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**Reduced Graphene Oxide-Assisted Crystallization of Perovskite via Solution-Process for Efficient and Stable Planar Solar Cells with Module-Scales**

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**Abstract**

Organometal trihalide perovskite solar cells (PeSCs) have recently opened a new era for photovoltaics power sources via the tremendous increase in power conversion efficiency (PCE) in the past five years. The next achievement will occur when scalable and processable PeSCs are realized because of a fundamental understanding of the interfacial characteristics and perovskite crystallization in PeSCs. Here, we report solution-processed planar PeSCs with well-tailored functional graphene, successfully demonstrating excellent module PCEs of 10.0% and 8.1% for rigid and flexible substrates, respectively, with active-area of 10 cm<sup>2</sup>. Systematic investigations reveal that molecular-doped reduced graphene oxide with fluorine atoms (MFGO) exhibits fast charge-extraction ability and well-aligned energetic interface characteristic due to its intrinsic structure, and MFGO promotes perovskite crystallization and orientation with minimized stoichiometric defects. The solution-processable graphene can function not only as an efficient and stable interlayer but also as an inducer of the crystallization of the perovskite layer in simplified device architectures without a complex process.

Keywords: perovskite solar cells, graphenes, interfacial layers, solar cell modules, flexible electronics

**1. Introduction**

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