IBS CINAP Seminar

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High Performance Perovskite Photovoltaic and Photodetector Devices

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Abstract: Organic–inorganic halide perovskites with the ABX3 composition is a new class of semiconducting materials due to its desirable properties such as efficient light absorption, facile solution process and high charge carrier mobility. Therefore, perovskite material has been utilized in wide applications (e.g., photovoltaic solar cells, photodetectors and light emitting diodes). [1-3] Here, we employed perovskite materials to obtain high performance of optoelectronic devices. We designed hole transport materials (HTMs) by conjugated polymer, TFB (Poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(4,4′-(N-(4-sec-butylphenyl)diphenylamine)]), and a non-hygroscopic p-type dopant F4-TCNQ (2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane) to improve the efficiency and stability of perovskite solar cells. [4] The fast hole mobility in suitable energy band alignment with the perovskite active layer increased the short-circuit current, which resulted in an enhanced power conversion efficiency of 17.46%. Also, the hydrophobic nature of F4-TCNQ-doped TFB was shown to remarkably enhance the long-term stability, maintaining ca. 80% of its initial efficiency after 10 days. Our simple, yet novel strategy paves the way for demonstrating a promising route for a wide range of highly efficient photovoltaic applications. We also investigate stoichiometry controlled perovskite solar cell under indoor light. [5] We have optimized the effective photoactive layer to form a uniform photoactive film by doping bromine into the conventional methylammonium lead iodide (MAPbI3) perovskite. As a result, under 1000 lx LED indoor lighting exhibited an averaged power conversion efficiency of 33.2 ± 1.3%, which is superior by 16% to that of a control device (28.7 ± 1.1%). To the best of our knowledge, this unprecedented achievement reaches to the highest uncertified records to date. These results suggest that perovskite photovoltaic cells can be potentially used under indoor lighting conditions as a power source for practical IoT, wireless sensors, and building-integrated photovoltaics. Also we introduce the perovskite material to the photodetector. We employed the Au NRs using localized surface plasmon resonance effects to the perovskite photodetector to enhance photocurrent. However, potential application of these materials has been limited due to high dark currents and low detectivity levels. Uniform Au nanorods and ~10 nm-thick polyethyleneimine ethoxylated (PEIE) interlayer were incorporated into vertical photoconductive photodetectors. The PEIE thin interfacial buffer layer was shown to strikingly suppress the dark current in these devices. The established synergetic effect between both components resulted in a significant enhancement of the device performance.

[1] Eui Hyuk Jung et al., Nature, 2019, 567,511–515
[2] H. Wang and D. H. Kim, Chem. Soc. Rev., 2017, 46, 5204–5236
[3] L. N. Quan et al., Nano Lett., 2017, 17, 3701–3709
[4] Hannah Kwon et al., Nanoscale 2019 11, 19586-19594.
[5] Hannah Kwon et al., Nano Energy 2019, submitted

Brief Bio:

Dr. Hannah Kwon obtained B.E (2014) in the Department of Chemistry at Hannam University and Ph. D (2020) in the Department of Chemistry and Nano Science at Ewha Womans University under supervision of Prof. Dong Ha Kim. She had worked in Photoelectronic Hybrid Research Center at Korea Institute Science and Technology (KIST) as a student researcher in Sep. 2015 to Oct. 2016. Her research interests are materials for energy and environmental applications, design and development of nanostructured materials for optoelectronic device applications. Her doctoral thesis title is “Nanostructured Materials for High Performance Perovskite Photovoltaic and Photodetector Devices”.

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