Risk Analysis of Uber High Power System of Solar Power Satellite

Speaker: Daichi Ota

Adviser: Koji Tanaka

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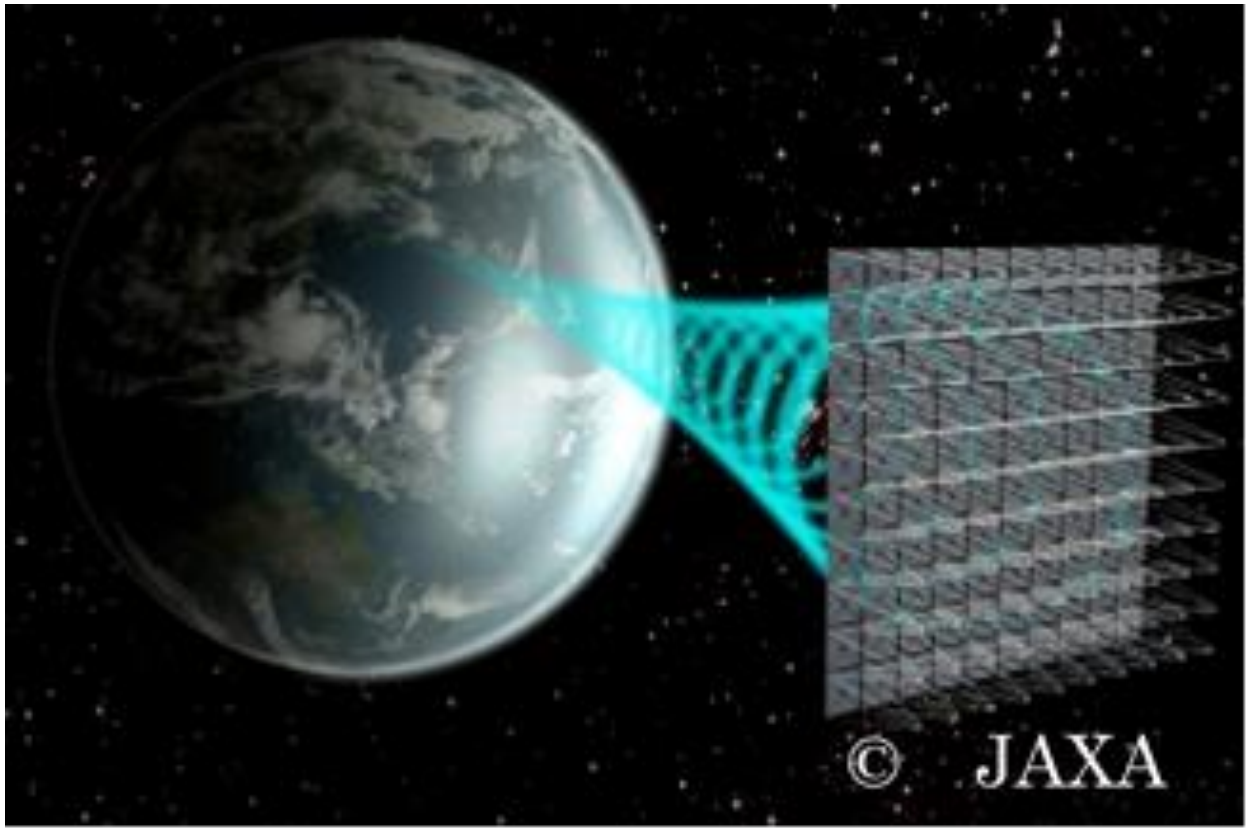
What is SPS?



Features

- Independent of weather
- Renewable source
- Unprecedented large scale
- Transmitting high power RF
- New energy for next generation

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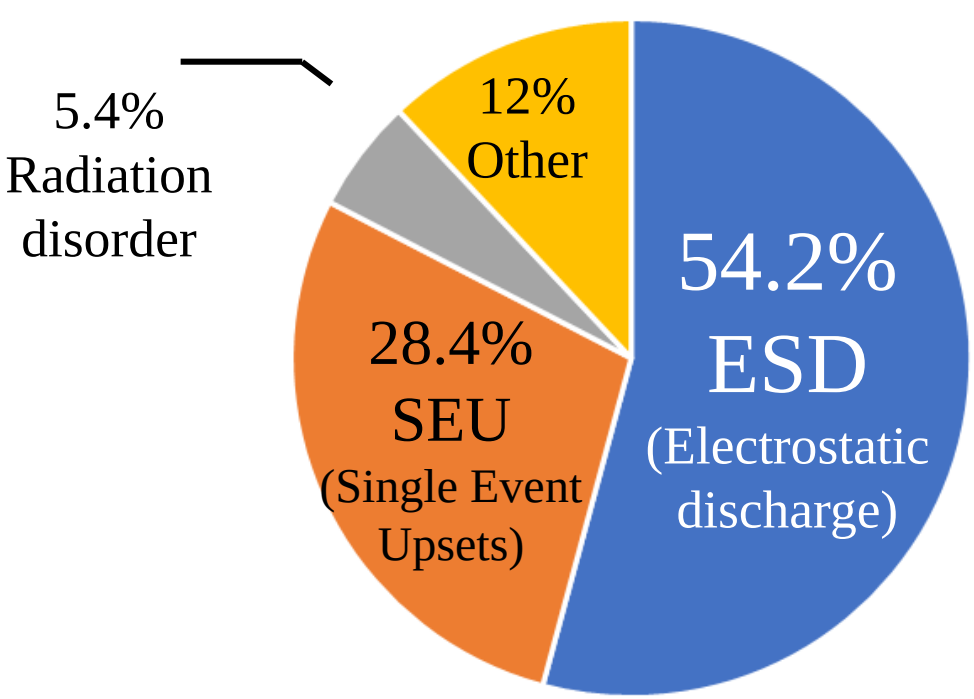
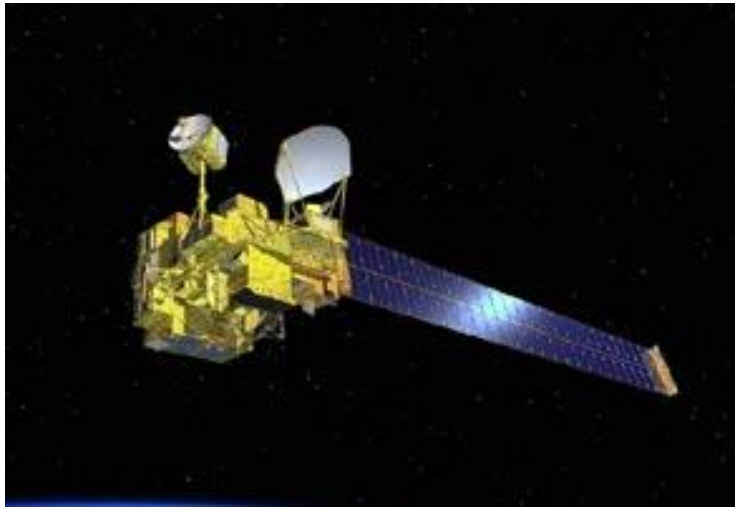
Discharge = The severest problem



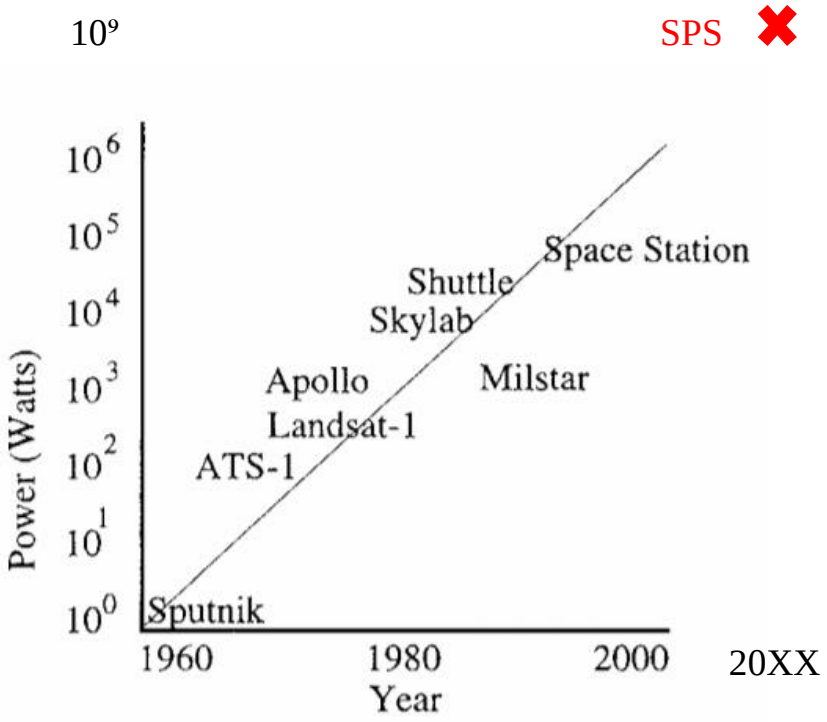
Proportion of satellite accidents caused by space environment
(H.C.Koons, etc, Proceedings of 6th Spacecraft Charging Technology Conference, 1998)



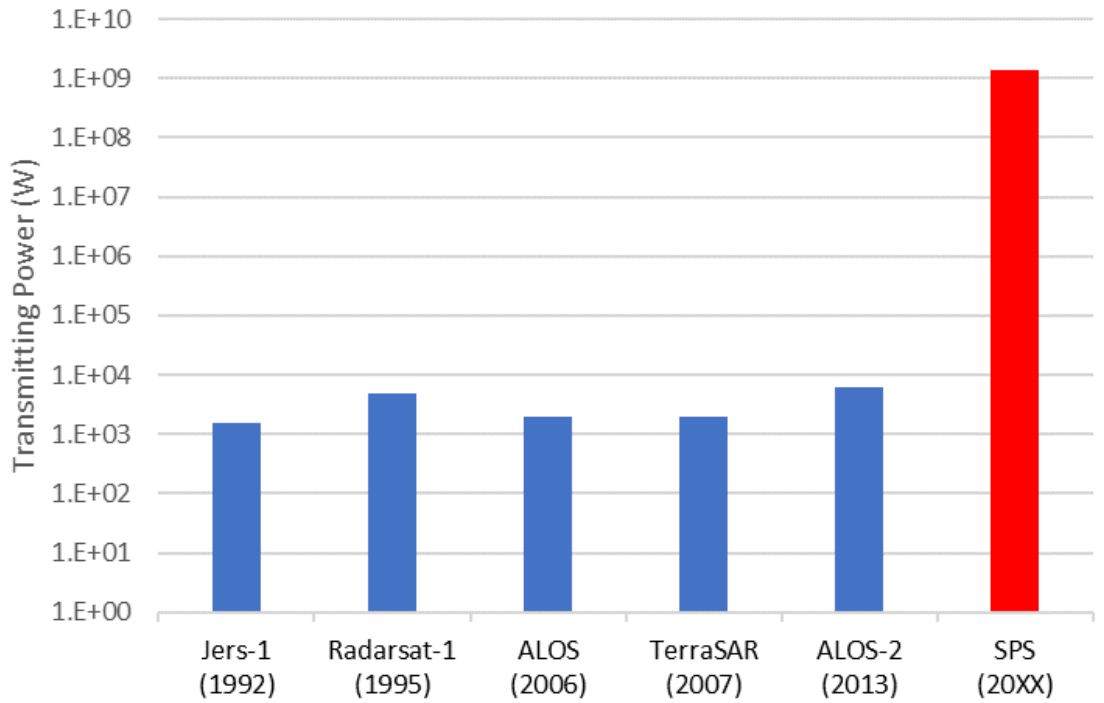
ADEOS-2

- Launched by JAXA, Japan
- Loss of mission by discharge in 2003

About risk



Spacecraft electrical power over past 40 years
(Hyder, J. Propulsion and Power, Vol.19, No.6, 2003)



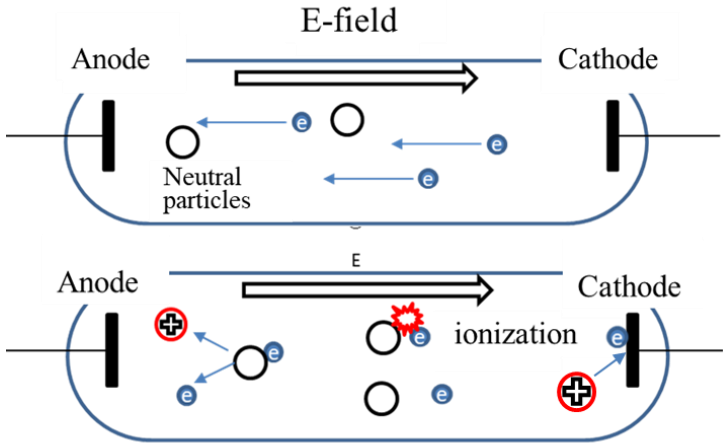
Radiated power from spacecraft

Required extremely high power for SPS

⇨ More likely to occur discharge in SPS

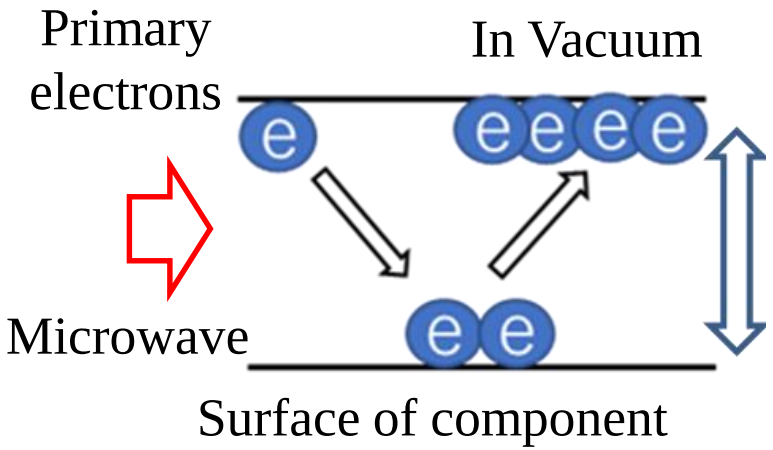
What is discharge?

Glow discharge



- Caused by ionization
- Dependence on pressure and distance between electrodes

Multipactor



- Main cause is SEE (Secondary Electron Emission)
- Highly affected by the surface condition

Mitigating discharge = Cutting off the source of electrons

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TOKYO UNIVERSITY OF SCIENCE

Object: To develop how to mitigate discharge in the RF devices

Experiment

Vacuum Chamber

TWTA

Inputting high power RF to the device in the vacuum

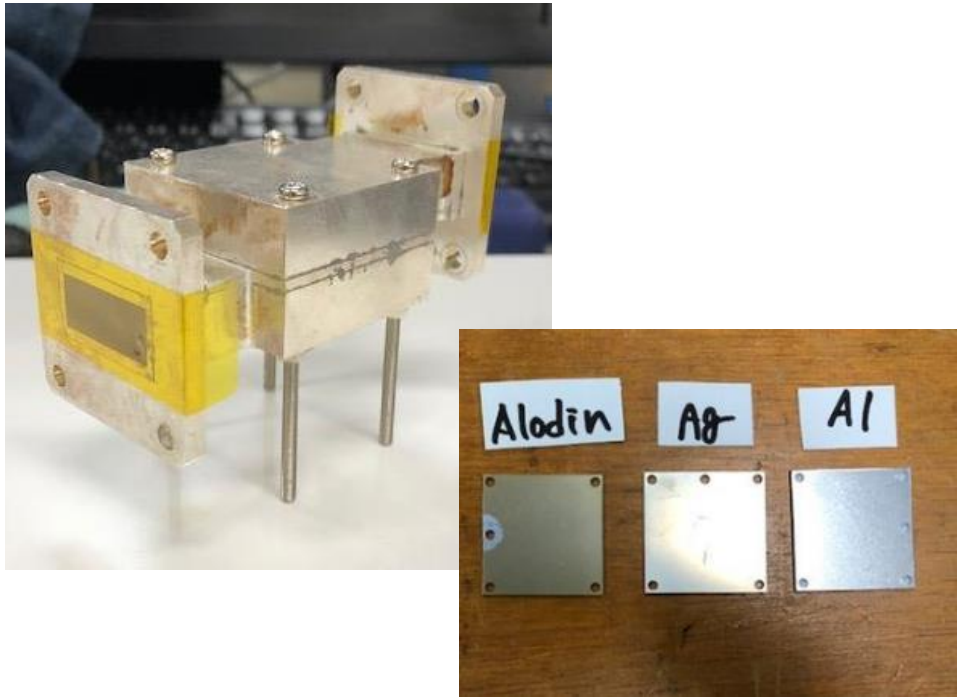
Simulation

- CST
  - ➢ 3D electromagnetic simulation
  - ➢ Exporting results to Spark3D
- Spark3D
  - ➢ Calculating RF breakdown level
  - ➢ Multipactor and gas discharge

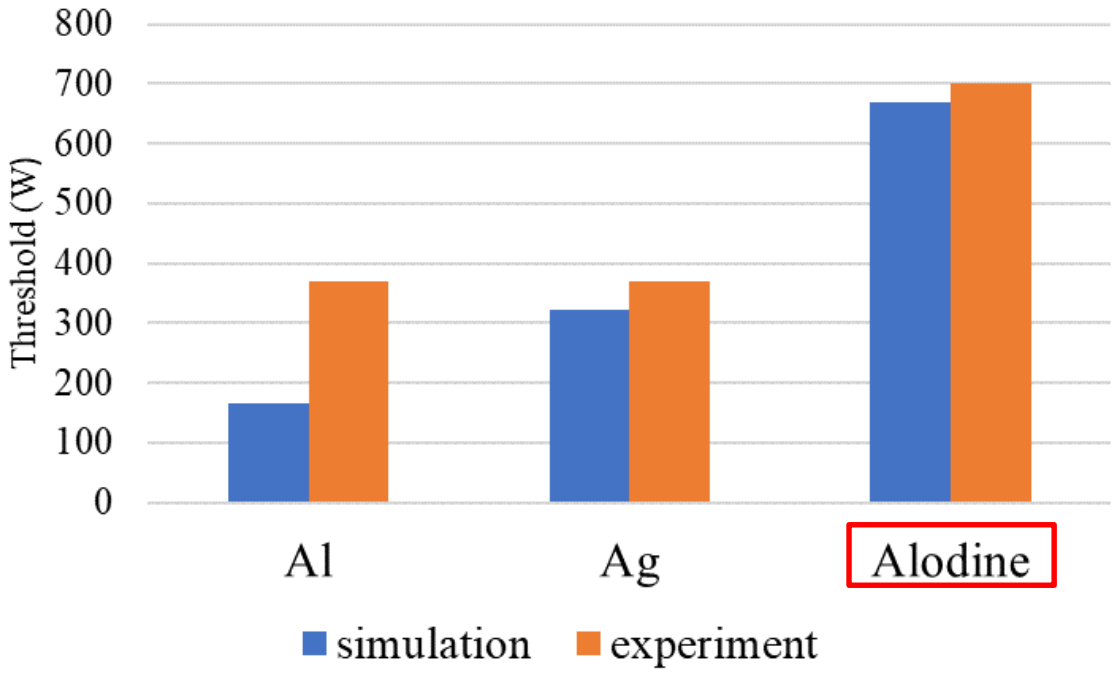
Comparing the numerical analysis and experiment resluts

Result

Target1: Coupled waveguide



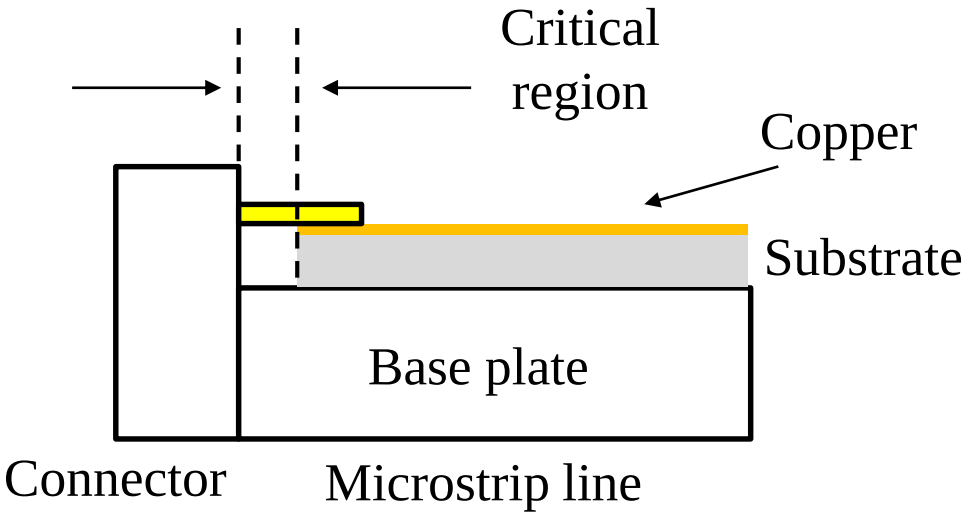
Sample coating inner surface

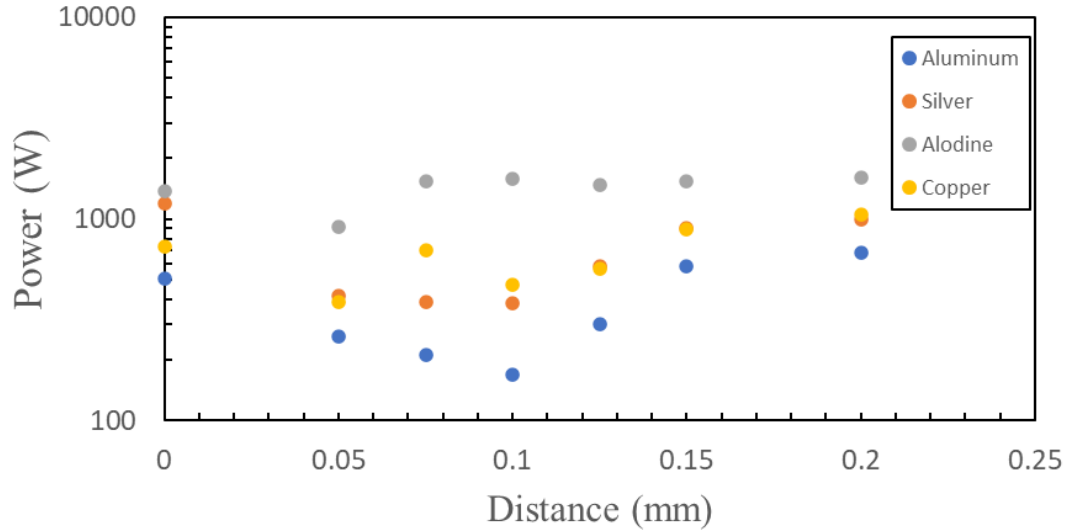


Threshold of multipactor in coupled waveguide

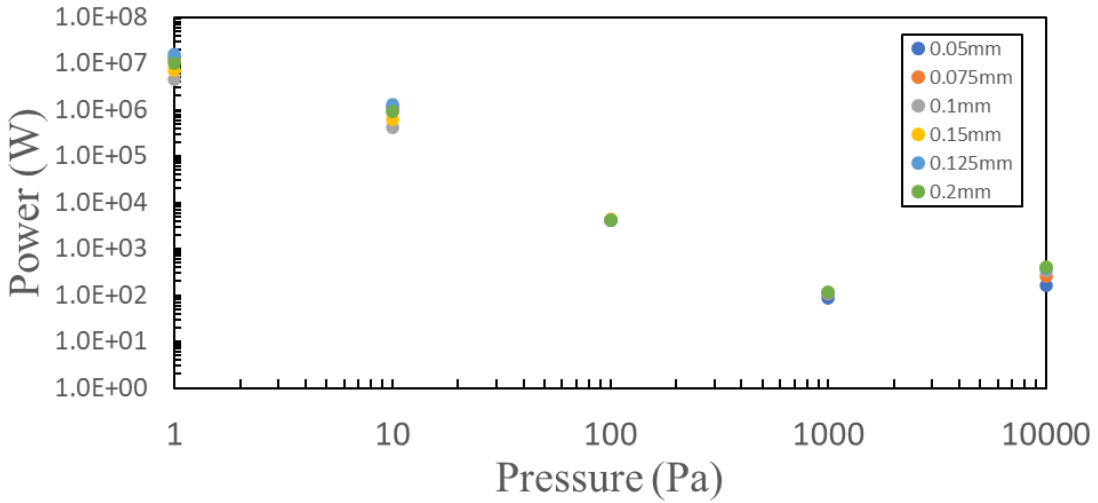
Result

Target2: Connector





Threshold of multipactor



Threshold of gas discharge

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However…

The space environment is more complex

- Plasma
- Debris
- Photoelectrons by sunlight
- High energy radiation etc…

Ground test is not sufficient

On-orbit experiment with the piggyback satellite

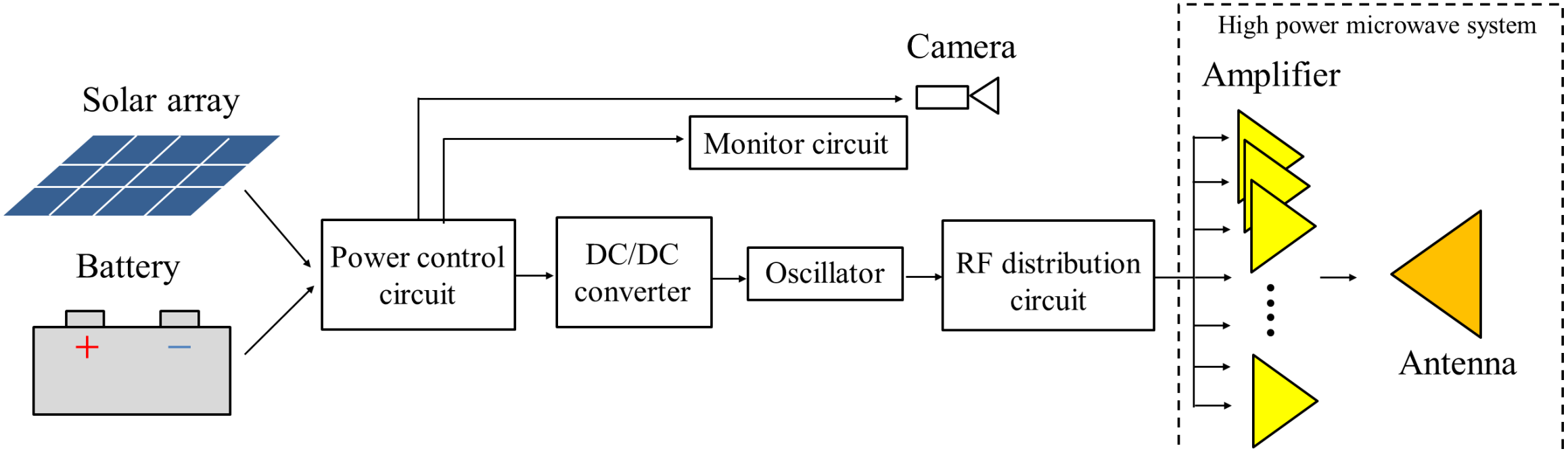
- Size: 50cm × 50cm × 50cm
- Weight: less than 50kg

Mission

① Measuring the discharge in the space environment
② Studying the method for mitigating discharge in the space

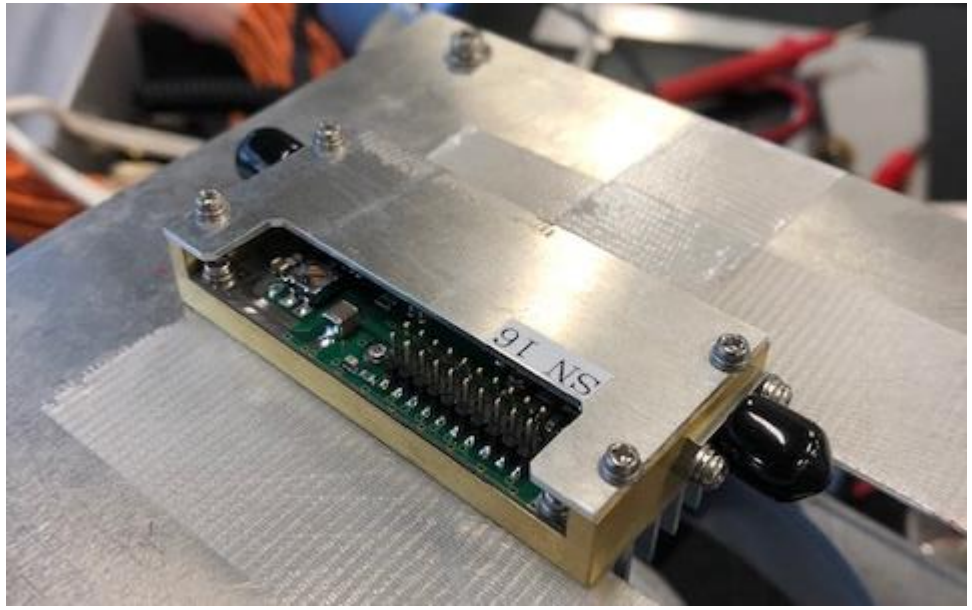
Challenges

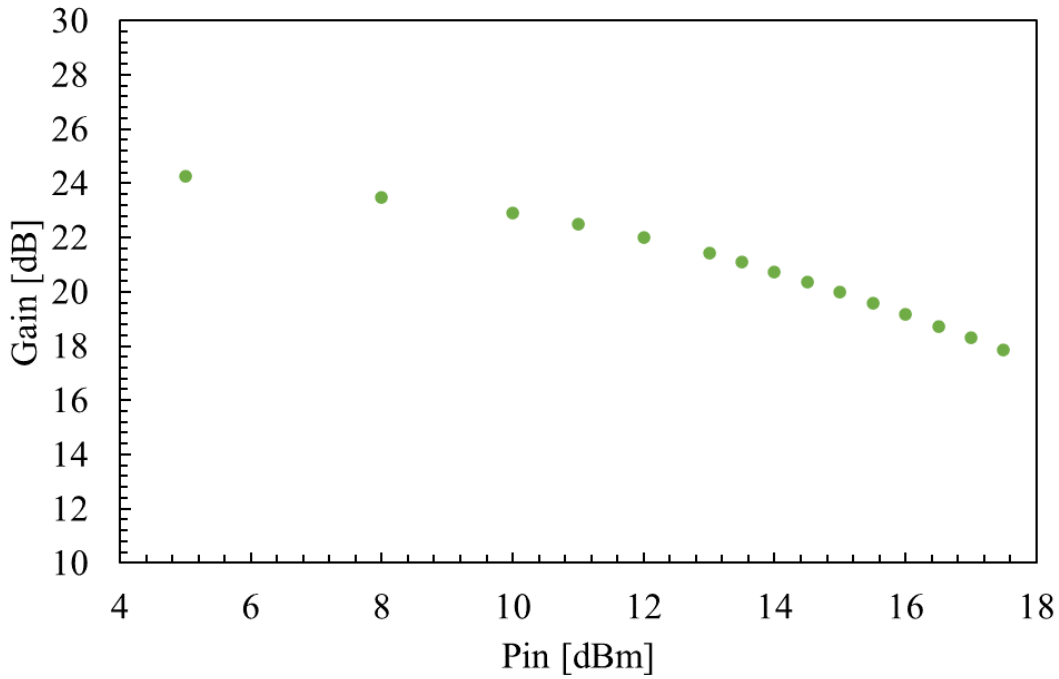
- How to measure discharge in the space
- How to realize high power microwave in the small satellite

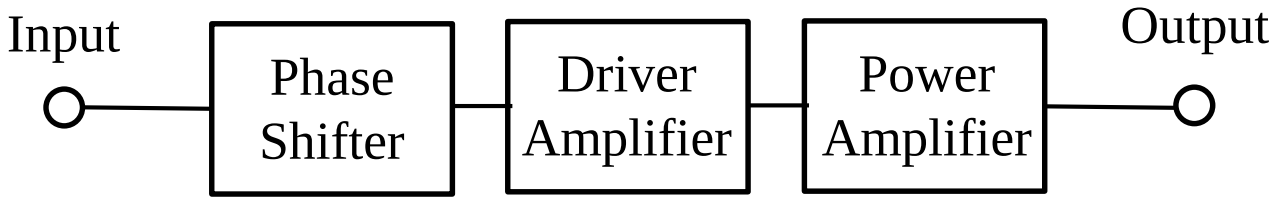


Configuration

Developing prototype of amplifier







Output 2W
@10mW input, 5.8GHz

Conclusion

- Discharge is dangerous phenomenon for spacecraft
- SPS has extremely high discharge risk
- Surface treatment is one of the optimal mitigating method for discharge
- Discharge in the space is more complicated than the one on the ground test
- A lighter & higher efficiency amplifier is required

Email: 1519509@ed.tus.ac.jp