Mixtures of PEDOT and dopant-free Spiro-OMeTAD as hole selective contact in regular perovskite solar cells

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The highest efficiencies of regular perovskite solar cells reported to date are obtained with doped hole selective contacts (HSC).[1,2] Although these dopants are necessary to provide sufficient conductivity in the HSC, they were shown to impose the dominating source for non-radiative recombination in high efficiency solar cells.[3] It is therefore of key importance to suppress recombination losses at the perovskite/HSC interface in order to increase the open circuit voltage (V_{OC}) and consequently the efficiency of the solar cells.

In this study, a poly(3,4-ethylenedioxythiophene) (PEDOT) layer doped with sulfonated copolymers is coated from a water-free dispersion and used as the HSC in regular perovskite solar cells. By adding undoped 2,2′,7,7′-tetrakis(N,N-di-p-methoxyphenylamine)-9,9′-spirobifluorene (Spiro-OMeTAD) into the PEDOT dispersion, the V_{OC} of the resulting devices increases to above 1.15 V. This even exceeds the V_{OC} for reference solar cells prepared here with doped Spiro OMeTAD as HSC. Furthermore, the stabilized efficiency is boosted beyond 15 % which more than doubles the highest value of around 7.5 % reported so far for regular perovskite solar cells comprising PEDOT as the hole contact.[4,5]

Transient photoluminescence and electroluminescence measurements imply enhanced hole extraction at the perovskite interface for solar cells with Spiro-OMeTAD enriched PEDOT layers. Photoelectron spectroscopy reveals a strong shift in ionisation energies at the surfaces of the mixed PEDOT layers and conductivity measurements shows a linear dependence of lateral conductivity of the resulting mixed films with the amount of added Spiro-OMeTAD. Both results indicate a homogeneus distribution of Spiro-OMeTAD throughout the PEDOT layer and the shift in ionization energies correlates with the increase in V_{OC} observed for the resulting solar cells.

In conclusion, a mixture of PEDOT and Spiro-OMeTAD as HSC is introduced in this study. The high V_{OC} values achieved for solar cells with this mixed HSC indicate suppressed recombination losses at the perovskite/HSC interface by the dopant-free Spiro-OMeTAD while the significantly more conductive PEDOT facilitates charge transport to the metal electrode. This mixed material approach and its capability to omit dopant-induced recombination losses might therefore provide potential to further enhance the overall efficiencies in regular perovskite solar cells.

References

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