Study of CIGS thin film solar cells for Space Applications

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Recently, space crafts are required low size, weight and cost. This requirement is available to apply thin film solar cells for solar paddle.

A copper indium gallium di-selenide (CIGS) thin-film solar cell is a promising candidate for future thin-film space solar cells since it has demonstrated conversion efficiencies exceeding 19%. This is significantly higher than other thin-film solar cells. Excellent radiation tolerance of CIGS thin-film cells has also been reported. CIGS thin-film solar cells exhibit superior performance compared to conventional Si and GaAs space solar cells. They are low-cost, lightweight, and flexibility since the cells can be formed on polyimide or metal sheet substrates. These solar cells can be developed on flexible solar panels. However, solar cells require coverglasses to protect the cell performance from low-energy protons in space.

This paper reported the radiation response of CIGS solar cells by ground tests and space demonstration.

Radiation damage studies for CIGS thin-film solar cells have revealed that electrical properties of the cells are not degraded by high-energy electron irradiation. The electrical performance of CIGS cells were monitored under electron irradiation. As a result, the performance degraded under irradiation. However, the performance was rapidly recovered at room temperature. This result indicates that CIGS cells have high radiation tolerance.

Cell performance is degraded by high-energy proton irradiation similar to other types of solar cells. Radiation damage to the cells due to proton irradiation gradually recovers when irradiated cells are kept at room temperature. The recovery rate depends on the temperature. Predictions of on-orbit performance of CIGS solar cells must consider their ability to recover well from radiation damage by thermal annealing.

We demonstrated CIGS solar cells on the MDS-1 satellite for 600 days since February 2002. The short-circuit current of the CIGS cells did not degrade, the open-circuit voltage of the cells degraded only about 1 %. In contrast, the performance of other solar cells on the satellite, including Si and GaAs space solar cells, deteriorated significantly. The superior recovery rate of CIGS solar cells from radiation damage by thermal annealing was established though ground tests. We predicted the degradation of the CIGS solar cells in space using the relative damage coefficient, the annealing rates of Voc and Isc for protons irradiating the cells, and the radiation response of the cells without thermal annealing. The results were in good agreement with observed data of the CIGS solar cells on the satellite. These results enabled us to predict that the electrical performance of the CIGS solar cells without a coverglass will not degrade in space.

We have been demonstrating CIGS solar module without coverglass on the Cubesat XI-V satellite for more than one year since October 2005. The satellite was 10cm$*$10cm$*$10cm cubic. There were six solar cell modules including the CIGS cell module. The generating currents of each module are monitored. As a result, the current of the CIGS module have no degradation since launch. The flight data confirmed that there was no degradation of the cell performance. This must prove for space using of CIGS solar cells.

From ground and space tests, it is revealed that CIGS solar cells have high radiation tolerance. In particularly, CIGS cells do not required coverglass for protecting low energy protons in space. Therefore, flexible solar paddles with thin-film solar cell modules are considered achievable. We have been studying the new type of solar paddles with thin-film solar cells.