Innovative Bifacial DSSC Technologies for Sustainable Agri-Photovoltaic and Urban Energy Systems

Integrated Photovoltaic Conference

Consiglio Nazionale delle Ricerche | IPCF

Mariangela Latino

PCHR

Main research activities:

- Liquid hydrogen carriers from photochemical and photoelectrochemical conversion of CO_2 and water;
- Development of non-critical materials and components for tandem photoelectrolysis cells for direct conversion of solar energy to hydrogen and advanced systems for solar and thermal assisted catalytic splitting;
- Dissemination.

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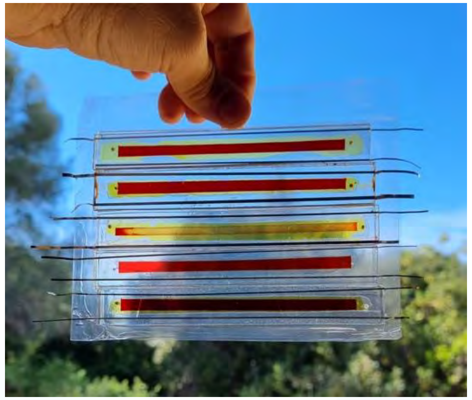
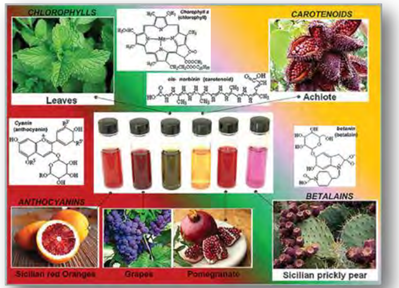
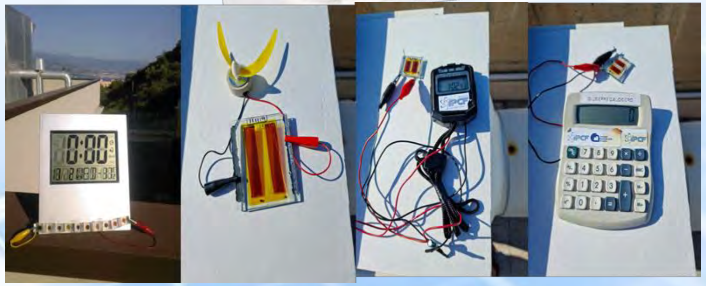
Design, manufacture and characterisation of third generation solar cells







Commercial flexible solar cell characterisation

Organic photovoltaic modules (2.5W)

Flexible silicon-based modules (3W)

NAUSICA project

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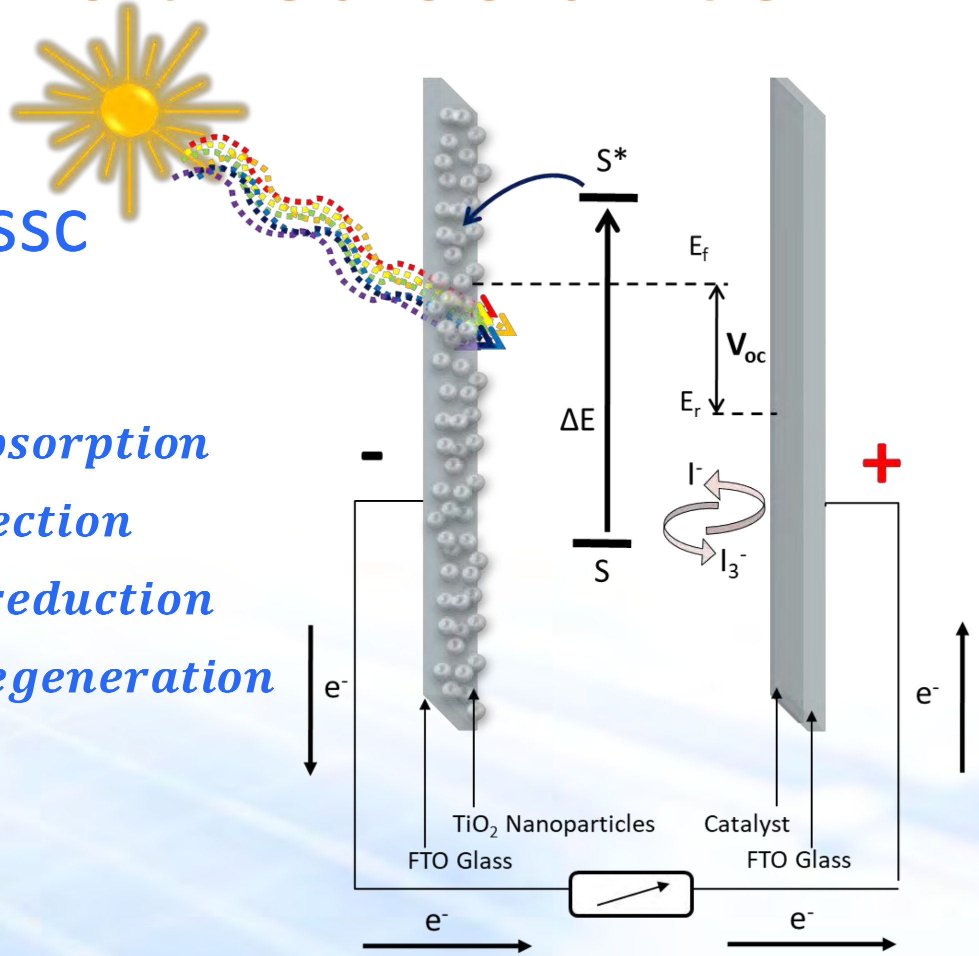
Diagram of a typical Dye-Sensitized Solar Cell (DSSC)

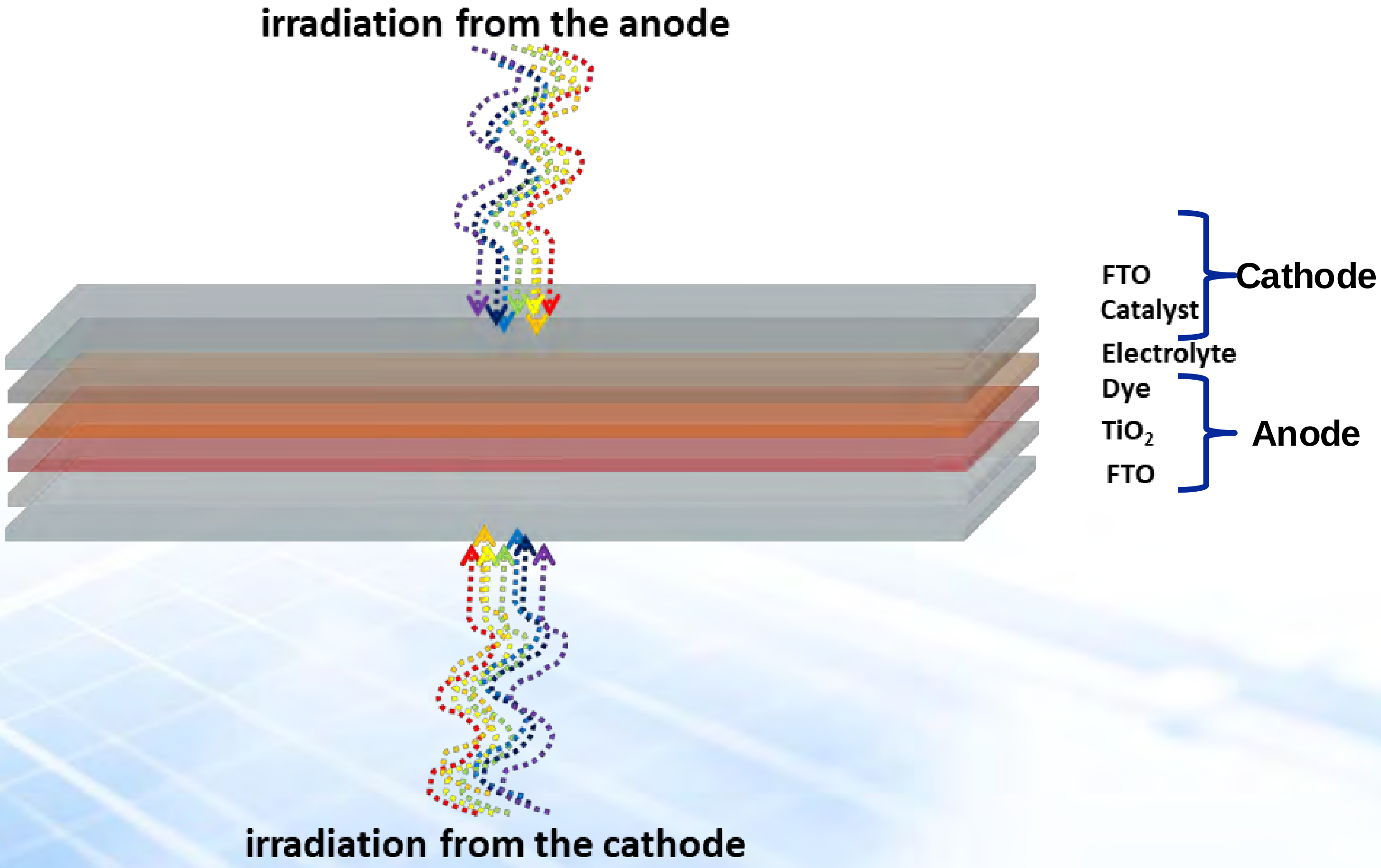
List of the main processes involved in dssc behaviour:

1. $S + h\upsilon \longrightarrow S^*$ *radiation absorption*
2. $S^* + TiO_2 \longrightarrow S^+ + e^-_{CB}\,(TiO_2)$ *electron injection*
3. $I_3^- + 2e^-(Pt) \longrightarrow 3I^-$ *electrolyte reduction*
4. $2S^+ + 3I^- \longrightarrow 2S + I_3^-$ *sensitizer regeneration*

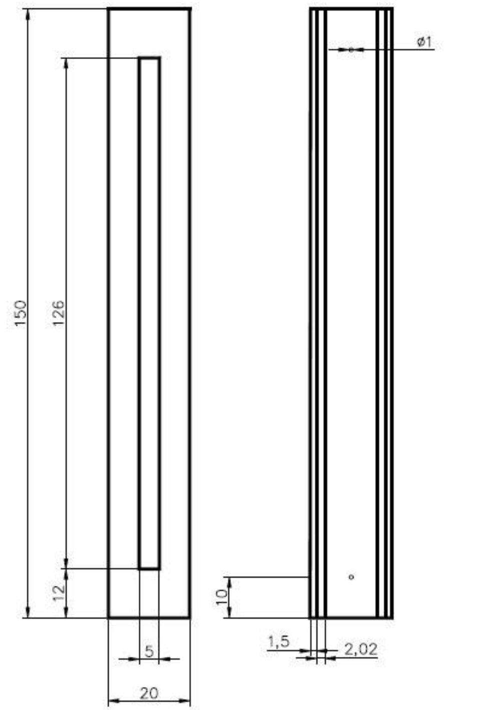


Semi-transparent, bifacial dye-sensitized solar cells (BFDSSCs)

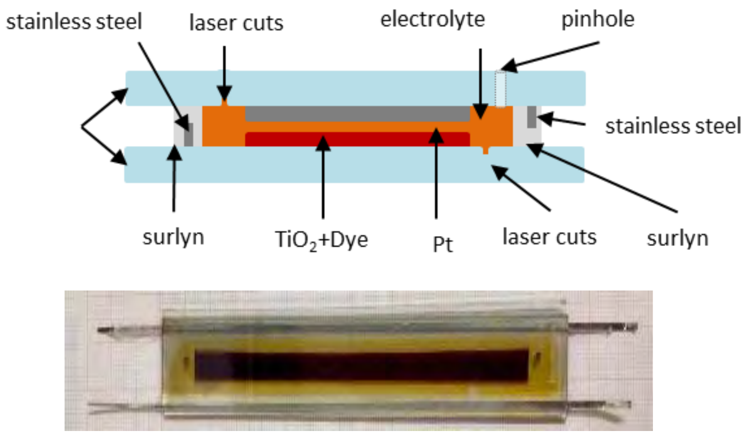
BFSSC devices capture photons that also arrive from behind, allowing you to make the most of diffuse sky radiation and light reflected from the environment.



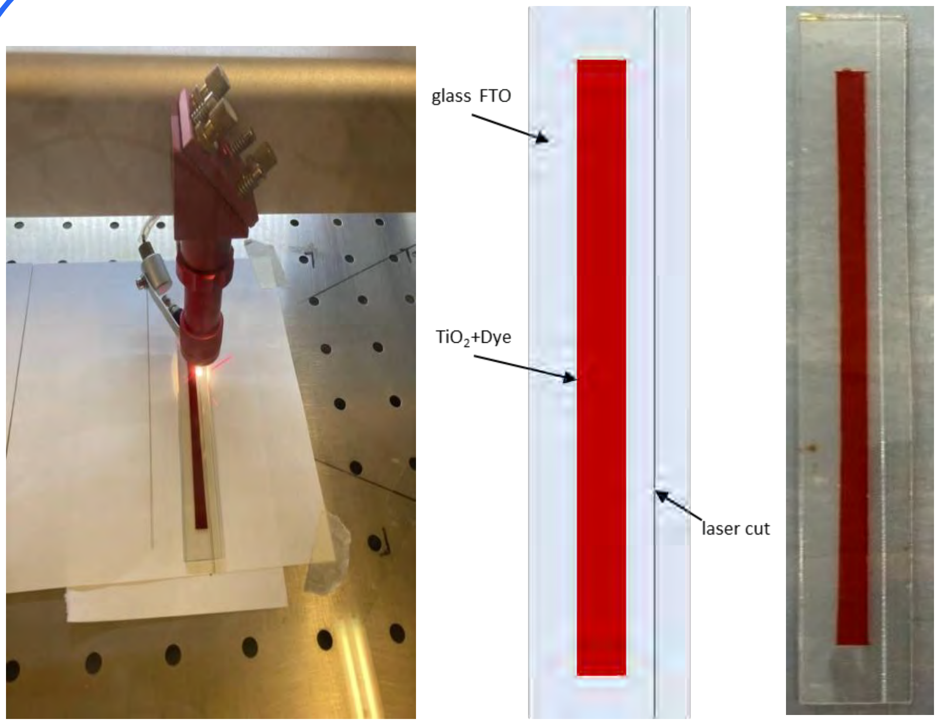
Preparation of electrodes and devices fabrication



Schematic design of cathode and anode



Scheme and photography of a closed dye-sensitized solar cell



Photography of the anode during the longitudinal engraving; scheme and photography of the anode.

Experimental results

The photoelectrochemical performance of the home-made devices was determined by measuring the current density versus voltage (Jsc-V) under solar irradiation (100mW/cm2).

The results, obtained under different illumination conditions, show a bifaciality factor (**BFF**) of **87%** in the case of a **white background**; this factor drops to **72%** in the case of a **black background**.

The results obtained are promising because they suggest the use of bifacial DSSC solar cells in an environment where it is possible to exploit part of the diffuse sunlight, effectively reducing the installation area.

Integration of Arduino-based technology

Using Arduino to:

- Monitor various environmental parameters inside the greenhouse
  - soil moisture
  - temperature
  - light levels
  - irrigation system
- manage an automated irrigation system

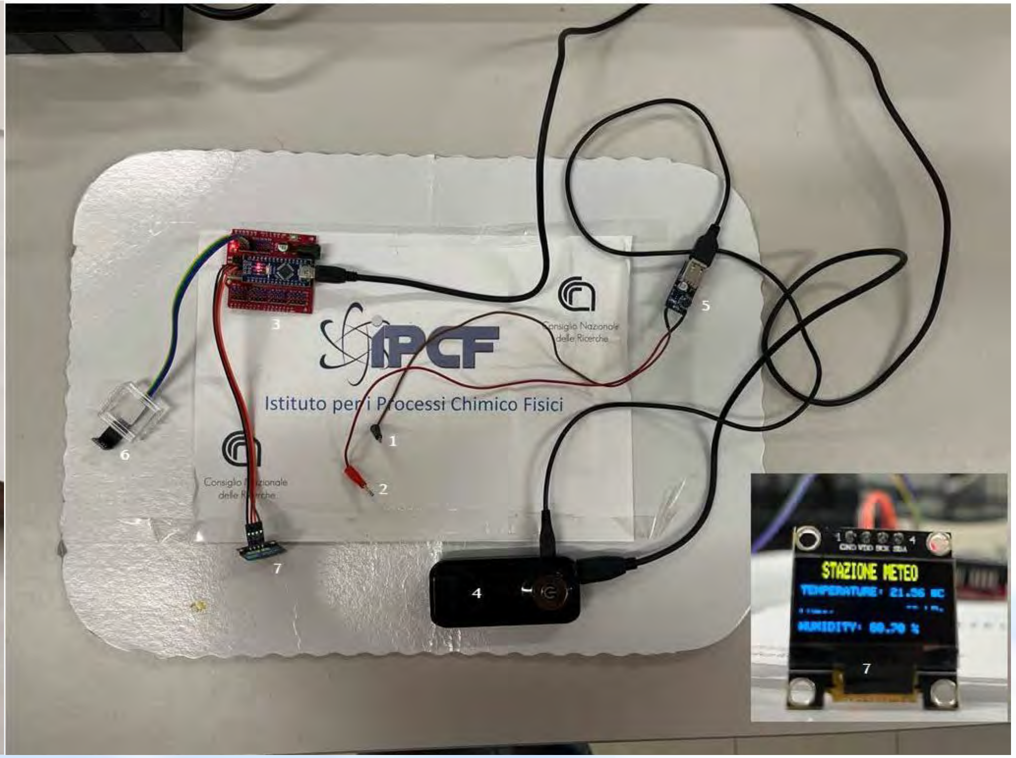
This smart system not only improves the efficiency of urban gardening, but also reduces water waste and increases user comfort by minimising the need for manual intervention.

AI and IoT technologies

- to predict weather patterns
- optimize irrigation schedules
- dynamically adjust energy consumption

To improve both energy efficiency and resource management.

Design and implementation of urban balcony photovoltaic greenhouses



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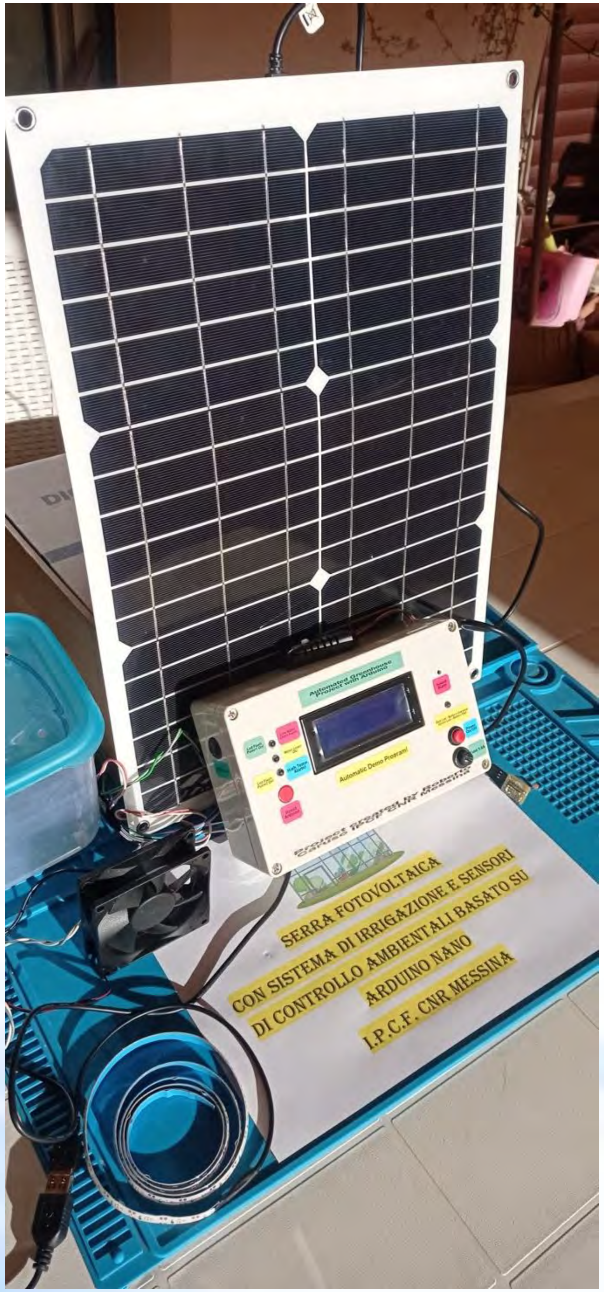
Use of commercial photovoltaics for irrigation or fertiliser delivery



Concluding remarks

This project highlights the potential of integrating bifacial DSSCs with smart, automated systems to create sustainable, self-sufficient solutions for urban living.

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The **S.O.L.A.R.E.** Group

(**S**pectrophotometry, **O**ptoelectronics, **L**uminescence, **A**nalysis, **R**elaxation, **E**nergy)

MARIANGELA LATINO
ILARIA CITRO
DONATELLA SPADARO
MAURIZIO LANZA
GIUSEPPE CALOGERO

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