Efficient and highly air stable organic and perovskite solar cells with graphene and related 2D materials as the charge transport layers

Prof. Emmanuel Kymakis

Center of Advanced Materials & Photonics and Department of Electrical Engineering, TEI of Crete, Estavromenos, Heraklion, Crete, Greece

kymakis@staff.teicrete.gr

In this talk, I will review our last years progress on the utilization of solution processable graphene derivatives and related 2D crystals (GRM) in organic (OSCs) and perovskite solar cells (PSCs) as universal charge transport layers [1]. Due to their solution processability, WF tunability and mechanical stability, they can directly be incorporated in OCs and PSCs fabrication lines, replacing traditional vacuum deposited materials. In this context, we have recently demonstrated the simultaneous utilization of WF tuned functionalized GO derivatives as both the hole and electron transport layers in OSCs. The WF tuning of GO took place by either photochlorination for WF increase, or lithium neutralization for WF decrease [2]. In this way, the WF of the GO-Cl layer was perfectly matched with the HOMO of the polymer donors, enabling excellent hole transport, while the WF of the GO-Li was perfectly matched with the fullerene LUMO, enabling excellent electron transport. In the same way, GO-Li was used as ETL in PSCs, resulting in enhanced performance and stability [3]. Furthermore, by inserting reduced GO within the mesoporous TiO_2 matrix, highly efficient solar cells with power conversion efficiencies (PCEs) to 19.54 % were realized, mainly attributed to enhanced electrons funneling through the ETM layer [4]. Similarly, rGO was introduced in the PCBM ETL of planar inverted PSCs, leading to a hysteresis free PCE of 14.5% and stabilization of the perovskite crystal structure after prolonged illumination under ambient conditions [5]. Finally, single layer MoS_2 flakes were introduced as an additional interlayer between the hole transport and the perovskite layer, leading to a PCE enhancement of 7%, but most importantly to a tremendous stability enhancement. The devices with the MoS_2 flakes, maintained 90% of their initial PCE after exposing them for 2000 hours at short–circuit condition to full solar irradiation, while the reference devices died after just 750min. So, it can be concluded that the utilization of WF tuned GRMs as universal buffer layers in OSCs and PeSCs for charge transport provide a clear advantage over traditional SOA materials in both performance and stability.

References

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