Nanostructure strategies towards performance-enhanced perovskite solar cells

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Organic-inorganic hybrid perovskite solar cells have attracted much attention due to their high power conversion efficiency (＞23%) and low-cost fabrication. Directions to further improve these solar cells include strategies to enhance their stability and their efficiency by modifying either the perovskite absorber layer or the electron/hole transport layer. For example, the transparent electron transport layer (ETL) can be an important tuning knob influencing the charge extraction, [1] light harvesting, [2] and stability [3] in these solar cells, or the use of up-conversion nanoparticles to get better performance in the near IR part of the visible spectrum. [4] Here we present two strategies based on nanostructuration, first a fundamental study of upconversion fluorescence enhancement effects near Au nanodisks by scanning near-field optical microscopy and second the effects of a nanocolumnar TiO2 layer on the performance and the stability of Cs0.05(FA0.83MA0.17)0.95Pb(I0.83Br0.17)3 perovskite solar cells. For the first case, the enhancement and localization of light near the metallic structures are directly visualized by using a single Er/Yb-codoped fluorescent nanocrystal glued at the end of a sharp scanning tip. [5] For the second we find that, compared to devices with planar TiO2 ETLs, the TiO2 nanocolumns can significantly enhance the power conversion efficiency of the perovskite solar cells by 17 % and prolong their shelf life. By analyzing the optical properties, solar cells characteristics, as well as transport/recombination properties by impedance spectroscopy, we observed light-trapping and reduced carrier recombination in solar cells associated with the use of TiO2 nanocolumn arrays. [6]

References

[1] S.S. Mali, et al., Chemistry of Materials 27, (2015) 1541
[2] C. Liu, et al., Journal of Materials Chemistry A 5, (2017) 15970
[3] M. Salado, et al., Nano Energy 35, (2017) 215
[4] M. Bauch et al., Plasmonics 9, (2014) 781
[5] L. Aigouy, et al., Nanoscale 11, (2019) 10365
[6] Z. Hu, et al., ACS Appl. Mater. Interfaces 12, (2020) 5979