A New Strategy for Monitoring the Charge Transfers from Perovskite Thin Films to Electron Transport Layers using Heterodyne Transient Grating Technique

(*Department of Chemistry, Chungbuk National University*) Young Hyun Kim, ○Woon Yong Sohn

Keywords: Perovskite solar cells; Electron transport layer; Charge carrier dynamics; Heterodyne transient grating; Time-resolved spectroscopy

The organic-inorganic lead halide perovskites exhibit the wide-range light absorption including visible light region, giving rise to the high-power conversion efficiency (PCE). In order to figure out the main factors influencing the efficiencies of the perovskite solar cells (PSCs), photo-excited charge carrier dynamics, taking place in the PSCs devices, have been investigated using various spectroscopic techniques, which could be the aid for the further development of the highly efficient PSCs. Particularly, the charge transfer kinetics between the perovskite material and electron transport layer (ETL) has been intensively studied by ultrafast time-resolved spectroscopic methods.[1, 2]

The ETL usually included in the PSC device plays very crucial roles in the extraction of the photo-excited electrons from the perovskite material and the retardation of the back electron-hole recombination with an aid of the spatially separated charge carriers between two layers, resulting from the construction of the type-II heterojunction. Generally, metal oxide materials such as TiO_2, ZnO and so on have been utilized for this purpose. Because it has been regarded as one of the most important processes in improving the efficiency of PSC device, it is very important to monitor the electron transfer between two layers for better understanding of its mechanism. However, because the charge transfer kinetics has been indirectly investigated in the perovskite layer so far, the understanding of the charge injection is still inadequate. In addition, due to the drawbacks of the femtosecond time-resolved spectroscopic techniques such as the complexities of the setup and the necessities of the expensive equipment, the number of the researchers who work on this topic is still not large.

Therefore, in this study, we fabricated $MAPbI_3$ and $MAPbI_3$/ZnO films and investigated the electron transfer between $MAPBI_3$ and ZnO using heterodyne transient grating (HD-TG) method, which is one of the time-resolved spectroscopic methods utilized for the investigation of the photo-excited charge carrier dynamics at the solid/liquid interface, by monitoring the surface trapped charge carriers in the ZnO layer, originating from $MAPBI_3$. In addition, we prepared $MAPbI_3$/PEAI/ZnO film in which PEAI acted as a passivation layer and measured HD-TG responses to reveal the acceleration of the charge transfer.

1) Wang, L.; McCleese, C.; Kovalsky, A.; Zhao, Y.; Burda, C. *J. Am. Chem. Soc.* **2014**, *136* (35) 12205–12208. 2) Li, C.; Wang, A.; Deng, X.; Wang, S.; Yuan, Y.; Ding, L.; Hao, F. *ACS Photonics* **2020**, *7* (8), 1893–1907