

Flight Arcing Experiment on Solar Array for High Voltage Space Systems in Low Earth Orbit

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1. Background and Purpose

Next generation space systems (ex. high voltage space system) will appear in low earth orbit because the launch cost is relatively cheap. However, high voltage generation of around 200V causes arcing on the solar array due to interactions with the ambient plasma, and the arcing may reduce efficiency or cause damage. Technology demonstration in space is important because spacecraft are not easily repaired. To accelerate the development of future systems, the technology demonstration must be done quickly. My research is to generate high voltage, to perform arc tests on solar arrays, and to demonstrate arc mitigation technology. The goals are 「Investigation of arc phenomenon in actual orbit」 and 「Evaluation of arc mitigation technology for low earth orbit」 on spacecraft solar arrays.

2. PASCAL and Horyu-2

PASCAL is a high voltage experimental system on-board the International Space Station. Horyu-2 is a nano-satellite that generated 300V in-orbit for the first time in the world. We performed arc tests during high voltage generation by these two systems in space.

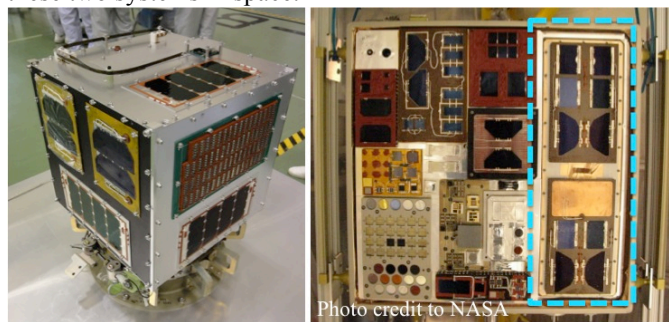


Figure1 Horyu-2 and PASCAL

3. Arc Mitigation Technology

ETFE film type arc mitigation solar array (FilmA) on-board Horyu-2 is a resistance plasma technology. FilmA can insulate ambient plasma from covering a solar array. FilmA successfully mitigated arcs during simulated 800V generation in a ground-based test. ETFE film's total light transmittance is 95%. The loss of solar cell efficiency due to the covered film is slight.

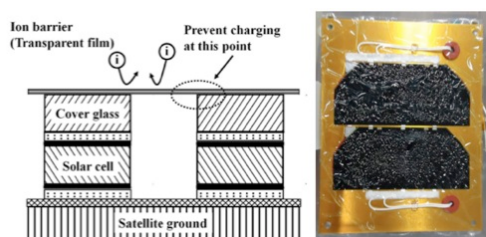


Figure 2 ETFE film type arc mitigation solar array

4. Arc test by Horyu-2 in space

Figure 3 shows the result of arc testing in space. Horyu-2 successfully generated 300V for 50 minutes for the first time in the world. Arcing occurred on FilmA. Arc locations were around the South Polar Region. We proposed the hypothesis that arcs were caused in part by high-energy electrons. From more analysis, "Satellite altitude data", "Plasma density data", and "Fault tree analysis" we thought that positive potential arcs occurred on FilmA. However, FilmA resisted arcing in plasma as no arcs occurred around the equator.

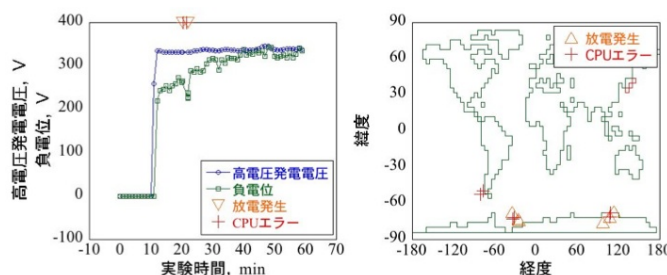


Figure 3 Test result and arc locations

5. Investigation test on FilmA

We investigated the cause of arcs occurring on FilmA by irradiating a sample with a simulated high-energy electron beam in a ground-based test. When surface potential was around 9kV, breakdown occurred on FilmA. From those results, we have considered taking arcing measurements on high-energy electrons for our next generation satellite named Horyu-3. We suggest "New fix method" and "Using the high dielectric voltage film" during the Horyu-3 mission.

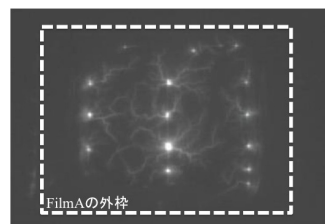


Figure4 Arc image

6. Summary and future task

We observed arcs in space and demonstrated an arc mitigation technology.

Arcing on FilmA was caused by high-energy electrons, however FilmA demonstrated resistance to arcing from the plasma effect.

The future tasks are to develop the feed backed high voltage experiment system from Horyu-2 and PASCAL experiment for Horyu-3 and calculate arc events.

Horyu-3 will be able to observe arc phenomenon in more detail and approach the realization of high voltage systems.

Research achievement (8)

Domestic conference

- Japan The Japan Society for Aeronautical and Space Sciences 2012
- Uchu kagaku rengou 2013
- Space environment symposium 2013

National conference

- Spacecraft Charging Technology Conference 2012
- 29th International Symposium on Space Technology and Science 2013
- 64th International Astronautical Congress 2013
- IAF-SUAC International Student Workshop 2013
- 51th AIAA AEROSPACE SCIENCES MEETING 2013

Others

- 2013 UNISECWORKSHOP First Prize

