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AUTONOMOUS IN-ORBIT PRODUCTION OF PEROVSKITE SOLAR ARRAYS FROM LUNAR REGOLITH: A MODULAR APPROACH TO SPACE ENERGY SUSTAINABILITY

Abstract

The impending surge in human activities in Earth's orbit and cis-lunar space highlights a growing demand for in-space energy supply. In the current paradigm, this would mean launching significant amounts of solar arrays into space from Earth. However, more than 90% of Perovskite solar array constituents can be found in lunar regolith (Aluminium, Silicon, Oxygen...). Moreover, advances in artificial intelligence-based production could soon facilitate autonomous in-orbit manufacturing. Therefore, a more sustainable and economically advantageous alternative could be given by in-space manufacturing of solar panels.

In a previous paper, the space station LUMO (Lunar Manufacturing Outpost) has been proposed to correspond to this exigence. However, the development and construction of a holistic space station for in-orbit manufacturing would imply a significant need for financial investment and payload mass into orbit. Thus, this paper takes a distinctive approach in proposing the development of a single module for In-orbit Servicing Manufacturing Assembly (ISMA) of perovskite solar arrays, intended to dock with a future commercial space station. Increased feasibility is achieved by circumventing the need for the construction of a complete space station and the reduced annual supply requirement of 164 kg instead of 3000 kg lunar materials, which is more in line with mid-term lunar extraction capabilities. System architecture, implementation, and sustainability aspects of the ISMA module are discussed in this paper.

Monolithic Perovskite/Silicon Tandem Solar Cells (PSCs) are chosen as end products for their manufacturability, superior efficiency potential (Shockley-Queisser Limit), and radiation tolerance compared to traditional silicon solar cells. The system architecture is based around a glass furnace with a robotic mechanism to produce foil glass, a crystal silicon vaporizer for silicon crystal manufacturing, and an aluminum printing stage for all the aluminum parts.

The proposed module could serve as a technology demonstrator to initiate a new paradigm of sustainable in-space manufacturing from lunar resources.