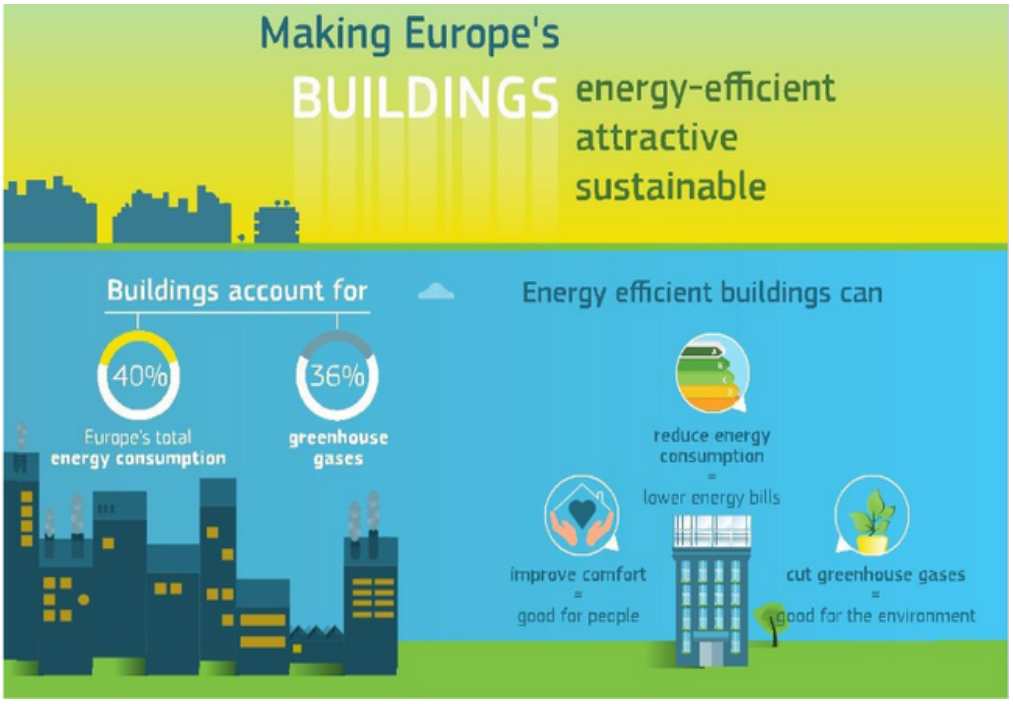
CITYSOLAR

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

Welcome to the second issue of CITYSOLAR Newsletter. You will find relevant information about the Project and its progress on developing innovative transparent and highly efficient window integrated multi-junction solar cells. In this issue we will share the main highlights of the progress with a focuss on the CNR-ISM partner and information about our partecipation in some virtual and face-to-face events.
We hope you enjoy reading it and we invite you to share your thoughts through our social media at the following adresses:
twitter.com/CITYSOLAR_H2020
linkedin.com/company/citysolar-eu
facebook.com/CitysolarH2020



RENEWABLE ENERGY IN BUILDINGS

The use of renewable energy is a priority in buildings considering that they are the largest energy consumers in Europe. With a consumption of 458 Mtoe in 2016, buildings account for 40% of the final energy consumption and 60% of the electricity consumption in the EU-28. Two thirds of this consumption are for residential buildings, Moreover, buildings are responsible for about 39% of all CO2 emissions with 28% for building operation.

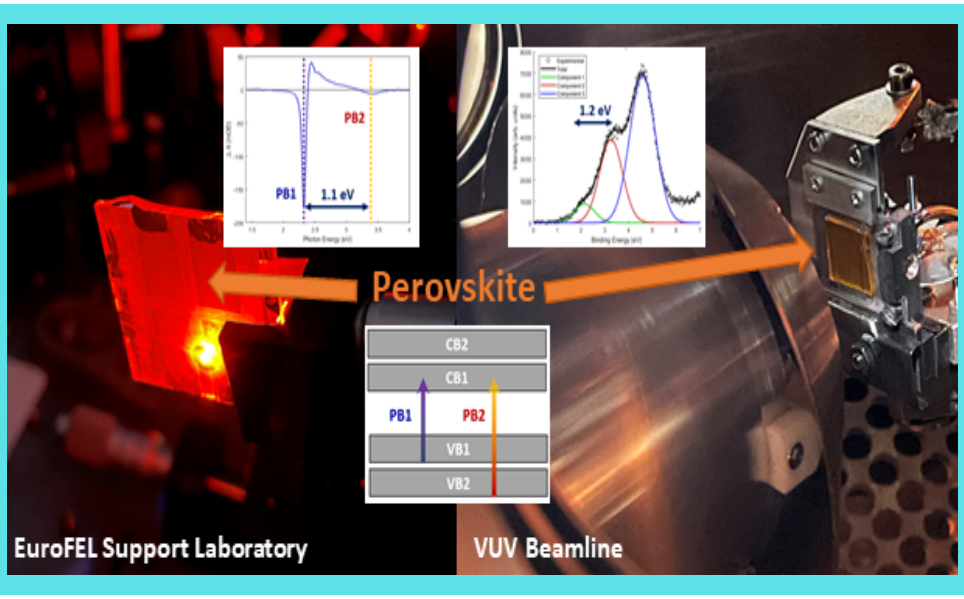
According to the International Energy Agency (IEA), moving to below 2°C path requires reducing the buildings sector's energy consumption by at least 30% through means of mainstreaming highly energy efficient new buildings and a deep renovation of the existing building stock of buildings by 2050

OPTICAL AND ELECTRONIC INVESTIGATION OF SEMI-TRASPARENT PEROVSKITES AT CNR-ISM

Semi-transparent formamidinium lead bromide (FAPbBr3) perovskite has been identified as one of the key absorbing materials in the visible and UV light for the top module of the solar cells under consideration in the CITYSOLAR project. The measurement of the static light absorption spectrum is not sufficient to give a complete description of the band structure of this material. The CNR-ISM group has combined advanced optical and electronic spectroscopies to elucidate the nature of the electronic states of FAPbBr3 films synthesised at the CHOSE laboratory of the University of Tor Vergata. The two types of spectroscopies applied are complementary to each other, with each of them providing answers to part of the puzzle.

Researchers of the EuroFEL Support Laboratory investigated FAPbBr3-based cells by transient absorption spectroscopy, which follows the time-evolution of the absorption spectrum upon femtosecond laser excitation and provides information inaccessible under static conditions, allowing the researchers to identify a contribution deriving from deeply lying states of FAPbBr3. These results called for a study of the low-energy electronic structure of the material by high-resolution photoemission spectroscopy. The experiment was carried out jointly with CNR-ISM researchers that manage the VUV-Photoemission beamline at the synchrotron Elettra in Trieste.

By comparing the experimental results obtained by transient absorption and photoemission spectroscopies to theoretical simulations of the electronic states of the perovskite, it was possible to link the newly found absorption feature in UV range to a transition between the second valence band and the first conduction band. Further studies will investigate the impact of this contribution on the efficiency of the FAPbBr3-based solar cells.



UHV MBE1 APPARATUS FOR FULLY INORGANIC PEROVSKITES AT IC11-LABORATORY (CNR-ISM)

In the frame of the CITY SOLAR Project at CNR-ISM, in the IC11 Laboratory (MBE1-UPS-BIS), has been developed an UHV Molecular Beam Epitaxy (MBE) apparatus for fully inorganic perosvskites/HTL/ETL epitaxial growth and structural/spectroscopic investigations.

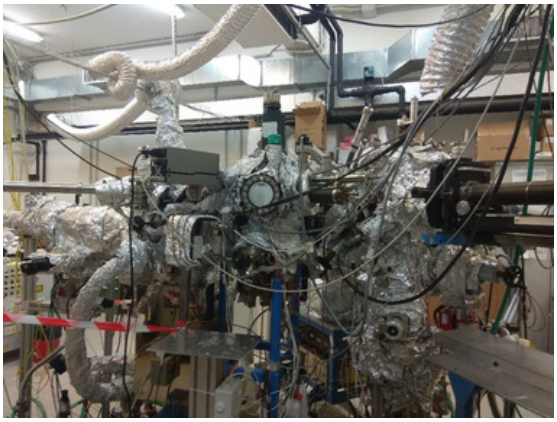
The UHV-MBE1 apparatus for epitaxial synthesis in UHV of ultra-thin, thin and thick film of perovskites and HTL/ETL layers is equipped with 11 MBE Knudsen evaporation cells of precursor salts for perovskite compounds. The UHV LN-cooled MBE1 system includes: 5-movements VG Manipulator at variable Temperature (up to » 1300 K); STAIB Electron GUN/RHEED/Screen for High Electron Energy Diffraction (RHEED) system; RGA-300 AMU, (SRS-Mod.) for mass spectroscopic analysis; 1 STM-100/MF quartz microbalance for flux and film thickness monitor, (SYCOM); 2 Fast-Entry chambers for samples loading /transfer; 3 RIBER MBE Knudsen evaporation cells and 8 MBE Knudsen evaporation cells for Lead-and Lead-free perovskites, and 2 additional evaporation cells for 2+ dopant atoms.

MBE1 system is directly connected to the UPS/BIS apparatus by UHV gate valves/samples transfer and fast-entry chambers (there are 5 places garage). UPS (He- I-II Lamp) and IPES (Geiger-Müller system) UHV chambers are equipped with Low Electron Energy Diffraction (LEED), CMA double-pass electron energy analyser for AES/SES/RHEELS; in-situ high-and –Low temperature (» 1300 K; » 80 K) manipulator sample holder; Si/Ag/Au/As/Ni/Sn Knudsen evaporation cells and O and Ar gas-line for SnOx and NiOx thin film growth, and 1 STM-100/MF quartz microbalance.

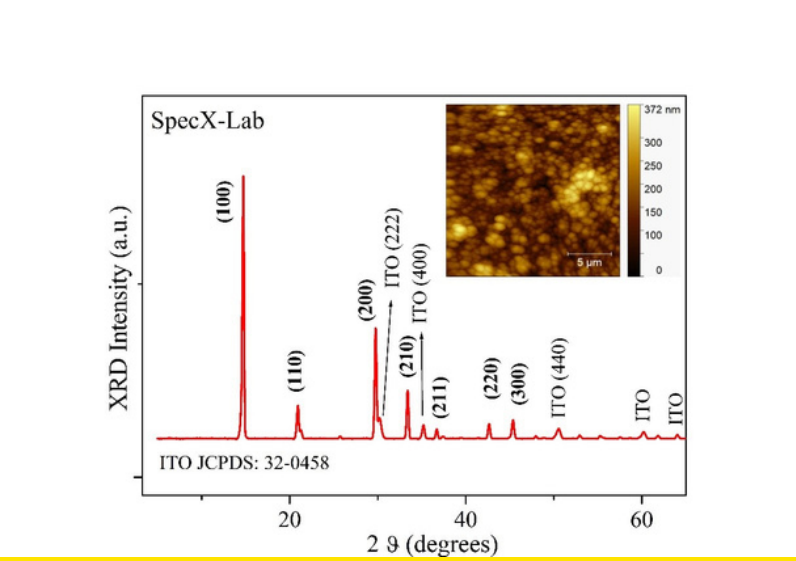
All UHV chambers are separated by gate valves, having own pumping systems, primary/secondary/ionic/Ti sublimation/LN-Getter/cryogenic LN systems and UHV ion-gauges.

The structural and electronic properties (Filled/Empty states) of synthesised materials will be investigated by RHEED/LEED/ AES/SES/REELS/UPS/IPES in the MBE1-UPS-IPES integrated system.

Integrated UHV MBE1-UPS-IPES-AES System for Perovskites/HTL/ETL Epitaxial Growth and Structural/Electronic Investigations.



SYSTEMATIC STUDY OF CSFAPBBR3 AND FAPBBR3 BASED DEVICES TO CORRELATE STRUCTURE/MORPHOLOGY TO OPTICAL AND ELECTRONIC PROPERTIES



XRD, AFM of ITO/SnO2/ FAPbBr3/PTAA/ITO top cell. Perovskite deposition by Spin on SnO2 by blade

In photovoltaic systems the optical and electronic properties strongly depend on the active materials structure and morphology.

Therefore, X-ray diffraction (XRD), a technique allowing to determine the molecular structural parameters through the systematic measurement of the intensity of the scattered X-rays originating from the interaction between the primary beam and the crystal lattice of a material, Energy Dispersive X-Ray Reflectometry (EDXR) providing thickness/roughness/electron density determination of thin films and multilayers and Atomic Force Microscopy (AFM), a powerful imaging technique that by scanning a sharp tip of 5–10 nm typical tip diameter over a surface produces topographical images at the nanoscale, were applied to the study FaPbBr3 and CsFaPbBr3 perovkite based devices deposited by spin and by blade and using SnO2 as ETL (low-T deposition for flexible devices).

XRD demonstrates that, for all the devices and intermediate samples studied, the absorbers are characterized by excellent crystalline quality of perovskites pure a-phase, independently of the deposition procedure used and active layer thickness.

Reversely, AFM and EDXR show that the morphological characteristics are much depending on the deposition used and on the perovkite layer thickness. Statistical analyses evidence homogenous texture of all samples, both for the intermediate samples and for the complete to cells. For all devices, rms is quite high, the complete cell ITO/SnO2/ FAPbBr3/PTAA/ITO (perovkite deposited by spin) being the significantly less rough one.

The XRD, EDXR and AFM results provide the needed information for the optimization of the perovskite layer structure and morphology in consideration of the role of deposition techniques of perovskite layer thickness and of the use of Tin oxide ETL

CITYSOLAR EVENTS, NEWS & PUBLICATIONS

This section presents the main highlights of CITYSOLAR Communication and Dissemination activities, the events in which CITYSOLAR partners have partecipated, the pubblication of papers and press release pubbblications

Events

2021 European Researcher Night

Sept 24, 2021 - Rome

HOPV - 13th Conference on Hybrid and Organic Photovoltaics

May 24-28, 2021 - Virtual

15th International Symposium on Flexible Organic Eletronics

July 4-7, 2021 - Thessaloniki (Greece)

2021 NanoGE Fall Meeting

October 18-22, 2021 - Virtual

Sonderborg Climate Neutrality conference 2021

September 28-29, 2021 - Virtual

Sustainable Places 2021

Sep 29-Oct 1, 2021 - Rome (Italy)

Scientific Publications

2D materials for organic and perovskite photovoltaics

Um Kanta Aryal, Mehrad Ahmadpour, Vida Turkovic, Horst-Günter Rubahn, Aldo Di Carlo, Morten Madsen

https://doi.org/10.1016/j.nanoen.2021.106833

Improved Air Processability of Organic Photovoltaics Using a Stabilizing Antioxidant to Prevent Thermal Oxidation

Marc Steinberger, Andreas Distler, Christoph J. Brabec, and Hans-Joachim Egelhaaf

https://doi.org/10.1021/acs.jpcc.1c07050

Generation of long-lived charges in organic semiconductor heterojunction nanoparticles for efficient photocatalytic hydrogen evolution

Jan Kosco, Soranyel Gonzalez-Carrero, Calvyn T. Howells, Teng Fei, Yifan Dong, Rachid Sougrat, George T. Harrison, Yuliar Firdaus, Rajendar Sheelamanthula, Balaji Purushothaman, Floriana Moruzzi, Weidong Xu, Lingyun Zhao, Aniruddha Basu, Stefaan De Wolf, Thomas D. Anthopoulos, James R. Durrant and Iain McCulloch

https://doi.org/10.1038/s41560-022-00990-2

Efficiency-Enhanced Scalable Organic Photovoltaics Using Roll-to-Roll Nanoimprint Lithography

Mohammed A. Yakoob, Jani Lamminaho, Karlis Petersons, Ashish Prajapati, Elodie Destouesse, Bhushan R. Patil, Horst-Günter Rubahn, Gil Shalev, Jan Stensborg, and Morten Madsen

https://doi.org/10.1002/cssc.202101611

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Project coordinator
Prof. Aldo Di Carlo
aldo.dicarlo@ism.cnr.it

Institute of structure of matter (ISM))
c/o Area della Ricerca di Roma - Tor Vergata
Via del Fosso del Cavaliere, 100 - 00133 Roma (RM)

Project website: https://www.citysolar-h2020.eu/

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