

University of Louisville
Department of Chemistry

Sashil Chapagain Research Seminar

When: October 13, 2022

Time: 3:45 p.m.

Location: CBL-16

Nonaqueous Tin (IV) Oxide Dispersion for the Scalable Fabrication of Efficient Inverted Flexible Perovskite Solar Cells

Abstract:

Hybrid organic-inorganic lead halide perovskites are attractive materials for photovoltaic applications owing to their solution processibility, low-cost materials, and high-power conversion efficiencies. The solution processibility of the perovskite materials provides an avenue for rapid deposition by high-throughput printing processes on flexible PET-based substrates for the fabrication of lightweight, and cost-effective flexible perovskite solar cells (f-PSCs). However, the highest PCEs have been obtained for PSCs fabricated on conductive glass substrates such as ITO or FTO by spin-coating, which limits their scalability. This seminar will focus on the development of scalable fabrication methods of the f-PSCs with a metal oxide ETL. Metal oxides ETL materials are inexpensive and scalable as compared to their organic counterparts. However, deposition of fully solution-processed metal oxide on perovskite to fabricate flexible perovskite solar cells (f-PSCs) is limited by solvent incompatibility of typical metal oxide dispersion media with the underlying perovskite layer and the high processing temperature of metal oxides nanoparticles. In this study, we investigated the direct deposition of tin (IV) oxide as an electron transport layer on the top of perovskite for the high-performance f-PSCs. Here, we synthesized SnO₂ nanoparticles using the sol-gel method and functionalized them with acetate through ligand exchange, allowing their dispersion in anhydrous ethanol. Additionally, we investigated *in situ* yttrium doping of SnO₂ during synthesis to enhance the performance of SnO₂ as an ETL. Nonaqueous dispersions of pristine and yttrium doped SnO₂ were directly deposited on the perovskite by blade coating followed by air knife treatment. There was no detectable damage to the underlying perovskite layer as evidenced by x-ray diffraction and scanning electron microscopy. Photoluminescence spectroscopy and device performance statistics confirm superior electron extraction by yttrium doped SnO₂ as compared to pristine one. After, yttrium doping, the champion power conversion efficiency was increased above 18% from 14.40%, which is unprecedented for an inverted device in flexible ITO-PET substrate employing SnO₂ as an ETL. This work highlights the possibilities of the scalable deposition of fully solution-processed metal oxide charge transfer layers directly on the perovskite to achieve highly efficient large-area flexible perovskite solar cells.

References:

1. McManus, J. S.; Cunningham, P. D.; Regan, L. B.; Smith, A.; McGrath, D. W.; Dunne, P. W., Highly soluble ligand stabilized tin oxide nanocrystals: gel formation and thin film production. *Crystal Growth & Design* **2014**, *14*, 4819-4826.
2. Chapagain, S.; Chandrasekhar, P. S.; McGott, D.; Bramante, R. C.; van Hest, M. F.; Reese, M. O.; Druffel, T.; Grapperhaus, C. A., Direct Deposition of Nonaqueous SnO₂ Dispersion by Blade Coating on Perovskites for the Scalable Fabrication of p-i-n Perovskite Solar Cells. *ACS Applied Energy Materials* **2021**, *4*, 10477-10483.
3. Yang, G.; Lei, H.; Tao, H.; Zheng, X.; Ma, J.; Liu, Q.; Ke, W.; Chen, Z.; Xiong, L.; Qin, P., Reducing hysteresis and enhancing performance of perovskite solar cells using low-temperature processed Y-doped SnO₂ nanosheets as electron selective layers. *Small* **2017**, *13*, 1601769