ParisTech ESPCI PARIS PSL

## RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

***Field: Energy, Processes***
***Subfield***: Materials for photovoltaics
***Title***: Material Strategies for More Stable Perovskite Solar Cells
***ParisTech School***: ESPCI Paris
***Advisor Name***: Dr. Zhuoying Chen
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***Research group/Lab:*** *Micro & Nano Characterization Group/LPEM*
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***Short description of possible research topics for a PhD***:

Research in the field of solution-processed organic-inorganic lead perovskite halide solar cells have witnessed remarkable progress over the past decade. The majority of research efforts have been focused on the improvement of the power-conversion efficiency, leading to a significant increase of this figure-of-merit reaching 25%. This progress and additional advantageous properties, such as ease of fabrication, low-cost, light-weight, flexibility and semi-transparency make these devices a bright contender for potential new industrial applications. However, when compared to silicon-based solar panels, which typically have a lifespan of 25 years, hybrid perovskite solar cells suffer from various degrees of material degradation related to the environment they are exposed to. Device stability, thus currently represents one of the utmost pressing issues preventing their large-scale application and exploitation.

While there are existing methods (e.g. additives, different transport-layers and interface modifications) towards better perovskite solar cell stability, the fundamental processes happening in the material and the device by these methods are still to be fully understood. In addition, while perovskite solar cell stability can be slightly enhanced by current methods, it is still by far inferior compared to silicon solar cells. There is still much room for further improvement. This thesis program will therefore focus on understanding the fundamental roles of current methods in order to propose further innovative and more effective stability enhancement strategies. Specifically, the PhD candidate will first study the microstructure, chemical, and optical origins of the stability enhancement of hybrid perovskite halides when applying different materials and device modifications methods by a combination of optical, structural, microscopic, and spectroscopic investigations. Upon obtaining fundamental understandings, he/she will propose new strategies with more effective impact on the solar cell stability.

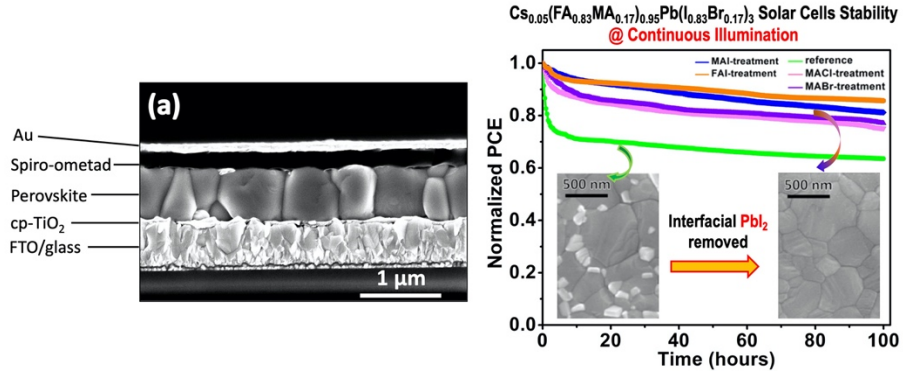


*Figure: (a) Cross-sectional SEM image of a perovskite solar cell fabricated in our lab; (b) Efficiency evolution over 100 hrs of the unencapsulated $Cs_{0.05}(FA_{0.83}MA_{0.17})_{0.95}Pb(I_{0.83}Br_{0.17})_3$ perovskite solar cells with different surface treatments under continuous AM 1.5G 1-sun illumination measured inside an Ar glovebox in our lab.*

***Required background of the student***: Solid academic background and a Master Degree on chemistry, material science, or applied physics. Good speaking & writing skills in English. Passionate in scientific experiments.

***A list of representative publications of the group on this subject:***


- "$TiO_2$ Nanocolumn Arrays for More Efficient and Stable Perovskite Solar Cells", ACS Applied Materials & Interfaces, 12, 5979-5989 (2020)
- "Microscopic Evidence of Upconversion-Induced Near-Infrared Light Harvest in Hybrid Perovskite Solar Cells", M. Schoenauer Sebag et al., ACS Applied Energy Materials, 1, 3537-3543 (2018)
- "Compact layer free mixed-cation lead mixed-halide perovskite solar cells", Z. Hu et al., Chemical Communications, 54, 2623-2626 (2018)
- "Effect of Ion Migration-Induced Electrode Degradation on the Operational Stability of Perovskite Solar Cells", ACS Omega, 3, 10042-10047 (2018)