MELCO's solar array panel/wing development

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1. Introduction

SAP(Solar Array Panel) is a main electrical power source for space satellites and spacecrafts, and typically consists of strings of CICs (coverglass interconnected cells), laid down onto a substrate with polyimide film on front side (Fig. 1). A unit of string is called CIC modules.

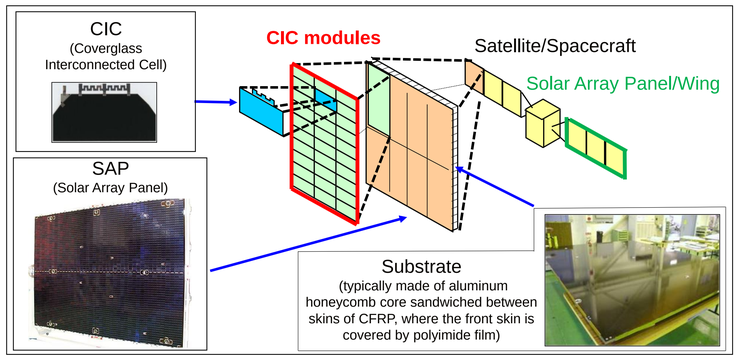

Fig. 1 Illustration of SAP and its Main Parts Terms

2. MELCO's SAP Heritage

Since 1976, MELCO has been designing and manufacturing rigid SAPs for various needs from domestic and overseas customers.

Table 1 MELCO's SAP in Orbit

Solar Cell Type	Orbit Type	Quantity of SAP in orbit	1st Flight year
Single Junction	GEO,LEO	650	1993
Dual Junctioun	GEO,Lunar	30	2002
Triple Junction (4inch Wafer)	GEO,LEO, Lunar	1120	2006
Triple Junction (6inch Wafer)	GEO	130	2020
Quad Junction (6inch Wafer)	GEO	12 SAPs are expected to be launched in 2026.	

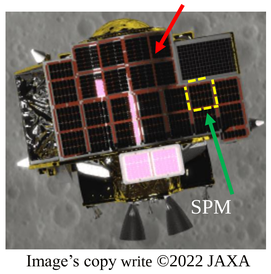

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Fig. 2 First Spacecraft built by MELCO with SPM[1]

SAP's built by MELCO and flown to orbits are listed in Table 1. MELCO has been building rigid SAP equipped with state-of-the-art space solar cells. Recently, MELCO's SAP with quad-junction GaAs solar cells from 6-inch wafers was manufactured and is planned to be launched in 2026.

Furthermore, for lunar mission requiring higher power per unit mass, MELCO developed SAPs with SPM (solar power modules) manufactured by domestic solar cell supplier. These SPMs adopted IMM-TJ (Inverted Metamorphic Triple-Junction) solar cells. This enabled not only high efficiency but also light weight and the flexibility required for integration into satellites composed of curved surfaces. The solar array panels were developed and successfully completed the lunar mission in 2024 (Fig. 2).

3. Expansion towards the world of low price and mass production

Based on MELCO's abundant SAP heritage through design to on-orbit evaluation, we are responding to the recent market demand, including satellite constellations, for low-cost, high-quality products in large quantities with a short lead time.

We achieve this goal through the following developments:

-New scalable solar array wing with low cost, low stowed volume, mass productivity, and easy satellite integration

-Utilizing terrestrial technology for solar cells that combine low cost and high efficiency with mass production capability and excellent radiation resistance

-Utilizing terrestrial technology for cover glass that ensures low cost and mass production capability

-Process development and new equipment installation to combine mass productivity, high quality, and low cost

3-1. MELCO's new solar array wing: FlatPack

FlatPack is MELCO's new scalable solar array wing characterized by four points: low cost, low stowed volume, mass productivity, and easy satellite integration.

FlatPack is oriented to modularize components (e.g. solar array units, mechanical units and so on), with each module adopting a simple, common design. This approach allows for a scalable configuration by flexibly selecting the quantity of modules according to the power requirement. The FlatPack wing can use any type of solar cell, and we are currently manufacturing BBMs (breadboard models) equipped with CIGS (Copper Indium Gallium Selenide), triple- and quad-junction GaAs, and Silicon solar cells.

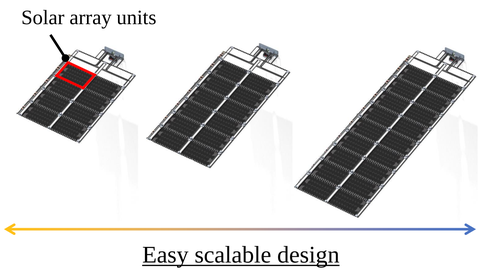

Fig. 3 Scalability of FlatPack

We conducted acoustic and vibration tests on the BBM models and confirmed that there was no critical issue with environmental resistance in all these tests. Furthermore, we prepared a coupon simulating the configuration of the solar array unit and conducted thermal cycle tests, ESD (electrostatic discharge) tests, atomic oxygen exposure tests, and thermal vacuum tests. We aim to conduct functional verification with a small-scale model by 2026 Q2 and complete qualification of the full-size model with 2.5kW power outputs per wing by 2027. Our goal is to finalize the qualification of scalable wings with power outputs from 100W to 10kW per wing by 2030.

3-2. New Solar Cells & Cover Glasses for Low-cost, Short Lead Time, High Volume

MELCO is collaborating with solar cell suppliers and cover glass suppliers for new solar cells and cover glasses that can be applied not only to existing rigid SAPs but also to FlatPack and SPM.

We are currently collaborating with solar cell and cover glass suppliers to enable MELCO to produce low-cost, highly mass-producible solar arrays. The current mainstream GaAs-based multi-junction solar cells and cover glasses face challenges of price increase and longer lead times due to the rise of satellite constellation programs. Therefore, we aim to complete the development and qualification of solar arrays with CIGS and new design cover glasses by 2027, and CIGS/perovskite tandem solar cells by 2030.

Cover glasses

-Achieving cost reduction and mass production capability by utilizing the existing composition and production lines for terrestrial use

Solar cells

-Achieving cost reduction and mass production capability by utilizing terrestrial technology

-Improving the BOL performance of CIGS solar cells, maintaining this BOL performance even under on-orbit radiation environments through annealing, and achieving higher EOL performance at a lower cost compared to Si solar cells.

-Enhancing efficiency through tandem technology of CIGS and perovskite solar cells to achieve efficiency equivalent to multi-junction cells while dramatically reducing costs.

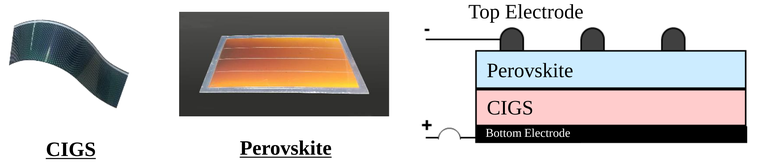

Fig. 4 Schematic diagram of tandem configuration

3-3. Mass Production Capabilities

MELCO's approach to mass production is to utilize automated manufacturing machines for both rigid SAP and FlatPack.

MELCO has extended ratio of process through years. All the welding process had been automized. One of two major adhesive bonding process had been automized. The machine below (Fig. 5) is cover glass bonding machine.

It bonds cover glass onto solar cell in vacuum chamber automatically.

Another automated process is the CIC bonding to the substrate/sheet. In this process, adhesive application is performed automatically by the machine. To further enhance productivity, we have introduced the new automated laydown machine (Fig.6). This machine features not only the adhesive application function of the previous model but also accurate CIC module locating and applying pressure to the bonding surface. Furthermore, this machine has the capability to heat the CIC during bonding, dramatically shortening the current tact time. This allows MELCO to achieve higher throughput than ever before for mass production. 2000 cycles of GEO TC has been done to verify the bonding process done by the machine. All the machines in MELCO for automation is applicable to rigid SAP, FlatPack and SPM.

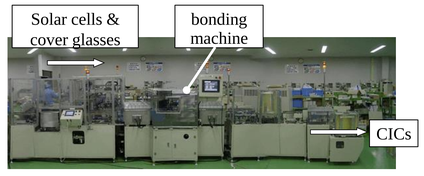

Fig. 5 Automated cover glass bonding machine

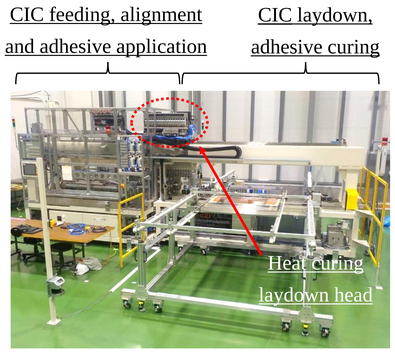

Fig. 6 New automated laydown machine for mass production

4. Reference and Acknowledgements

[1] Image cited from https://www.isas.jaxa.jp/home/slim/SLIM/index.html

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