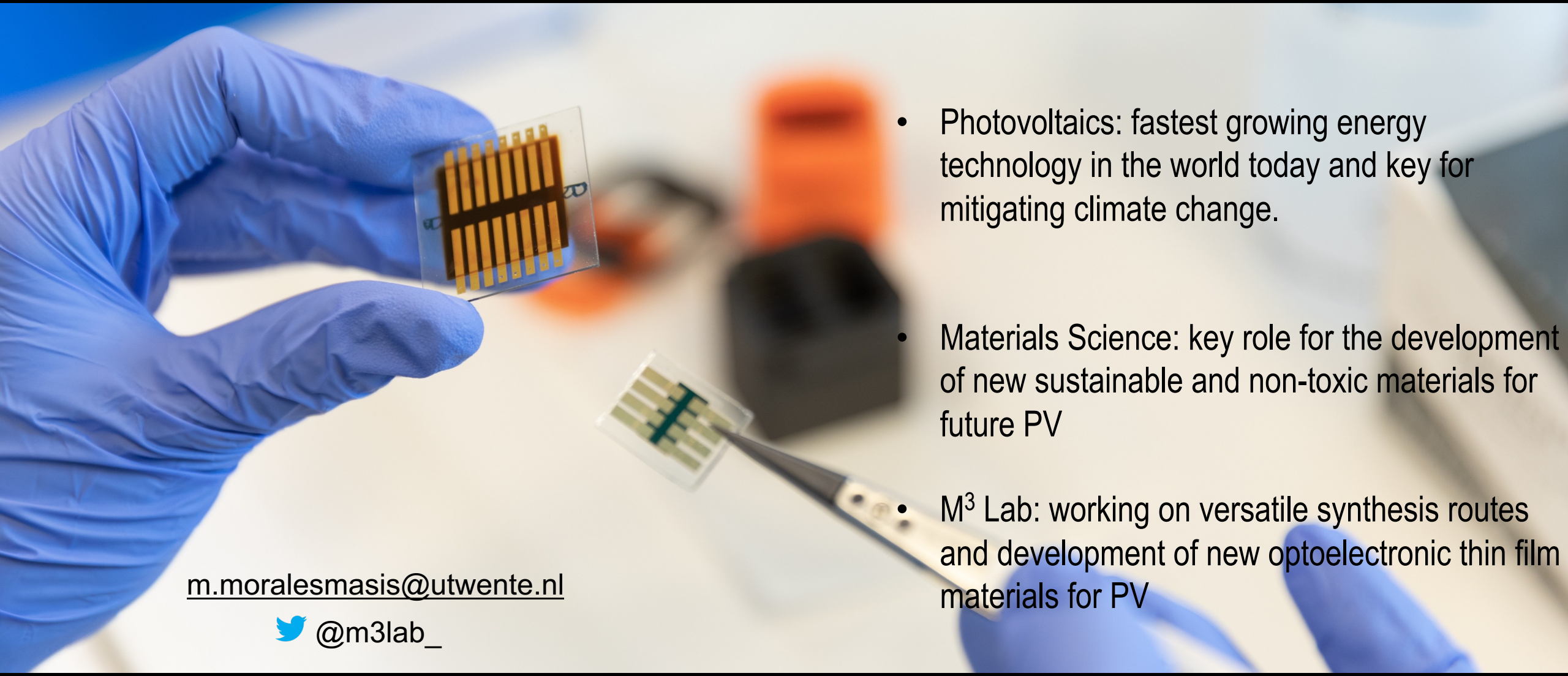
Summary



- Photovoltaics: fastest growing energy technology in the world today and key for mitigating climate change.
- Materials Science: key role for the development of new sustainable and non-toxic materials for future PV
- M^3 Lab: working on versatile synthesis routes and development of new optoelectronic thin film materials for PV

m.moralesmasis@utwente.nl

@m3lab_

Big PV Initiatives in NL

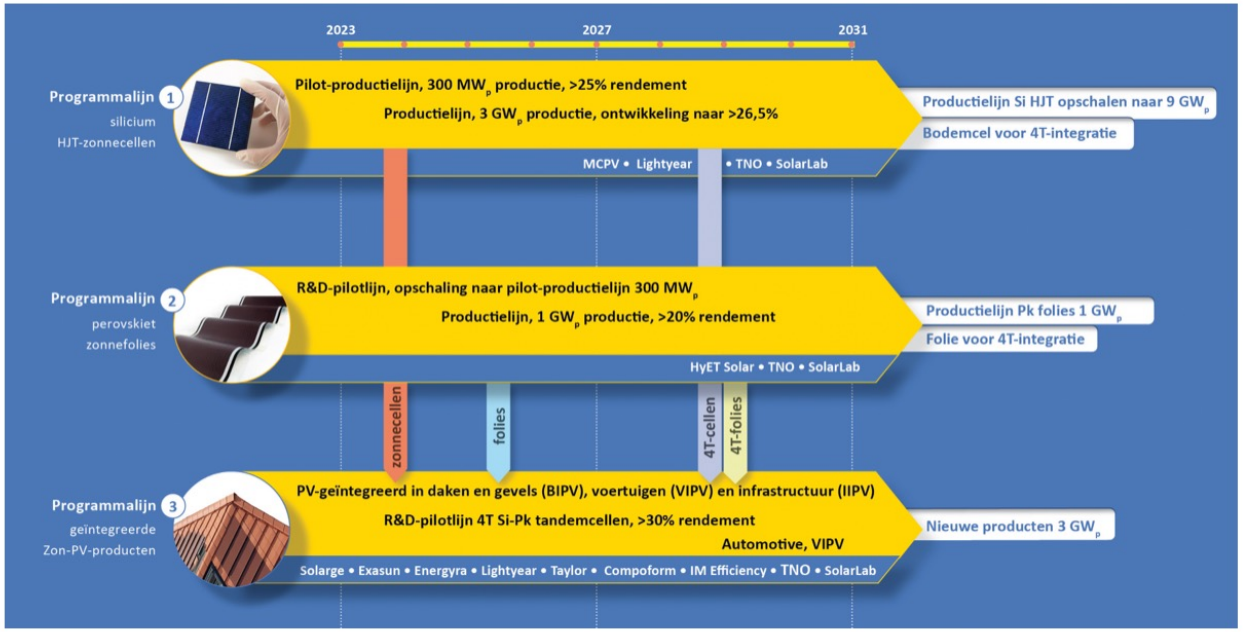
SolarNL

Si HJT cell factory

Flexible solar foils

Lightweight/integrated

Solarlab.nl



This Growth Fund proposal aims to create the necessary innovative PV technologies and industrial basis in the Netherlands to capture economic value of billions of euros for decades to come. In addition, this ‘local manufacturing’, using short lines from supply to markets, will generate multiple environmental benefits and reinforce strategic autonomy in our energy supply. On all these points, the proposal is fully aligned with the currently accelerating momentum towards new industrial public policies on EU level.