Organo-metalic hybrid perovskites sparked research interest following Kojima's breakthrough investigation in 2009, when organic–inorganic lead halides were first used as light harvesters in dye-sensitized photovoltaics. Subsequently, his work instigated an avalanche of publications on perovskite photovoltaics up to date. Since high efficiency is the trademark of these devices, research efforts have been heavily shifted towards improvement of photoconversion capabilities, eventually overshooting initially projected mark of 20% for power conversion efficiency. However, it is of paramount importance for further development of perovskite photovoltaics to investigate charge carrier behavior within such devices, elucidate its origins, as well as identify suitable figure of merit to describe charge transport physics. Charge transport is one of the main parameters determining device efficiency and stability; however, this area of research remains relatively unbroached, especially in the case of fully assembled operational solar cells. In our study, charge selective photoinduced carrier extraction by linearly increasing voltage is employed in order to provide direct observation of charge transport properties within planar (ITO/PEDOT:PSS/perovskite/PC$_{70}$BM/Al) and mesostructured (FTO/compact-TiO$_2$/mesoporous-TiO$_2$/perovskite/Spiro-OMeTAD/Au) perovskite solar cells with respect to signal delay and light bias. Measurements were performed on two types of comparatively efficient, most commonly encountered device architectures: mesoporous and inverted planar solar cells. Appropriate comparison was drawn in regards to charge mobilities and trapping dynamics caused by defects and complex interfaces. Very similar charge carrier mobilities were observed within mesoporous devices, whereas holes trailed about half an order of magnitude behind electrons in planar structured samples, as a result of hindered injection from PEDOT:PSS layer. Furthermore, dispersive transport was identified in the electron selective devices with titanium oxide electron transporter, suggesting considerable presence of shallow trapping states at the perovskite interface. No such behavior was recorded in planar samples due to the passivating nature of PC$_{70}$M. In both cases, time delayed charge extraction showed no signs of film charging effect. Overall, we provided a simple pathway towards direct observation of charge transport properties and pinpointed critical areas within device responsible for trapping disorders.

Figure 1: Cross sectional SEM view of mesostructured (a) and planar (b) device structures and j-V curves with major performance parameters of mesostructured (c) and planar (d) devices