University of Florida

Integrated PV/Storage and PV/Storage/Lighting Systems

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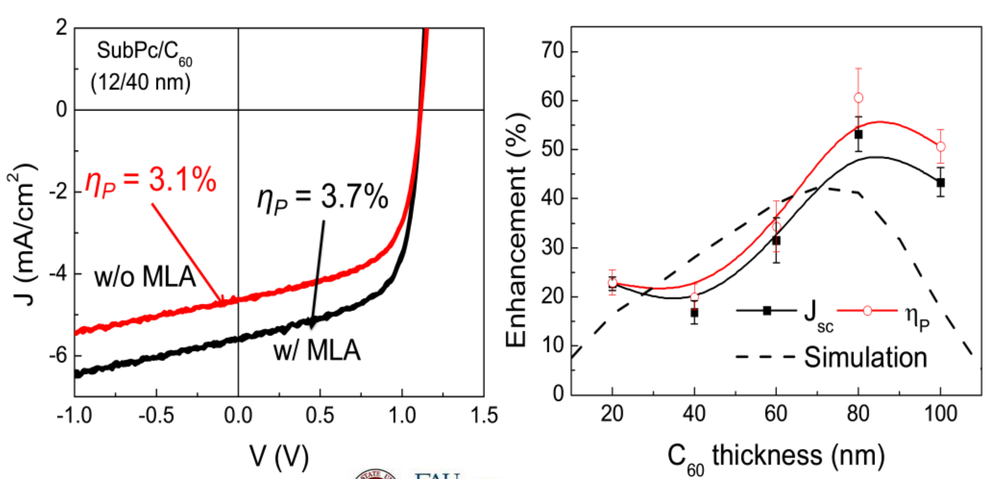
Description: The goal is to increase the efficiency and reduce the cost of solar power through the integration of PV, Li-battery, and LED lighting technologies. Since all components are in the form of thin films, the PV/battery/LED system can be integrated as a single module. Since half of the materials 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

Progress Summary

Organic and hybrid organic-inorganic photovoltaic cells

We have 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. Figure a shows the current density-voltage characteristics of a bilayer SubPc/C_{60} cell under 1 sun AM1.5G solar illumination, which shows a 20% enhancement in efficiency with the microlens array. Figure 1 shows that by varying the C_{60} layer thickness, a maximum enhancement of 60% could be achieved.



High Power and High Energy Spinel Based Electrode Materials

First-principles computation is carried out for investigating the electronic, structural and electrochemical properties of $LiM_{1/2}Mn_{3/2}O_4$ (M=Ti, V, Cr, Fe, Co, Ni and Cu). The computation results suggest that $LiM_{1/2}Mn_{3/2}O_4$ spinel materials family can have significantly different activation barriers for Li diffusion depending on the doping elements, and doping with Co or Cu can potentially lower Li diffusion barrier compared with Ni doping. We found that the amount of Cu will affect the lattice parameters, the cation disorder in the spinel lattice, the particle morphology, as well as the electrochemical properties. With detailed electrochemical measurements and in situ x-ray absorption spectroscopy (XAS) experiments of $LiNi_{0.25}Cu_{0.25}Mn_{1.50}O_4$, the proposed explanation of the voltage profile by the first-principles computation was proven. Ni, Cu and Mn are 2+, 2+ and 4+ respectively in the pristine sample and a second plateau at 4.2V originates from the oxidation of Cu2+ to Cu3+. Cu cannot be further oxidized to Cu4+ and the plateau at 4.95V originates from extra electrons provided by oxygen ions. Although the reversible discharge capacity decreases with increasing the Cu amount, optimized composition such as $LiCu_{0.25}Ni_{0.25}Mn_{1.5}O_4$ exhibits high capacities at high rates. The good rate capability of $LiCu_{0.25}Ni_{0.25}Mn_{1.5}O_4$ spinel oxide is attributed to the single phase reaction during charging, the lower Li diffusion barrier induced by Cu doping, and possibly higher electronic conductivity contributed by Cu doping.

OLED lighting

In collaboration with Dr. Nelson Tansu at Lehigh University, OLEDs were fabricated on grating substrates. These grating substrates were fabricated by coating 1 μm diameter SiO_2 microlens array on glass substrates. The 1-μm-diameter-microlens array pattern of the template was transferred to an epoxy layer by imprinting process. A 120-nm-thick ITO layer was subsequently deposited on the epoxy layer by sputtering and organic layers for OLEDs were subsequently deposited. With the grating structure, light extraction was enhanced by 1.6 times due to enhanced extraction of thin film guided modes. To extract the substrate modes, a hemisphere lens was attached on the back of the glass substrate to extract substrate modes. A further enhancement of 1.5 times was obtained. With our approach, a total enhancement of 2.4 times in OLED efficiency was achieved.