Introduction of MELCO's solar array panel/wing development plan

Hirokazu Aoki(1), Natsuki Asano(1), Kei Akazawa(1), Shinobu Miyagi (1), Yu Kamikawa(1), Fuminori Yamazaki(1), Mitsuru Okubo(1) | Mitsubishi Electric Corporation (MELCO), Japan

TH8-25-0090

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.

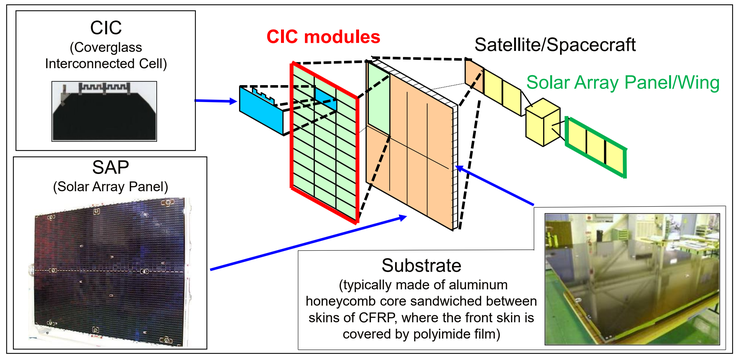

Fig. 1 Illustration of SAP and its Main Parts Terms

2. MELCO's SAP Heritage and Key Challenges

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 to be expected	

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

MELCO's solar array panels (SAPs) have extensive flight heritage across multiple orbits (Table 1). Historically, MELCO has advanced SAP designs in step with developments in solar cell technology. For lunar mission requiring higher power per unit mass, MELCO developed SAPs with SPM (solar power modules) manufactured by domestic solar cell supplier (Fig.2).

The current market demands large volumes of low-cost, high-quality solar arrays delivered on short lead times. However, solar cells and cover glass—the critical components for cost reduction and scalable manufacturing—are experiencing price escalation and prolonged lead times driven by the proliferation of satellite constellations. This trend represents a major challenge to satisfying market requirements.

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

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

MELCO will achieve these goals through developments by establishing autonomous domestic supply chain for those major parts, namely;

Development of Domestic Solar Cells, Cover Glass, and Solar Arrays by the support of SSF (Space Strategic Funds)

- ✓ Co-development with a terrestrial solar cell manufacturer improve low cost and high efficiency with mass production capability and excellent radiation resistance
- ✓ Co-development with terrestrial cover glass manufacturers ensures low cost and mass production capability.

3-1. Development/verification of parts/components for establishing satellites supply chain under SSF

SSF was founded at JAXA(Japan Aerospace Exploration Agency) by request of Cabinet Office & Three ministries of Japan to achieve three goals (Double the size of Japanese domestic space market, Contribute to solving global and social issues by utilizing space, and Pioneering frontier.)

Fig. 3 Scheme of SSF[2]

MELCO was awarded a part of Development/verification of parts/components for establishing satellites supply chain by proposing qualification and mass production of domestic solar cell arrays achieving both low cost and high performance. MELCO is planning to develop solar array with domestic solar cells and coverglass, which have been cost and schedule drivers for the conventional solar array panels and wings.

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.

Cover glasses

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

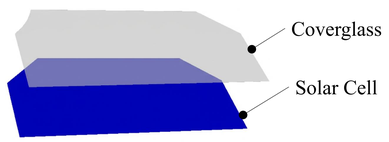

Fig. 4 Schematic of solar cell and coverglass

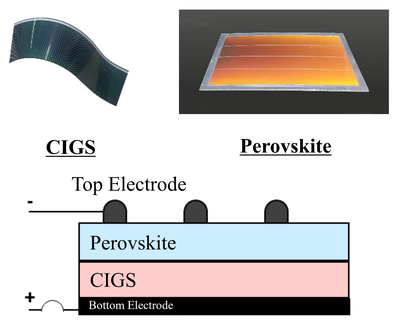

Fig. 5 Schematic of tandem cells

3-2. Mass Production Capabilities

MELCO's approach to mass production is to utilize automated manufacturing machines for new technologies.

MELCO has extended rationalization of its solar array panel processes over the years. All the welding process had been automized. One of two major adhesive bonding processes had been fully automized. The machine below (Fig.6) is coverglass bonding machine. It bonds coverglass onto solar cell in vacuum chamber automatically. The machine is planned to be used for those new coverglass and solar cell in mentioned in Sec. 3-1.

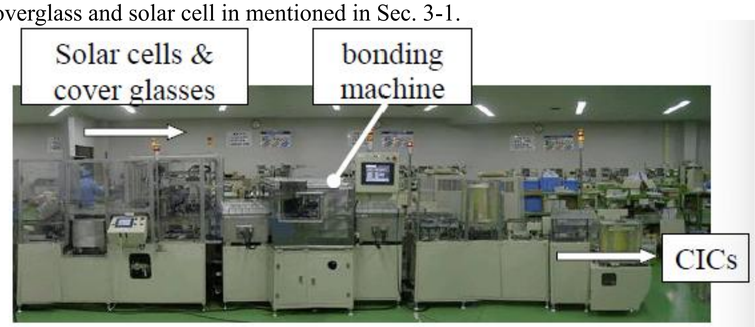

Fig. 6 Automated coverglass bonding machine

3-3. MELCO's new solar array wing : Flat Pack

MELCO's new solar array wing characterized by following points:

- ✓ ***Low cost (60% reduction!* **)***
- ✓ ***Low stowed volume (70% reduction! **)***
- ✓ ***Mass productivity and Short lead time (50% reduction!**)***
- ✓ ***Easy scalable design***
- ✓ ***Easy Installation and removal on/from satellites***

* Expect solar cell
**vs. conventional rigid solar array wing

- Designed for mass production and lead-time reduction; when the previously mentioned technologies and conventional automated manufacturing processes are applied, synergy delivers remarkable solutions.
- Easy scalable design with modular architecture. A common platform supports any solar cell, enabling rapid, right-sized solutions to power requirements.

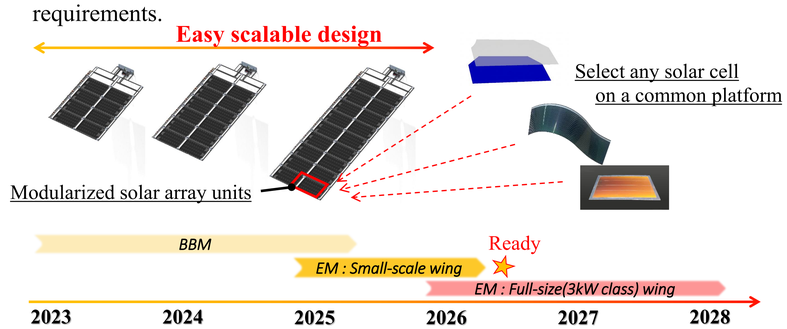

Fig. 7 Schematic and Development Schedule of FlatPack

4. Reference and Acknowledgements

[1] Japan's SLIM moon lander imaged by small rover LEV-2. Credit: JAXA/Takara Tomy/Sony Group Corporation/Doshisha University

[2] https://fund.jaxa.jp/content/uploads/Overview_of_The_SpaceStrategy_Fund.pdf

This development was partially conducted with the support of the Strategic Promotion Program for the Utilization of Space Technology Research and Development (STARDUST) and the Japan Aerospace Exploration Agency (JAXA) Space Strategy Fund "Development of Domestic Solar Cells, Cover Glass, and Solar Arrays" (JPJXSSF24KS210087/JPJXSSF24KS21008).We would like to express our deepest gratitude to all those involved.