**Link:** <https://solar-power-tech.com/e-posters/psc_eposter_16/>

**Abstract**

Carbon based perovskite solar cells (C-PSCs) are an attractive concept that allows promising results in terms of performance and stability of perovskite devices without having recourse to expensive hole transporting layers (HTL), such as the commonly used Spiro-OMeTAD. However, the absence of an HTL hinders the performance of the C-PSCs mainly perceived in the lower fill factor (FF) values obtained, which is an important indication of the performance and quality of solar cell devices. This work reports on a certified world record efficiency of 15.5% for a hole selective layer (HSL) free printed carbon-electrode based perovskite solar cell. The same device yields a fill factor as high as 78.8% obtained through the certified measurements, which approaches the highest values reported in metal-based electrode devices employing highly selective HSLs. In this regard, we review methods to assess loss mechanisms in the fill factor established in silicon PV research that are not yet commonly applied in the perovskite field. Furthermore, the theoretical physical constraints on the FF and practical limitations such as impact of the non-radiative recombination and resistivity losses on are assessed. We find only 3%abs loss due to non-radiative recombination with respect to the FF in the radiative limit of 90%,[1] which can be attributed to an optimal diode ideality factor approaching 1.0. Moreover, contributions of shunt resistive losses are found to be negligible, leaving the largest potential to further increase the FF to lateral and interfacial resistance losses.