CITYSOLAR

ENERGY HARVESTING IN CITIES WITH
TRANSPARENT AND HIGHLY EFFICIENT WINDOW
INTEGRATED MULTI-JUNCTION SOLAR CELLS

In this fourth installment of the CITYSOLAR newsletter you will find the most recent information about the project and its progress on developing innovative transparent and highly efficient window integrated multi-junction solar cells. This time we will put a spotlight on several conference contributions, in which we showcased the results obtained in the framework of the CITYSOLAR project, as well as two selected projects on the integration of OPV/PSC tandems and the anaylsis of self-healing capabilities in halide perovksites.

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GENERAL ASSEMBLY MEETING JUNE 8th-9th, 2023

On June 8th and 9th, IPVF hosted the general meeting of the H2020 CITYSOLAR project to discuss the recent advances on new breakthrough concepts for transparent photovoltaics which will be developed by exploiting the combined use of emerging technologies, namely multi-junction solar modules developed from near-ultraviolet perovskite and near-infrared organic solar cells. The consortium partners came from nine participating institutions in four European countries as well as Saudi Arabia. Within the consortium, there is a clear emphasis on research excellence with four renowned universities in the field (FAU, UNITOV, SDU and KAUST), two national research centres (CNR and CNRS-IPVF), two large companies specialized in the energy field and life cycle assessment (ENI, EDF) and a SMEs specialized in functional materials (Brilliant Matters).

In the General Assembly we discussed the progress in each work package on OPV and perovskite PV cells and module development, light management strategies, tandem PV integration along with material, thin film and device characterization, project management, exploitation, dissemination and communication. The partners also had the opportunity to visit IPVF laboratories. The positive conclusions and plans for the next months of the CITYSOLAR project were followed by a social dinner in Paris, attended by all project partners.

CITYSOLAR NETWORK EVENTS

EMRS SPRING MEETING – MAY 29th – JUNE 2nd, 2023

Fabio Matteocci from CNR CHOSE contributed two oral presentations to the EMRS 2023 Spring Meeting in Strasbourg with a focus on lead bromide perovskites for semi-transparent PSC, X-rays and particles detection. More specifically, he spoke about strategies to manipulated the average visual transitivity and power conversion efficiency in wide band gap perovskite solar cells for BIPV in symposium B2_01 (Advances in wide bandgap semiconductors 1), and the impact of light, thermal and X-ray irradiation stresses on semitransparent wide-bandgap bromide-based perovskites solar cells and detectors in symposium O1 (High energy detection).

CITYSOLAR SPOTLIGHT BOX

Picture taken of semi-transparent FAPbBr3 sample on 10 x 10 cm substrate. The FAPbBr3 deposition was performed by employing a dipping process in the second step of the sequential deposition. Figure adapted from [1].

HOPV – JUNE 12th – 14th, 2023

The CITYSOLAR consortium was represented by Prof. Aldo di Carlo at the 15th Hybrid and Organic PhotoVoltaics (HOPV) conference, 12-14th June 2023 in London (UK). HE discussed key results from all consortium partners together with the attendants to evaluate new possible developments. The project entered its final phase that yield the final demonstrators of semitransparent tandem perovskite/organic solar cells and modules.

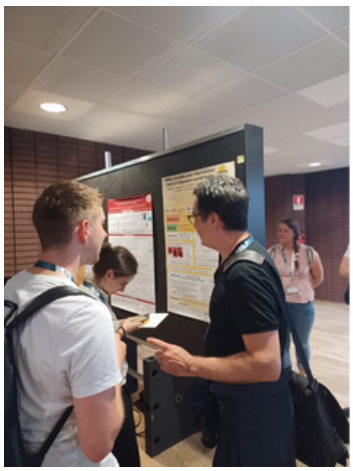
CONFERENZA 2023 RETE NFV – JUNE 22nd – 23rd, 2023

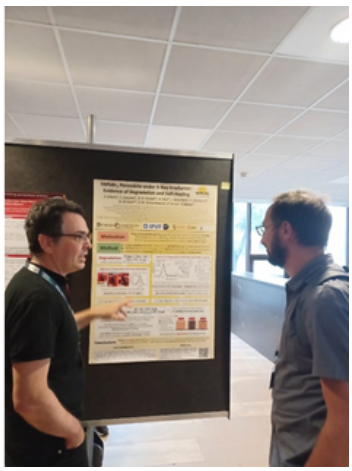
Michela Prete from the University of Southern Denmark presented her work on scalable transparent organic agrivoltaics. The results comprise the development and fully scalable fabrication of semi-transparent organic photovoltaics, yielding an average power conversion efficiency of 7.1% using slot-die coating in air. This is paired with the initial data on the implementation of fabricated Distributed Bragg Reflectors (DBR) to embed light management in the cells. These initial results are showing an improvement of around 15% in the short-circuit current density of the devices, owing to an increased absorption between 650-850 nm, leading to a PCE of 8.2% upon DBR integration, without hampering the average visible transmittance. This work is bringing semi-transparent OPV one step closer to industrial applications.

CITYSOLAR NETWORK EVENTS

CMD30 FisMat2023 JOINT CONFERENCE IN MILAN – SEPTEMBER 4th – 8th, 2023

Paolo Moras presented a poster on the degradation and self-healing of the large band gap perovskite, FAPbBr3, that is used for the top cell within the tandem structures developed in the CITYSOLAR consortium, at the FisMat2023 conference in Milan. Further details on the paper and publication are given on page 5 of this newsletter in the Scientific Highlights.

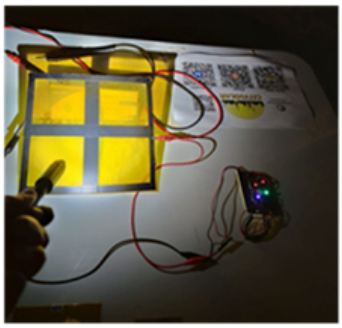




CITYSOLAR ON NATIONAL TV!

The Citysolar Project presented on the Italian National Television Rai2 during the show Quasar. You can watch the entire episode at the following link: https://www.raiplay.it/video/2023/04/Quasar---Puntata-del-15042023-711fd428-649a-4009-ae79-121c2091b464.html

EUROPEAN RESEARCHERS' NIGHT – SEPTEMBER 29th – 30th, 2023



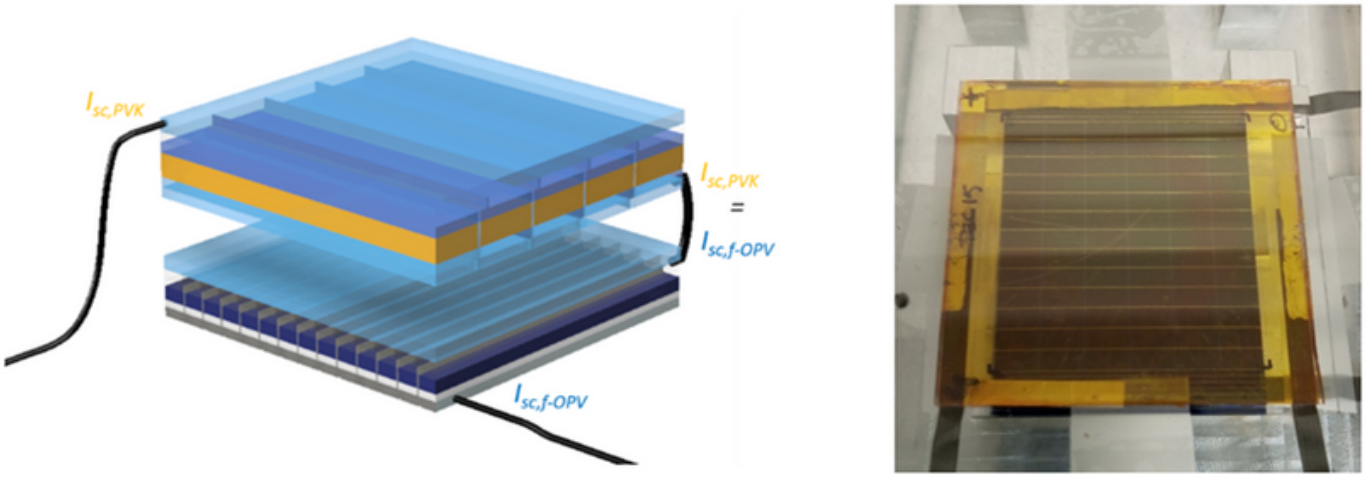
The main concepts and latest innovations of CITYSOLAR were explained to the public during the "European Researchers' Night" event held in Rome at the "Città dell'altra economia" venue. The overall event attracted more than 17,000 people over two days, and the CITYSOLAR group participated with a well-attended stand. Through interactive demonstrations the public was able to measure first-hand the energy produced by the transparent prototypes of devices produced so far in the project and understand what an extraordinary resource transparent photovoltaics will represent for the cities in the future.

https://www.scienzainsieme.it/wp-content/uploads/2023/09/PROGRAMMA_NET-2023.pdf *(italian)*

MATCHING THE PHOTOCURRENT OF PEROVSKITE/ORGANIC TANDEM SOLAR MODULES BY VARYING THE CELL WIDTH

Conventional monolithic perovskite- and organic-based tandem solar cells are sequentially fabricated at the small scale (< 1.0 cm2) on a single substrate, which imposes a number of restrictions that complicate their development for real-world applications: 1) the wide- and narrow-bandgap semiconductors must have complementary light absorption ranges to minimize the thermalization losses occurring in the latter for energies higher than its bandgap, 2) selection of orthogonal solvents to avoid the dissolution of the films comprising the first deposited sub-cell, and 3) the deposition of a highly conductive and transparent recombination layer that is typically obtained by time-consuming and energy-intensive methods, such as thermal evaporation.

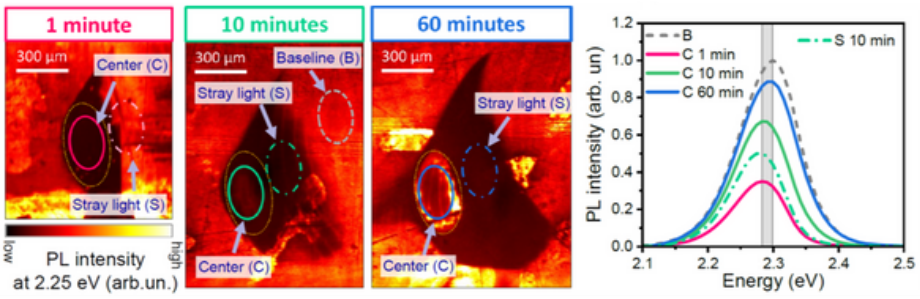
In this work, we demonstrated a strategy that allowed us to overcome each of these limitations and that has the potential to ease the fabrication of thin film tandem devices at an industrial scale. Independently fabricated perovskite (FAPbBr3, Eg= 2.28 eV) and organic (PM6:Y6:PCBM, Eg= 1.39 eV) modules were connected in series by matching their short circuit current via the fine-tuning of the sub-cell width of the organic module, which led to a tandem power conversion efficiency up to 14.94% for an aperture area of 20.25 cm2. This efficiency was higher than those of the individual perovskite (6.69%) and organic (12.46%) modules, a notable improvement considering the significant non-complementarity of these semiconductors that validates the tandem concept. Furthermore, we proved that this strategy can be extended for the matching of the open circuit voltage, a concept that would result in opaque or semitransparent perovskite/organic tandem modules with enhanced robustness against variations in light intensity. Cerillo et al. [3].

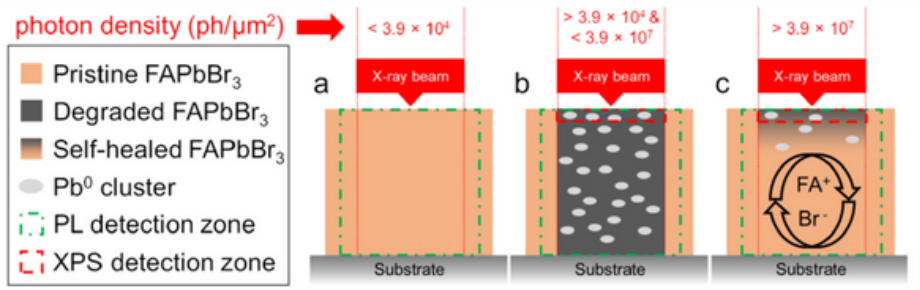


Schematic representation and photograph of connected PSC OPV tandem module.

DEGRADATION AND SELF-HEALING OF FAPbBr3 PEROVSKITE UNDER SOFT X-RAY IRRADIATION

The extensive use of perovskites as light absorbers calls for a deeper understanding of the interaction of these materials with light. Here, we track the evolution of the chemical and optoelectronic properties of formamidinium lead tri-bromide (FAPbBr3) films under the soft X-ray beam of a high-brilliance synchrotron source by photoemission spectroscopy and micro-photoluminescence. Two contrasting processes are at play during the irradiation. The degradation of the material manifests with the formation of Pb0 metallic clusters, loss of gaseous Br2, decrease and shift of the photoluminescence emission. The recovery of the photoluminescence signal for prolonged beam exposure times is ascribed to self-healing of FAPbBr3, thanks to the re-oxidation of Pb0 and migration of FA+ and Br– ions. This scenario is validated on FAPbBr3 films treated by Ar+ ion sputtering. The degradation/self-healing effect, which was previously reported for irradiation up to the ultraviolet regime, has the potential of extending the lifetime of X-ray detectors based on perovskites.





Top left: Photoluminescence (PL) image of FAPbBr3 thin film after 1, 10, and 60 min of X-ray irradiation.

Top right: PL spectra in selected areas marked in the PL image.

Bottom: Schematic showing the behavior of the perovskite under (a) low (b) medium and (c) high density of soft X-ray photons.

The combination of XPS analysis, which provides chemical sensitivity, and PL imaging at the microscale allows to obtain a comprehensive picture of the processes occurring in FAPbBr3 under soft X-rays. The self-healing of FAPbBr3 stimulated by X-ray exposure is reported for the first time in the present study. The experimental observations and the proposed chemical paths for the degradation and restoring of the optoelectronic properties provide a complementary perspective to previous studies exploring the interaction of FAPbBr3 with lower energy light. From the technological point of view, the results suggest that FAPbBr3 films could be exploited as light adsorbers in X-ray detectors operating in high-doses environments. Milotti et al. [2].

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CITY SOLAR

ENERGY HARVESTING IN CITIES WITH TRANSPARENT AND HIGHLY EFFICIENT WINDOW INTEGRATED MULTI-JUNCTION SOLAR CELLS

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