University of Florida

Integrated PV/Storage and PV/Storage/Lighting Systems

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Description: The goal is to increase the efficiency and reduce the cost of solar power through the integration of PV, Li-battery, and LED lighting technologies. Since all components are in the form of thin films, the PV/battery/LED system can be integrated as a single module. Since half of the materials cost of each device is the substrate, integrated module will also reduce materials costs and processing steps. Importantly, their integration further eliminates the need for inverters since they are all low-voltage devices. Such an integrated device can be used to store energy during the day and power the LED panel for lighting in the evening. In addition, we will explore the possibility of fabricating a semi-transparent module. The success of this task will lead to a novel solar-power lighting panel that can be used as a sky light during the day and a lighting panel during the night without using grid-power. We not only will develop the technologies, but also integrate devices and perform technology-economic evaluation, including life-cycle costs.

Budget: $576,000
Universities: UF
External Collaborators: University of California San Diego, Oak Ridge National Lab

Executive Summary

In this final report, we will summarize the work we have done in OLED, PV and lithium ion batteries. In the area of lighting and photovoltaics, we focused on light management and hybrid light emitting and PV devices. We have made use of "defective" grating structures to extract thin film guided modes in OLEDs. Because of the lack of long range ordering, we were able to achieve lambertian-like emitters with a 2X enhancement in light output. We have also developed novel optical structures for enhancing the efficiency of organic and hybrid organic-inorganic photovoltaic cells by allowing the active materials to more efficiently absorb the incident light. Two different optical structures were created and applied to the PV cells using a soft lithographic process, which could be easily implemented in large-scale high throughput manufacturing systems. Such enhancement mechanism could also be universally applied to any active materials or device platforms. For hybrid solar cells, we have significantly improved the efficiency of hybrid polymer-colloidal nanocrystal solar cells by engineering the chemical and electronic structures at the polymer-nanocrystal interface. This yields a maximum power conversion efficiency of 5%, the highest for solid-state hybrid solar cells. Finally, we also developed fully solution processed, multilayer quantum-dot based light-emitting devices that show high efficiency and full visible spectrum color tunability.

Lithium-ion batteries are efficient, light-weight and rechargeable power sources for consumer electronics such as laptop computers, digital cameras, MP3 players and cellular phones. However, for the use as energy storage component in this proposed work, the energy density, power density safety and cycling performance still can't achieve the requirements. In this research, three different strategies were selected to improve the rate capability, cycling performance and investigate the solid electrolyte interface. First, the first principles computation was used to selected suitable doping metal and proved by real experiment. Second, the TiO_2 nanostructure was synthesized and the electrochemical properties were examined. Finally, the thin film batteries were fabricated by pulsed laser deposition (PLD) and the solid electrolyte interface were investigated by XPS. In addition, the layered lithium excess layered oxide compounds $Li[Ni_xLi_{1/3-2x/3}Mn_{2/3-x/3}]O_2$ ($0 < x < 1/2$) are of great interests as a new generation of positive electrode materials for lithium-ion batteries because of higher energy densities and lower costs. However, the rate capabilities of these materials are not adequate for future applications. Preliminary studies have proposed mechanisms to explain this material's anomalous capacity; however the mechanism still remains unclear. In order to break the rate capability barrier, a complete understanding of the lithium diffusion mechanism needs to be understood. We uses a series of characterization techniques to identify the rate limiting step that impedes lithium diffusion and propose new strategy to further improve the electrochemical properties of this new family of electrode materials.

This project has been completed, the final report can be found here.