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Research Seminar

When: April 14, 2022
Time: 12:00 p.m.
Location: CBLL-16

Solution Processing of NiO_x for Large Area Perovskite Solar Cells

Abstract

Ever growing energy and environmental concerns has led to a significant rise in the development of renewable energy alternatives such as solar. In the last decade metal halide perovskites have emerged as a scalable alternative to silicon through solution processing. Despite record devices reaching as high as 25% photoconversion efficiency for small area devices, the development of large area deposition systems on plastic and glass needs improvement.[1, 2] Additionally, the large area deposition of charge transfer materials that are stable and low cost, such as nickel oxide (NiO_x), is significantly underdeveloped. Herein we describe a series of NiO_x nanoparticles and suspensions for large area deposition by blade coating and roll-to-roll coating for use both on top of and underneath the metal halide perovskite. NiO_x is a p-type semiconductor with high optical transmittance, high charge carriers, good environmental stability, and favorable band alignment with perovskites, making it an ideal choice for the hole transport layer (HTL) of a perovskite device.[3, 4] For deposition on the perovskite surface the HTL needs to be suspended in a perovskite antisolvent such as chlorobenzene. Previous work to stabilize NiO_x in chlorobenzene has focused on using long insulating alkyl chains ligands with limited success.[5] The effects of varying the chain length were explored through a series of xanthate ligands. It was found that by using a coordinate solvent system we were able to successfully suspend NiO_x in a chlorobenzene system without the use of long alkyl chain ligand.[6] By combining solution composition with post deposition treatment, we have developed a NiO_x system for uniform large area deposition on plastic substrates on a roll-to-roll system. The incorporation of a copper dopant and annealing with intense pulsed light and corona discharge further improved charge extraction and overall device performance. The resulting high-performance devices demonstrate the large-scale application of NiO_x as an effective hole transport material and the feasibility of upscaling perovskite solar cell fabrication.

References

1. J. Jeong, M. Kim, J. Seo, H. Lu, P. Ahlawat, A. Mishra, Y. Yang, M. A. Hope, F. T. Eickemeyer, M. Kim, Y. J. Yoon, I. W. Choi, B. P. Darwich, S. J. Choi, Y. Jo, J. H. Lee, B. Walker, S. M. Zakeeruddin, L. Emsley, U. Rothlisberger, A. Hagfeldt, D. S. Kim, M. Grätzel and J. Y. Kim, *Nature*, 2021, **592**, 381-385.
2. N. R. E. Laboratory, Best Research-Cell Efficiency Chart, https://www.nrel.gov/pv/cell-efficiency.html, (accessed April 8th, 2022).
3. M. A. Haque, A. D. Sheikh, X. Guan and T. Wu, *Adv. Energy Mater.*, 2017, **7**, 1602803.
4. H. Tian, B. Xu, H. Chen, E. M. J. Johansson and G. Boschloo, *ChemSusChem*, 2014, **7**, 2150-2153.
5. X. Liang, Q. Yi, S. Bai, X. Dai, X. Wang, Z. Ye, F. Gao, F. Zhang, B. Sun and Y. Jin, *Nano Lett.*, 2014, **14**, 3117-3123.
6. P. J. Armstrong, P. S. Chandrasekhar, S. Chapagain, C. M. Cline, M. F. A. M. van Hest, T. Druffel and C. A. Grapperhaus, *Nanotechnology*, 2021, **33**, 065403.