Highlights

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Unravelling the low-temperature metastable state in perovskite solar cells by noise spectroscopy

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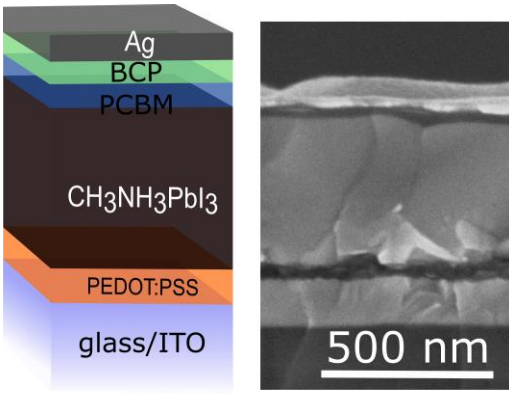
The hybrid perovskite methylammonium lead iodide $CH_3NH_3PbI_3$ recently revealed its potential for the manufacturing of low-cost and efficient photovoltaic cells. However, many questions remain unanswered regarding the physics of the charge carrier conduction. In this respect, it is known that two structural phase transitions, occurring at temperatures near 160 and 310 K, could profoundly change the electronic properties of the photovoltaic material, but, up to now, a clear experimental evidence has not been reported. In order to shed light on this topic, the low-temperature phase transition of perovskite solar cells has been thoroughly investigated by using electric noise spectroscopy. Here it is shown that the dynamics of fluctuations detect the existence of a metastable state in a crossover region between the room-temperature tetragonal and the low-temperature orthorhombic phases of the perovskite compound. Besides the presence of a noise peak at this transition, a saturation of the fluctuation amplitudes is observed induced by the external DC current or, equivalently, by light exposure. This noise saturation effect is independent on temperature, and may represent an important aspect to consider for a detailed explanation of the mechanisms of operation in perovskite solar cells.



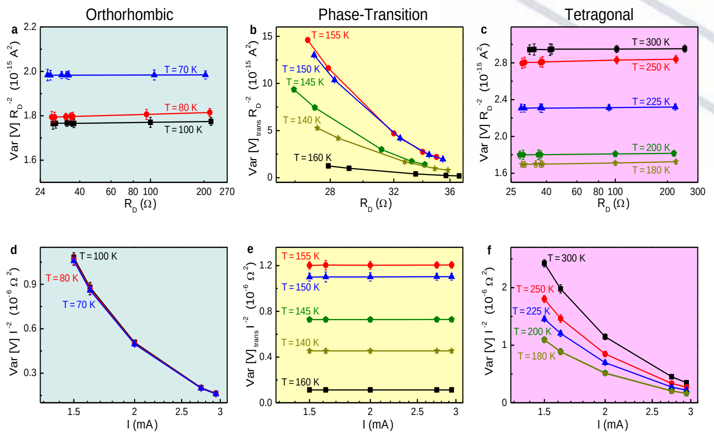


Figure 1. Sketch of the used inverted perovskite solar cell structure, consisting of the layer stack glass/ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/$PC_{61}BM$/BCP/Ag. The cross sectional scanning electron micrograph is shown in the right image.

Figure 2. Behavior of the noise amplitude in different temperature regions. The normalized noise is shown as a function of the differential resistance R_D (upper panels) and of the bias current I (lower panels).