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Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

Università degli Studi di Padova

Photovoltaic and Solar Thermal: the role of UNIPD

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Goal of Spoke 1

To boost the sectors of Photovoltaic (PV) and Concentrating solar power (CSP), Concentrated Solar Thermal (CST) toward

- higher amount of production at **competitive costs**
- overtaking the actual **limits of current technologies**
- introducing **innovation at low Technology Readiness Level**

Strategy: horizontal integration, eco-design approach

People (critical mass):

- Matteo Meneghini (DEI, PO)
- Davide Del Col (DII, PO)
- Enrico Napolitani (DFA, PA)
- Lorenzo Franco (DISC, PA)
- Nicola Trivellin (DII, PA)
- 2 RTDa (Berto, Sgarbossa)
- 2 PhD (Tormena, Zatta)

Images: https://d3hnfqimznafg0.cloudfront.net/image-handler/ts/20191111052332/ri/950/src/images/Article_Images/ImageForArticle_980(1).jpg
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https://cdn.greenmatch.co.uk/cdn-cgi/image/format=auto/2/2022/10/flexible-solar-cells.png

Partners & Network

ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

Consiglio Nazionale delle Ricerche

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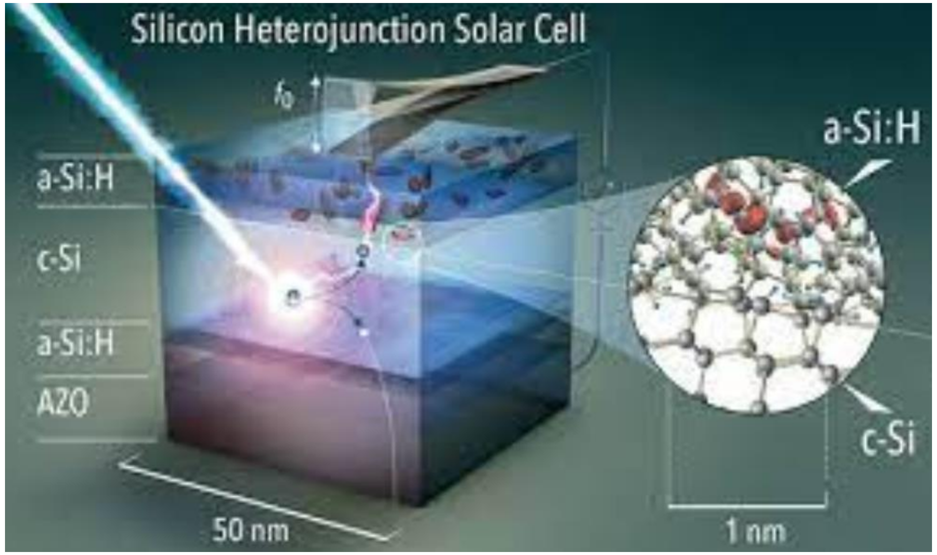
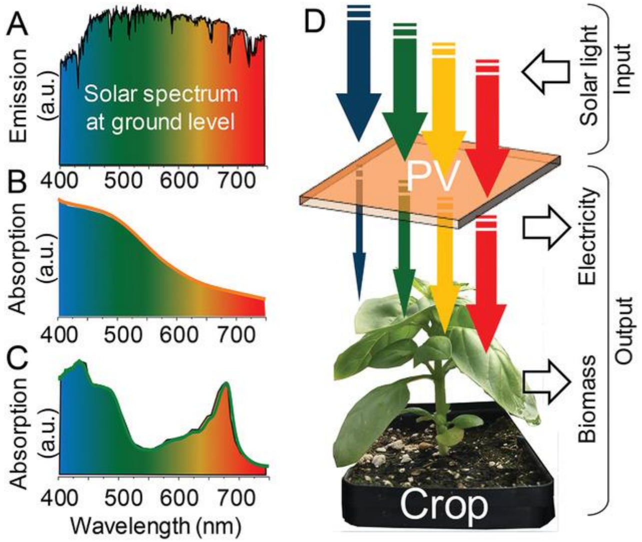
WP1.1 Technologies for innovative high performance solar cells and PV module

Innovation of materials and processes to be introduced in cells and module manufacturing to **enhance the efficiency and reduce the manufacturing impact**





Innovative **semitransparent spectrally selective solar cells** and module allowing complementary use of the solar light for PV and photosynthesis

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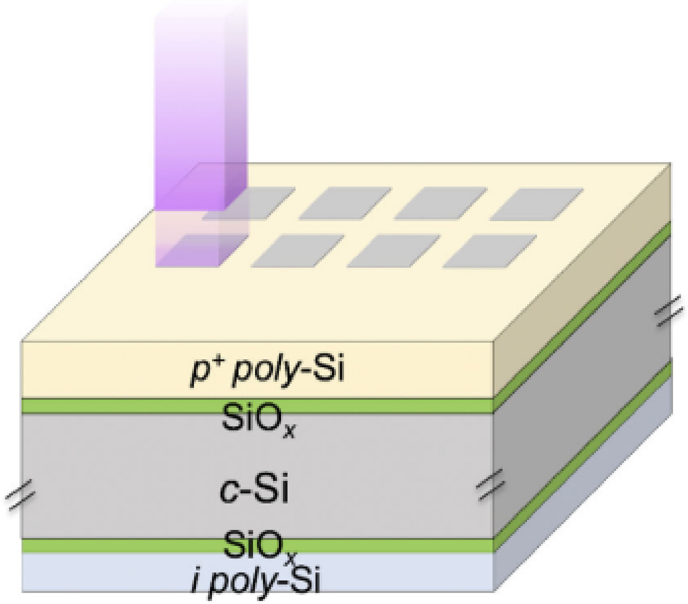
WP1.1 Activities at UNIPD

DFA: Collaboration with NREL (USA) for for the development of **TOPCon technology and its future application** in the next generation PV cells

- **Hyper doping** of TOPCon Si samples for thermal stability studies via **Pulsed Laser Melting.**
- Study the effects of **thermal post annealing process** on Pulsed Laser Melting TOPCon samples: electrical measurements on thermal stability samples.

NREL Transforming ENERGY



Main reference:
C. Kejun et al. *Energy & Environmental Materials* 6, 3 (2022)

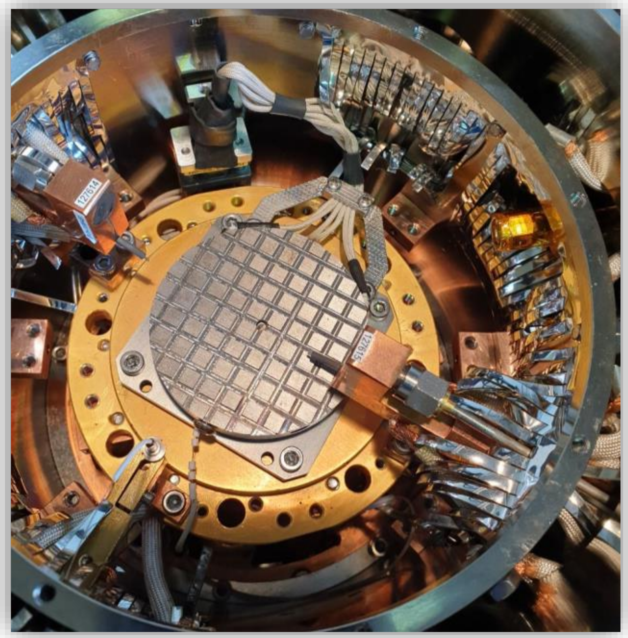
WP1.1 Activities at UNIPD

DEI: advanced characterization and modeling of heterojunction solar cells

Goals: to describe the physical processes responsible for efficiency losses and degradation

Main partner: ENEA (feedback on device properties for technology improvement)

Techniques: Cryo-T measurements, capacitance spectroscopy, EQE, DLTS, …

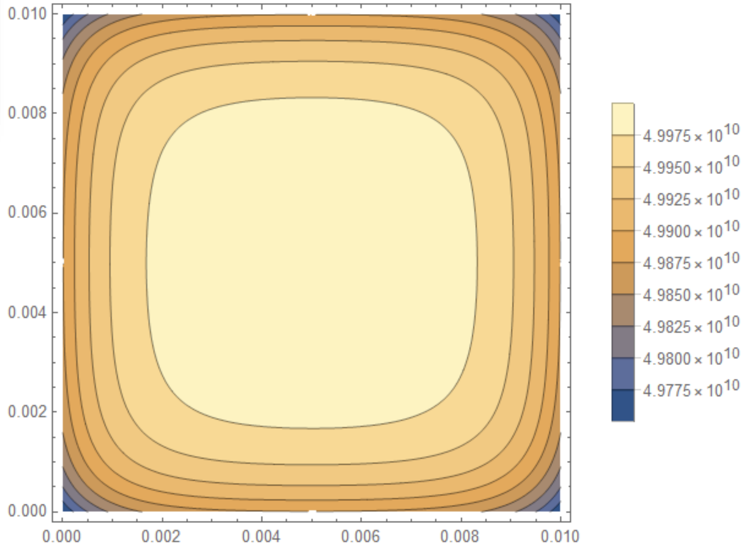


$$\frac{\partial \Delta n_p}{\partial t} = 0 = D_n \frac{\partial^2 \Delta n_p}{\partial x^2} - \frac{\Delta n_p}{\tau_n} + G$$

$$\Rightarrow \frac{\partial^2 \Delta n_p}{\partial x^2} - \frac{\Delta n_p}{L_n^2} + \frac{G}{D_n} = 0, \quad L_n = \sqrt{D_n \tau_n}$$

Examples:

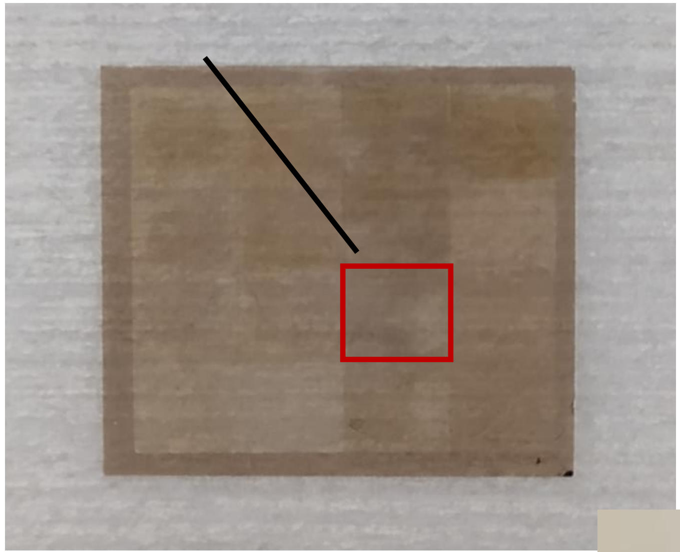
- Experimental characterization at cryogenic temperatures for model definition
- 2D modeling of carrier losses near surfaces, based on solution of differential equations



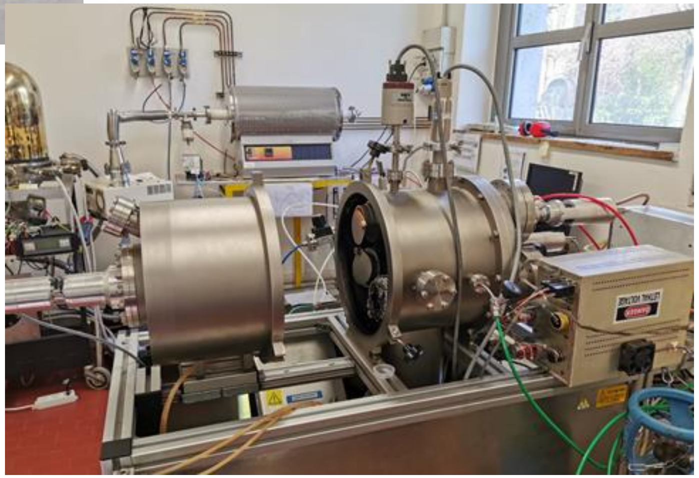
WP1.1 Activities at UNIPD

DFA/DISC: new synthesis methods for 2D materials for PV cells, such as the MoS2 transport layer.

- **Thin film MoS_2 deposition on glass**: sputtering deposition
- **MoS_2 crystallization** via pulsed laser annealing
- **Synthesis of perovskite on MoS_2 layer** used as transport layer (planned for future)



Different laser treatment on MoS_2 / glass, after laser processing

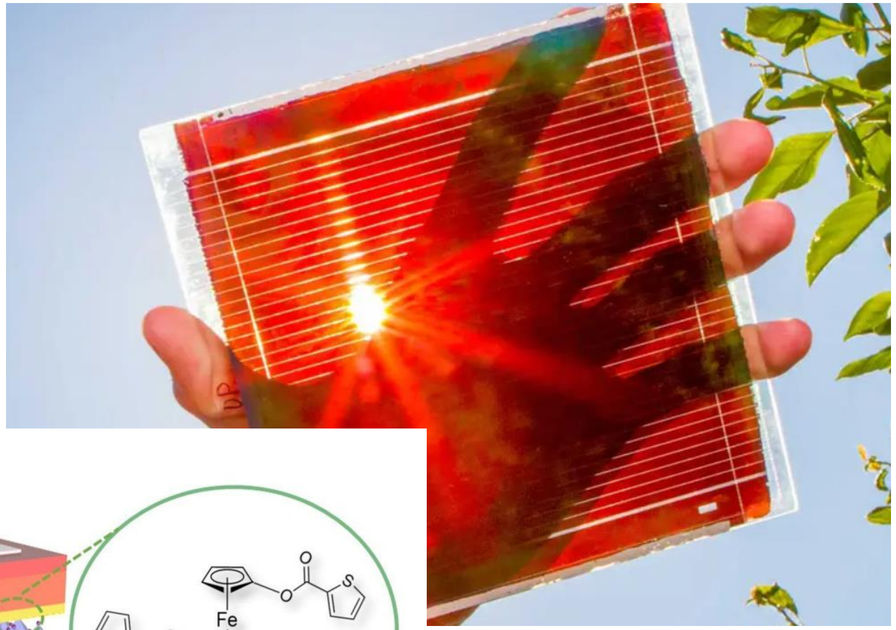


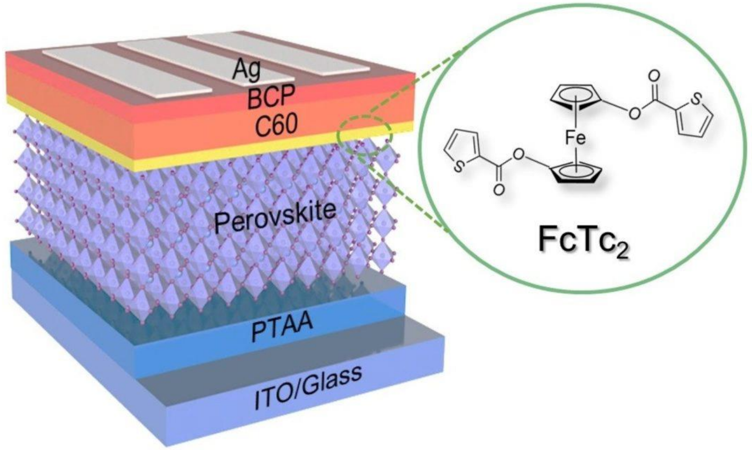
Sputtering system

WP1.1 Technologies for innovative high performance solar cells and PV module

Perovskite films are developed

- for **tandem cells**
- to **demonstrate the stability of large area cells** and minimodules under sunlight exposure
- **reducing** both intrinsic and extrinsic causes of **degradation**

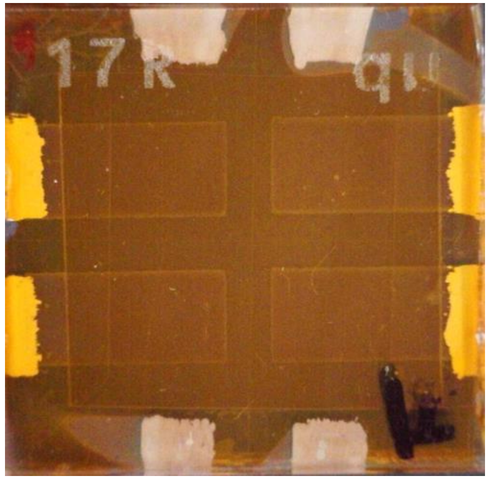


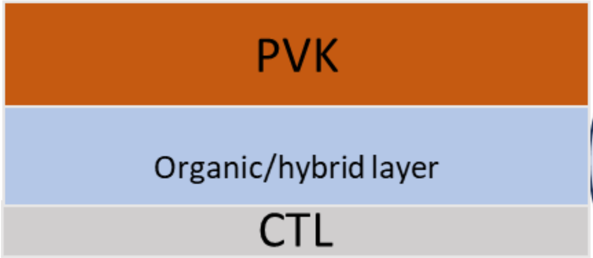


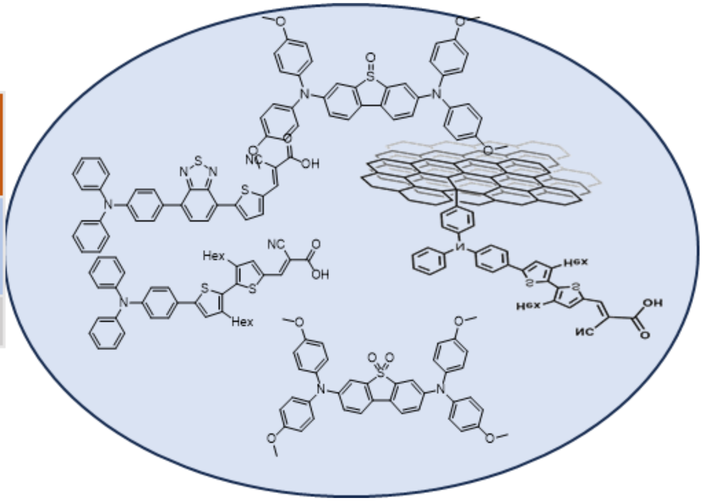
- **Performed Activities (DEI/DISC):**
  a) **Design of new organic/inorganic materals** for passivating/transport layers in **perovskite** and **tandem solar cells** (with UNIPA, CNR-ISM)

  b) **Synthesis and chemical characterization** of new **organic/hybrid HTM: polyarylamines, graphene-dyes, Graphene-P3HT composites**.

  c) Study of **Perovskite solar cell properties and degradation**, based on electrical and optical testing (with CNR)





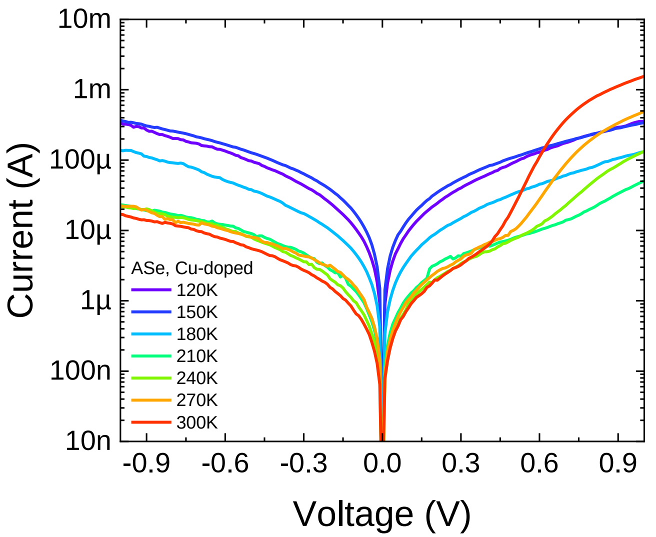


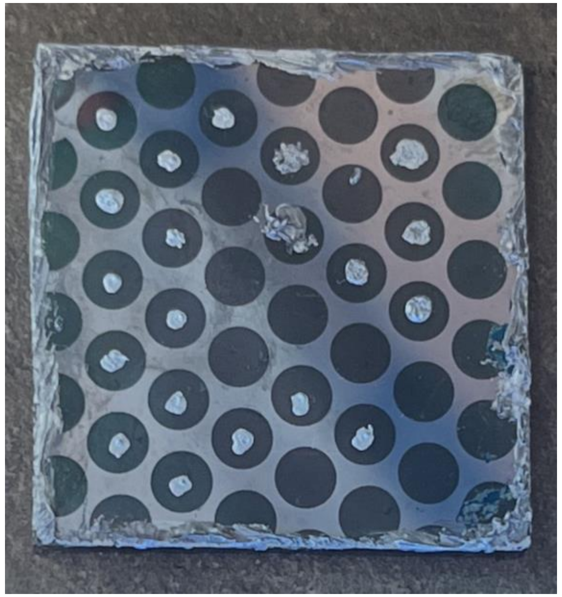
WP1.3 Advanced technologies and solution for BIPV and BAPV

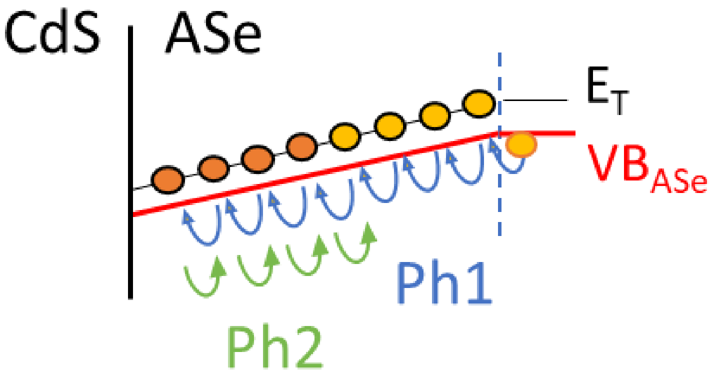
Multidisciplinary approach to address specific functions of integrated PV cells and modules such as

- **transparency**
- **flexible integration** in architectural components
- **colour and aesthetics**
- **energy** integration

- **Performed and planned Activities (DEI/DFA)**
  - Study of thin film solar cells (provided by CNR)
  - Main semiconductor is ASe
  - Cryogenic temperature analysis and defect spectroscopy
  - Lifetime analysis and degradation studies







WP1.4 New concept for CSP/CST systems

T1.4.2: **CSP/CST hybridization with other renewable** sources

- **Coupling of solar thermal collectors with heat pumps**, using PV modules integrated with evaporators

INVOLVED PERSONNEL: *Davide Del Col* (Full Professor), *Arianna Berto* (RTDa), *Stefano Bortolin* (Associate Professor), *Marco Azzolin* (RTDa), *Waseem Raza* (PhD student)

T1.4.3: Development and characterization of **new heat transfer fluid and heat storage materials**

- Experimental study of a **volumetric solar collector operating with nanofluids** for the direct absorption of solar radiation
- Numerical studies for the design of new volumetric solar collectors

T1.4.6: Developing advanced TES solutions for CSP/CST systems

- **Design of aluminum heat exchangers** operating with phase change materials for solar thermal energy storage

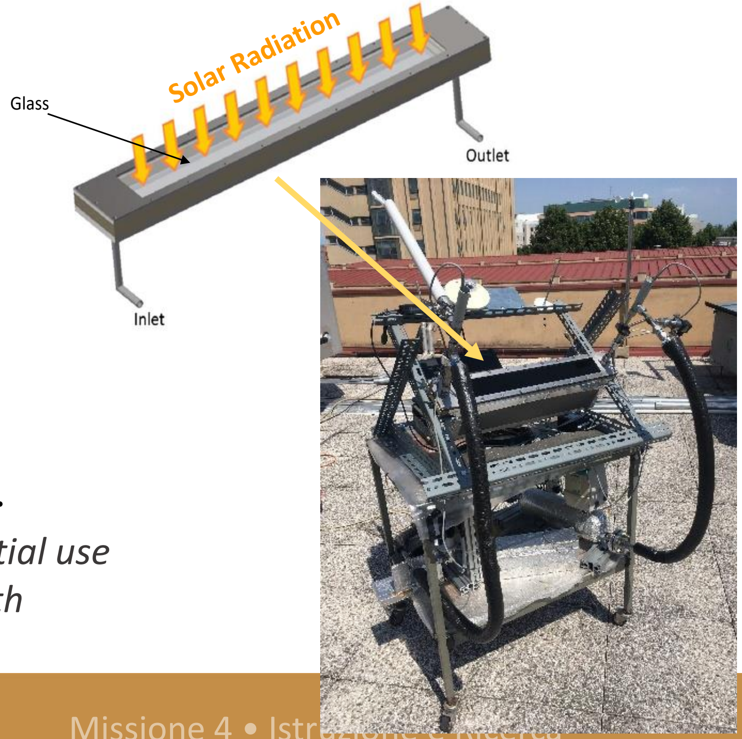
PERFORMED ACTIVITIES (WP1.4 UNIPD)

T1.4.2: *CSP/CST hybridization with other renewables sources*

- Analysis of a **solar assisted heat pump** for space heating:
    - a **solar evaporator with photovoltaic-thermal (PV-T) collectors** which are cooled down by the evaporating refrigerant,
    - it uses **CO_2 as working fluid** (natural refrigerant, no flammability, high pressure),
    - when the solar radiation is not sufficient, **it can work with air** as thermal source.

T1.4.3: *Development of new heat transfer fluids and heat storage materials*

- The addition of small concentrations of carbon nanoparticles (less than 0.1 g/L) can greatly enhance the optical properties of the fluid and improve the efficiency of the solar collector.
- The nanofluid **degrades after some circulation hours**. We are working to improve this.



T1.4.6: *Developing advanced TES solutions for CSP/CST systems*

- Preliminary tests with paraffin PCM RT-42 in an aluminium internally finned heat exchanger.

Berto A., Mattiuzzo N., Zanetti E., Meneghetti M., Del Col D., "Decarbonizing the heat for residential use by absorbing the solar energy through carbon nanofluids". Submitted for oral presentation to 18th SDEWES Conference, 24-29 September, Dubrovnik (Croatia).

Thanks for your attention!

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Backup slides