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Silicon photovoltaics, a low cost technology to power HAPS and Satellites constellations

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Abstract

Currently, solar generators are made of several photovoltaics arrays (PVA) constituted of III-V triple-junction cells bonded to a very light structure as honeycomb. This architecture benefits from a strong space heritage and excellent and long lasting performances in space environment. However, this technology is relatively expensive because built on ~ 100 €/W cells, which represents ~50 % of the solar generators cost. In the context of increased space PV power needs and new HAPS (High-Altitude Platform Station) market and cost reduction pressure of the Low Earth Orbit (LEO) constellations, game changing solutions are needed. A promising way, at short/midterm perspectives, for offering cost reduction and suppression of critical raw materials such as Ge, is to leverage the well-established and industrial mature silicon terrestrial photovoltaic solutions, while taking into account the specificity of space constraints [1]. For 2018, the STRATOBUS balloon of TAS has integrated Silicon solar cells [2]. This paradigm shift requires solar generators system level optimizations; the work presented here will focus on the PVA more specifically.

In terms of architecture, the terrestrial PVA uses a single frontsheet covering several strings of cells embedded in adhesive films and assembled in one single step using lamination. This approach is industrially mature, suppresses the risk of electrostatic discharges (triple points) and offers compatibility with several type of materials and solar cells technologies: qualified III-V [3], Commercial-Off-The-Shelf (COTS) Silicon, and Perovskites. In addition, this approach offers room for increased specific power (W/m2), as illustrated in terrestrial PV where efficiency cells to module ratio beyond 90 % are reported. In terms of materials, the introduction of COTS components is highly expected provided that performance compromises can be found. In that sense, radiation and thermal cycling are key ageing tests in the selection process. Experimental results of electrons COTS Si cells irradiations (1MeV) and thermal cycles on laminated Si PVA coupons (-140/+140 °C) will be presented [4]. The experimental results of Si PVA thermal cycling will be analyzed with insights from thermo-mechanical simulations of the cells interconnects behavior. Careful design and selection of COTS Si PVA components allows to reach EOL AM0 efficiencies for LEO in the 10-14% range, with a stable performance demonstrated over ~ 2000 cycles so far; improvement paths will be discussed.

References:

[1] Mihailetchi V.D. et al., Suitable Silicon Solar Cell Technologies for Use in Space Applications, 2021 EUPVSEC
[2] Gaume J. et al, Development of lightweight and flexible c-Si photovoltaic modules for the STRATOBUS TM, 2018 IEEE 7th World Conference on Photovoltaic Energy Conversion, 2018, WCPEC 7th
[3] Vergnet D. et al. Advanced Lightweight Flexible Array with Mechanical Architecture. 2019 IEEE 46th Photovoltaic Specialists Conference (PVSC)
[4] Cariou R. et al., How Silicon Technology May Modify the Current Solar Array Game?, 2022 Space Power Workshop