Studying Aging Evolution of Triple-Cations Perovskite Thin Films with Transport Characterizations

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Among the different types of materials for photovoltaic application, recent attention has focused on hybrid inorganic-organic absorbers. In just a decade, perovskite solar cells (PSCs) efficiency has rapidly increased from 3.8% to a remarkable value over 25%, already comparable with that of commercial silicon solar cells, and it is still growing up while writing this communication. However, even though it was demonstrated that PSCs are stable for thousands of hours in laboratory tests, their stability under outdoor conditions is still an issue and can be a barrier for long term applications. Environmental factors coming from atmosphere, light, moisture, and even thermal effect, can be detrimental to the stability of the PSCs performances. In order to investigate on the origin of these mechanisms, we have applied photoconductivity-based characterizations to perovskite thin films under different conditions, the layer being studied in air, in vacuum as well as after light-soaking under heavy light.

Among all the photoconductivity-based methods developed to study semiconductor materials, we have chosen to use the Fourier transform photocurrent spectroscopy (FTPS) to investigate on the variation with light energy of the absorption coefficient, especially in the below gap weak absorption region, since this experiment can reveal information on the defect states present in the gap. Compared to the Constant Photocurrent Method (CPM), where each wavelength is selected from the light source with a monochromator, FTPS presents at least two advantages: its rapidity, it can provide a spectrum within only few minutes, and its nanometric resolution, far better than the CPM resolution. In this study we have also studied some of the transport properties of perovskite thin films by measuring their carrier ambipolar diffusion length L_{amb}. For this purpose, steady state photocarrier grating (SSPG) technique was used allowing us to directly measure L_{amb}. In addition to these sophisticated techniques dark conductivity measurements, as well the steady state photocurrent (SSPC) experiment, which can provide further information about the transport properties of the material. By employing a wide range of characterization techniques (SSPC, SSPG, FTPS, and also photoluminescence measurement) we attempt to draw a link between the measured opto-electronic properties and the state of the materials, whether in air or under vacuum or after light soaking, to study their stability.