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Dissertation Defense

When: November 21, 2023
Time: 9:00 AM
Location: CBLL-16

Scalable Solution Processing of NiO_x Nanoparticles

ABSTRACT:

Perovskite solar cells (PSCs) are a promising alternative to silicon-based photovoltaics. However, PSCs face several challenges due to shortcomings in their stability, module efficiency, and scaled production. Although PSCs is still a young field of research, significant attention has been given to demonstrating power conversion efficiencies that are on par with traditional silicon. With that target reached, converting the laboratory demonstration into practical materials to increase access and abundance of solar energy are among the next large targets for the field. This comes with material challenges for perovskite and their companion charge transport layers (CTLs). Among the charge transport materials often used, NiO_x nanoparticles have stood out as a leading material for an efficient, stable, and scalable CTL.[1]

In this work the scalable deposition of NiO_x is addressed through compositional design and solvent engineering. Two NiO_x nanoparticle formulations have been developed and deposited by scalable coating methods to fabricate functional PSC devices. Using compositional design, NiO_x nanoparticles were successfully suspended in a nonpolar solvent system. It was found that the addition of large ligands was unnecessary for particle stabilization in a chlorobenzene-based solution, and that the presence of these ligands significantly obstructed charge extraction.[2] Through further work with solvent engineering, a water based NiO_x suspension that did not require additional ligands was developed. This NiO_x formulation allowed for rapid large area coating on both blade coating and slot die coating systems. Utilizing intense pulsed light (IPL) annealing, processing time was further decreased with an increase in device performance. When used in a slot die coating system with IPL we were able produce a champion device PCE of 12.23%.[3]

In a related study of nanoparticle interfaces the stability of the novel SnO_2/Ag interface was explored.[4] Perovskite ion migration is a leading source of degradation with the formation of AgI a common by product. Prevention of iodide migration through a solution coated SnO_2 layer is investigated. A series of imidazoles were evaluated to identify structural features that contribute to an effective blocking layer. It was found that imidazoles with conjugated planer systems and hydrogen bonding heteroatoms were able to prevent ion migration and retain device performance.[5]

REFERENCES:

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(5) Armstrong, P. J.; Chapagain, S.; Chacko, E.; Druffel, T.; Grapperhaus, C. Evaluation of Imidazole Blocking Layers for Perovskite Stability. **2023**. DOI: http://dx.doi.org/10.2139/ssrn.4635152 SSRN.