Radiation Hard And Highly Efficient Homojunction Perovskite Solar Cell for Space Missions

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Abstract:
The future of space missions highly relies on photovoltaic (PV) technologies in powering satellites and space vehicles. In the last decade, organic-inorganic metal halide-based perovskite solar cells (PSCs) have been an excellent light harvester for PV technologies due to high absorption coefficient, high carrier mobility, low cost, ease of fabrication etc. Compact cells provide excellent specific power of 23 W/g, ensuring lightweight and low-cost of launching [1]. Moreover, the feasibility of growing PSCs over flexible substrates, less greenhouse gas emission, and better radiation hardness as compared to space-deployed silicon/group III-V solar cells, suggested by initial reports, makes it an excellent choice for space missions [2]. The further boost of specific power through enhancing power conversion efficiency (PCE), together with radiation hardness estimation, has gained significant attention in recent times. Different approaches have been utilized to boost the PCE, including defect-passivation, additive engineering, 2D materials, and energy band alignment, but still, it falls below the Shockley-Queisser (SQ) limit. A new generation of PSCs known as homojunction PSCs has shown great improvement in PCE due to the reduction of carrier recombination inside the active layer, thanks to in-built electric field at p-n homojunction. Benefitted from the unique self-doping property of perovskite, the first experimental report on homojunction PSC demonstrated PCE of 20.8% [3]. Later, in the presence of all losses and experimentally reported parameters, we numerically reported a PCE of 22.7 % with graphene in the electron transport layer [4]. Our further study pointed out that homojunction PSC offers two extra degrees of freedom in terms of doping profile and relative thickness of the doped sections for band alignment [5]. Utilizing this, together with optimized band offsets with the charge transport layers the maximum PCE of the homojunction PSC is estimated to be 25.43%. Here we investigated the radiation hardness of the homojunction PSC for near-earth missions, where charged particles especially protons, are the dominant source. The numerical analysis is carried out with different values of fluence (F) for proton irradiation energy of 0.05 MeV, since in near-earth orbits particle fluence around this energy is 10 times higher than high-energy protons [6]. The numerical investigation predicted that the PCE starts reducing after F = 10^{12} cm^{-2} and holds 92% of its PCE even after F = 10^{14} cm^{-2}, reflecting excellent radiation hardness considering the usual particle fluence in near-earth orbits [6].

Conflicts of Interest: We don't have any conflict of interest.

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