

***New EEE components R&D
activity in JAXA for realization of
novel space missions***

Mar. 1-3 2016

Hiroyuki Shindou (shindou.hiroyuki@jaxa.jp)

Research Unit I, R&D Directorate, JAXA

Today's talk

A satellite is shown in space, with the Earth's surface visible in the background. The satellite has a complex structure with various instruments and antennas. The background is a dark blue and black space with the white and blue patterns of the Earth's atmosphere and clouds.

- Introduction.
- Updated status of JAXA's EEE components development.
- New component technology research activities to realize novel space missions.
- Summary.

A satellite in space with solar panels and Earth in the background.

→ Introduction.

Updated status of JAXA's EEE components development.

New component technology research activities to realize novel space missions.

Summary.

Research and Development of Space parts & Technology

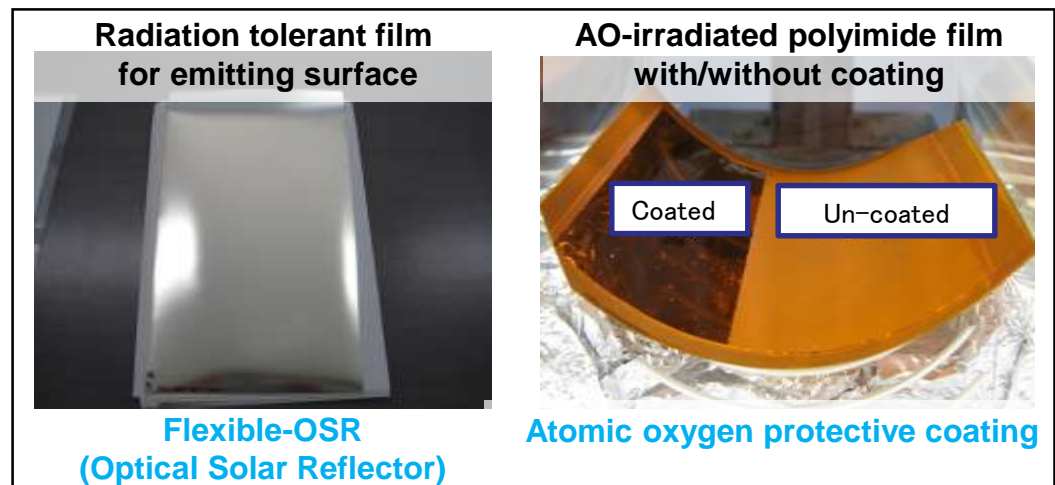
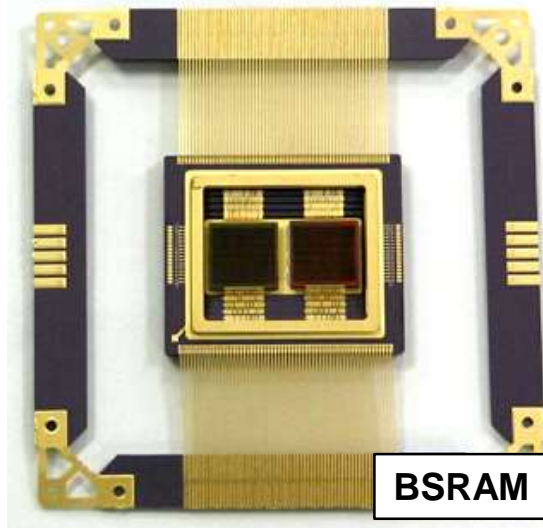
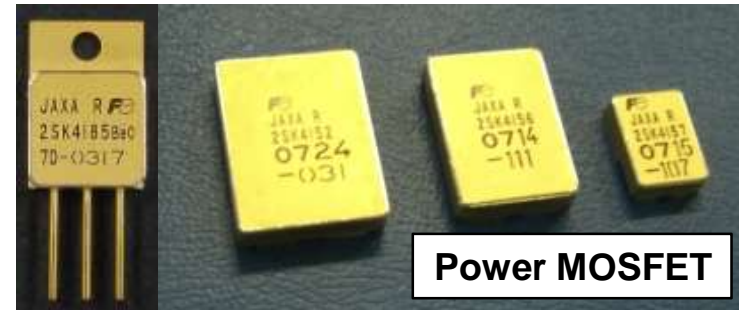
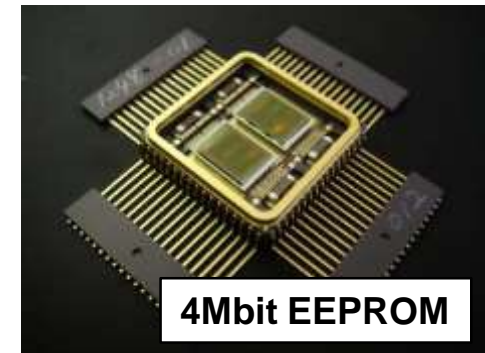
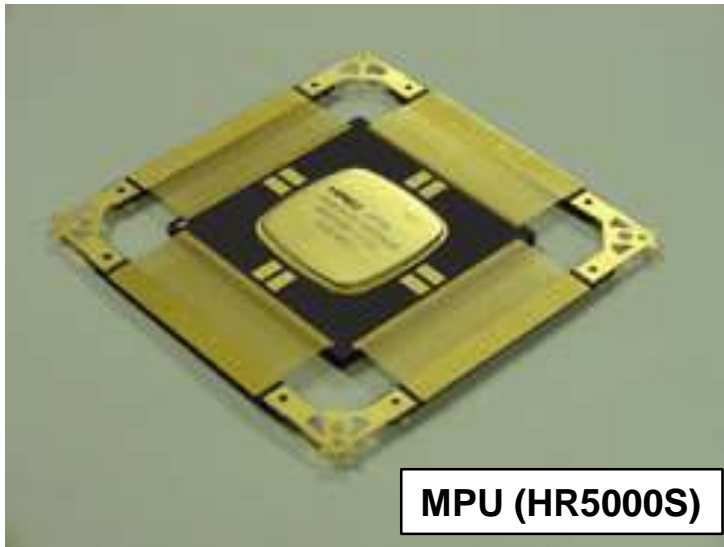
- Development of strategic components:
JAXA qualified EEE parts : high-performance and high-density IC, etc.
- R&D for the advanced technologies
(challenging for the breakthrough)

Today's talk

Qualification and Engineering Support regarding EEE parts

- Cooperation with foreign entities:
Improving independence from ITAR by cooperating with European countries
- Ensuring quality of imported components:
Ensuring the quality of the imported components
- Promoting utilization of JAXA qualified components:

JAXA qualified parts and materials





Introduction.

→ Updated status of JAXA's EEE components development.

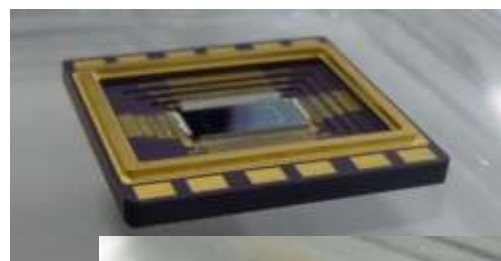
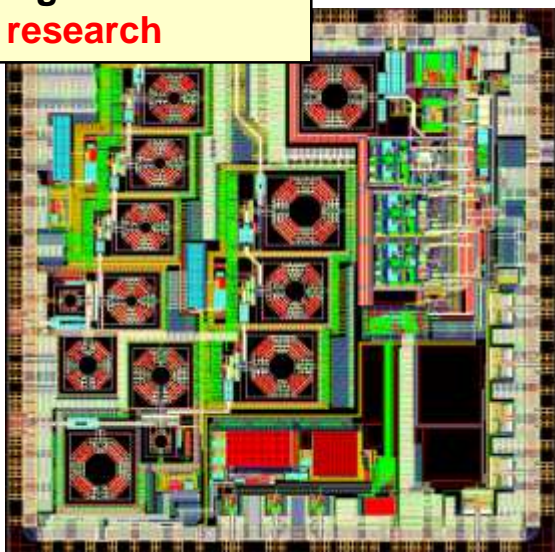
- ◆ C-BGA package.
- ◆ SJ Power MOSFETs.

New component technology research activities to realize novel space missions.

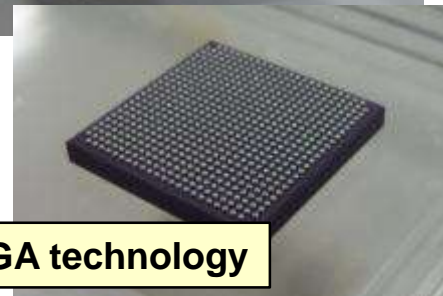
Summary.

Developing high-performance and downsizing technologies

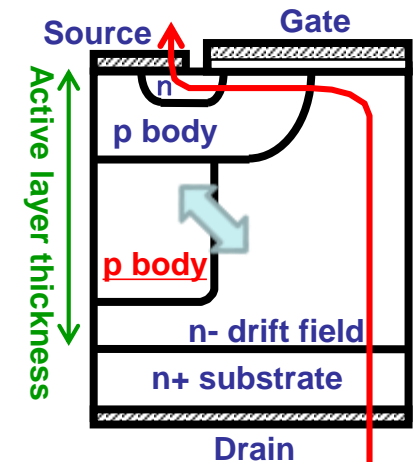
Mixed signal SOI-ASIC
Under research



BGA technology



Super-Junction
Power MOSFET
To be qualified in Q4 2016



QCM* Sensor
To be released in March 2017

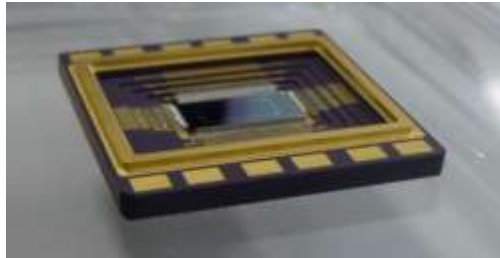
*QCM: Quartz Crystal Microbalance



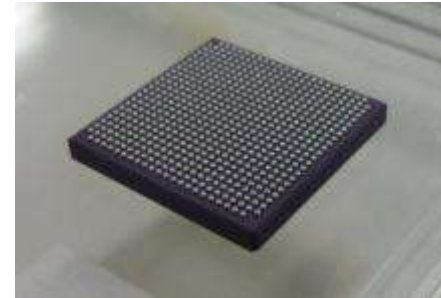
Leded Thermistor



- ✓ Now in evaluation phase. QT will be completed 1st quarter 2017.



C-BGA package without seal-cap (top-side)



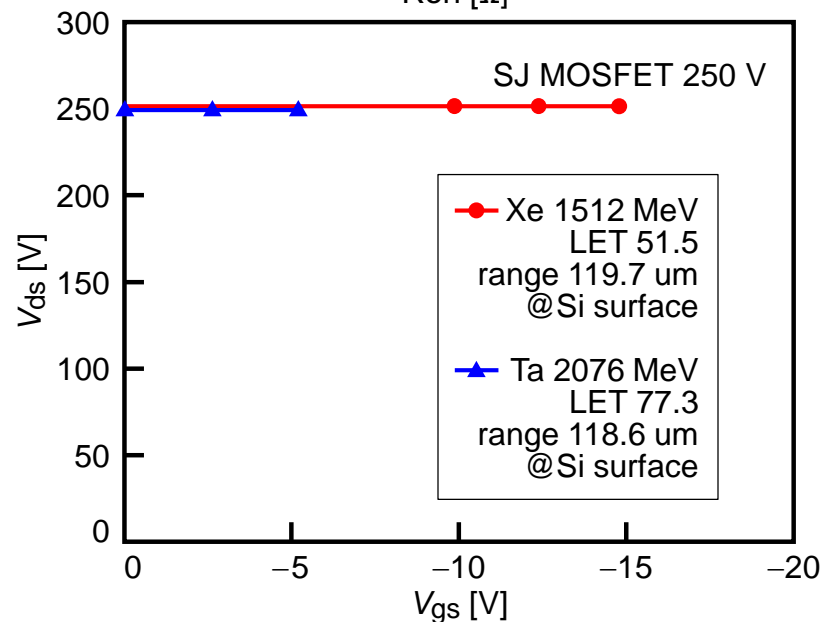
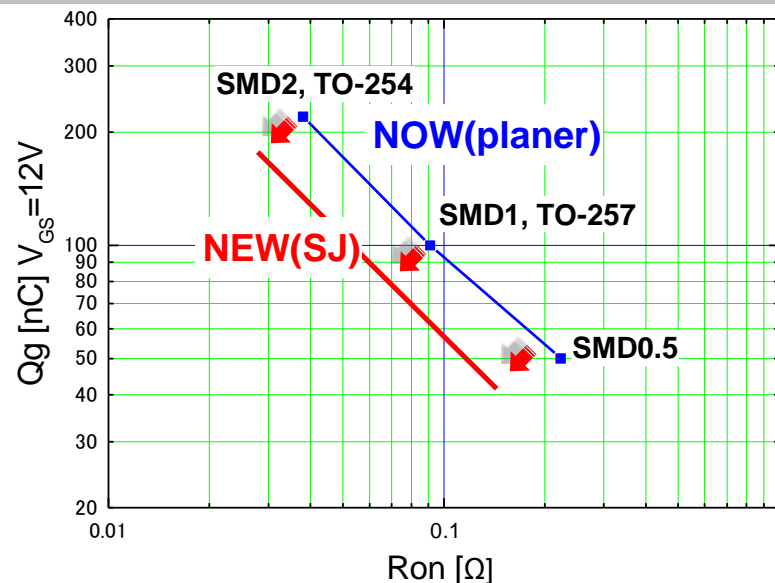
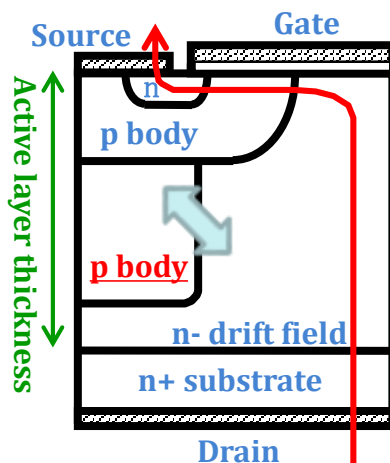
C-BGA package (bottom-side)

Target feature of C-BGA package

	Target feature	Remark
TYPE	C-BGA	Al ₂ O ₃
Pin count	572 / 357 / 165	24x24 / 19x19 / 13x13 (no corner-pins)
Pin pitch	1.0 mm	
Pin material	Solder	63Sn/37Pb and 10Sn/90Pb Attached with a vacuum reflow
Internal Wiring	Al wire-bonding	Conventional process
Mount tech.	BGA	With/without underfill

SJ Power MOSFET

- Low $R_{ON} \times Q_g$ (compare to planer type)
 - 45% reduction (250V type)
 - 75% reduction (600V type)
- High SEGR/SEB tolerance
 - SEGR/SEB FREE up to LET of 75 MeV/(mg/cm²)
 - NOW: Manufacturing QT parts.
 - By 4th quarter, 2016: QT will be completed.





Introduction.

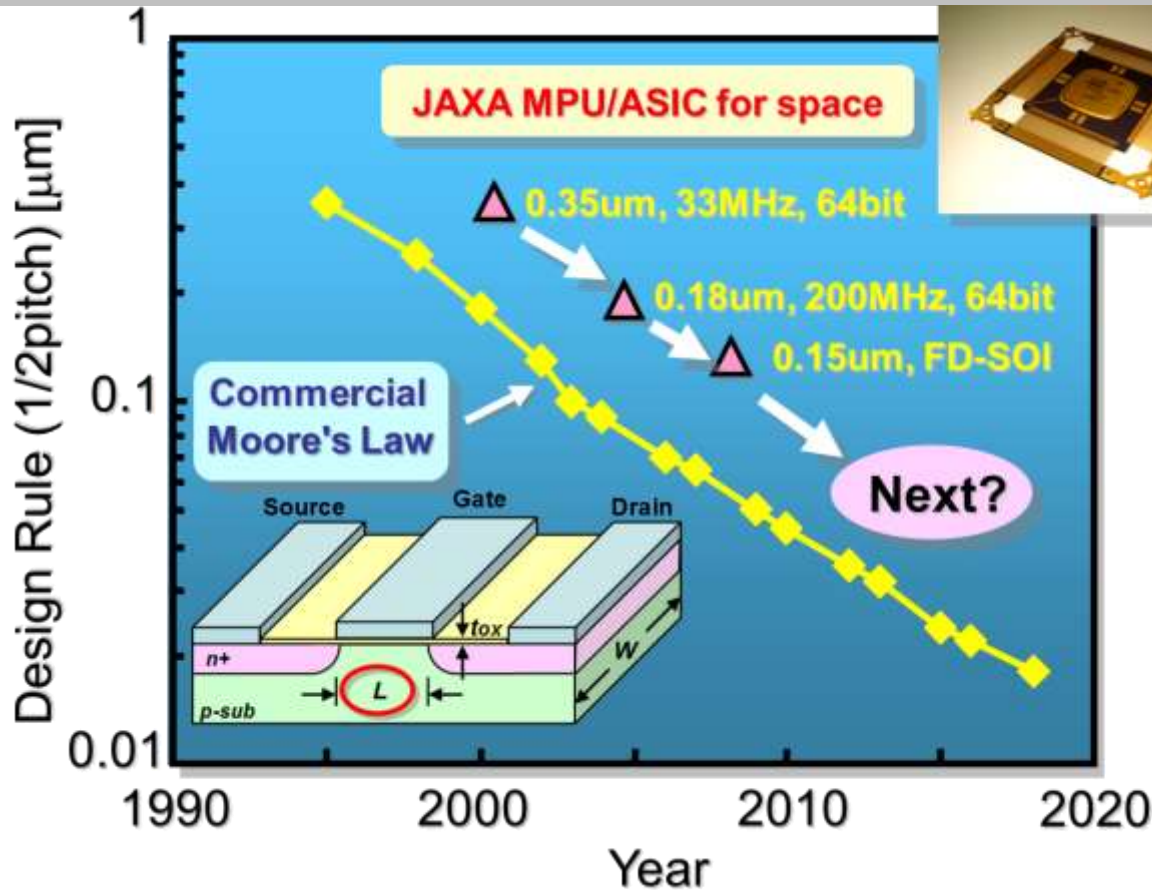
Updated status of JAXA's EEE components development.

➔ New component technology research activities to realize novel space missions.

- ◆ RHBD methodology for nano-scale CMOS process.
- ◆ Ultra-low power consumption technology.
- ◆ High-density surface mount technology.

Summary.

CMOS scaling trend comparison



Recently, due to the requirements for higher density integration and device scaling, the logical circuits have been designed with <100 nm design rule. **Single-Event Effects become serious problems for those integrated circuits.**

RHBD for nano-scale (Hyper- DICE)

- ✓ It was indicated from our previous research that SEUs caused by charge sharing can not be ignored for nano-scale devices.
- ✓ JAXA proposed a new RHBD circuit which is applicable for nano-scale technology called “Hyper-DICE”. Four critical transistors have to be affected simultaneously for memory state upset in Hyper-DICE.
- ✓ JAXA designed and fabricated memory circuit based on Hyper-DICE on 65nm bulk CMOS process. Irradiation tests are in progress.

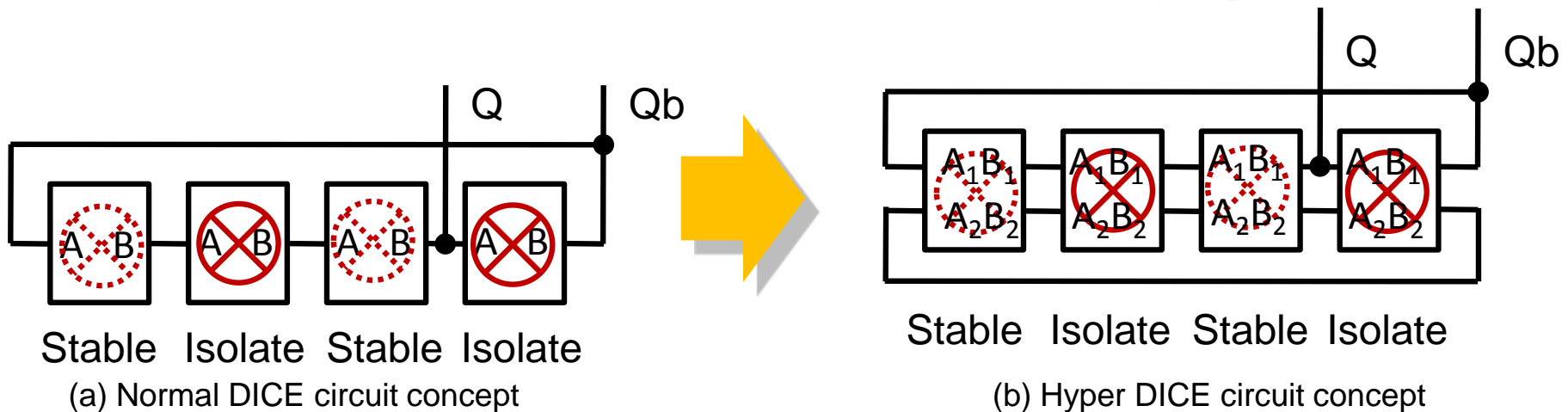


Fig. Hyper DICE and Normal DICE circuit concept

RHBD : Radiation Hardness By Design

DICE : Dual Interlocked Storage Cell

- ✓ Recently, it is concerned that **power consumption** of IT devices in terrestrial, as well as in space, is **increasing explosively!**
- ✓ To reduce the energy consumption, “**Normally-off computing**” which is shut power down whenever not being used, and/or ultra-low power operation are strongly desired.



JAXA has started the investigation of state-of-the-art non-volatile memory technologies for new memory of high performance, ultra-low power consumption and high radiation immunity in space.

Keyword: MRAMs, Atom switch, etc.

Atom switch : A nano-scale switch which controls connection/disconnection of Cu^+ ion bridge electrochemically.

- ✓ Atom switch has features of low power, small area and non-volatility for the memory applications. In addition, it is also expected to replace a conventional SRAM/Pass-Tr. switch for a reconfigurable LSI.

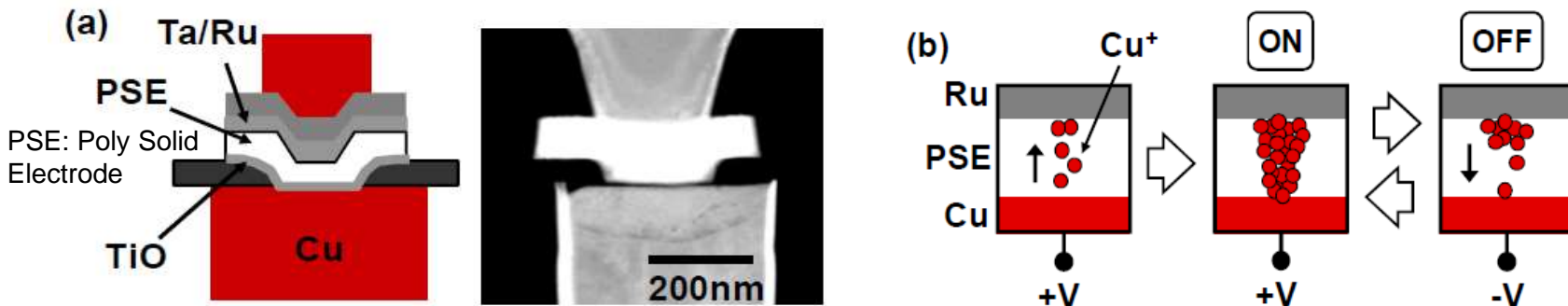


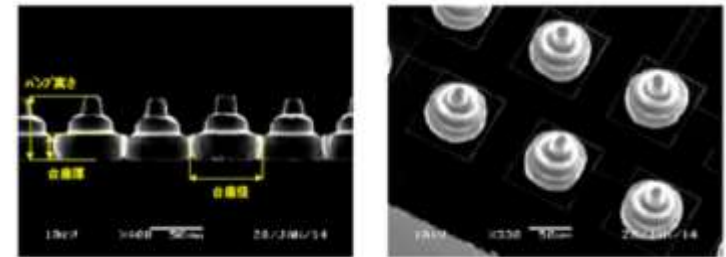
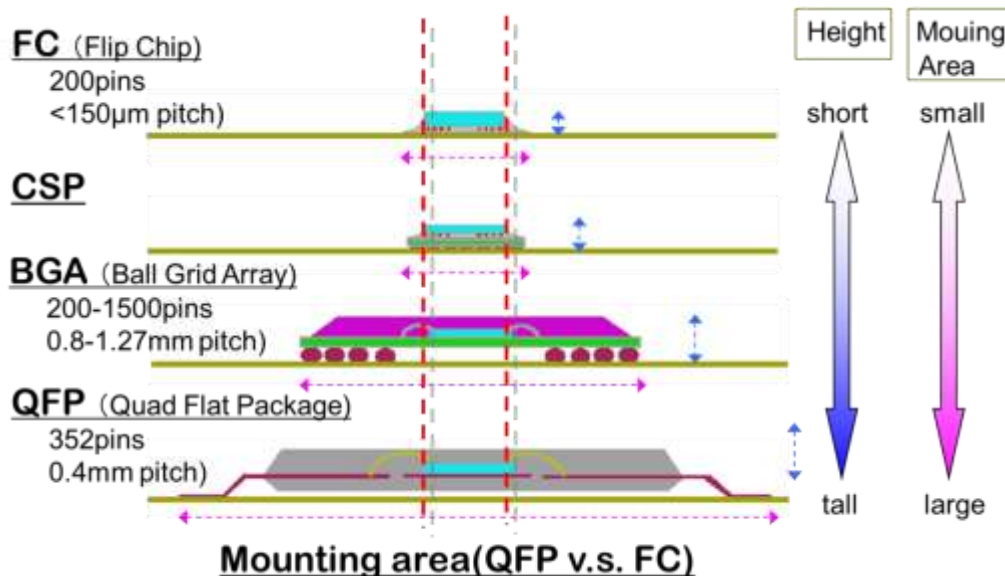
Fig. (a) Cross sectional illustration (left) and TEM image (right) of atom switch cell, (b) Schematic diagrams of switching mechanism.

Ref: K. Okamoto et al., “Conducting mechanism of atom switch with polymer solid-electrolyte,” Tech. Dig. Int. Electron Devices Meet. IEDM, vol. 1, pp. 279–282, 2011.

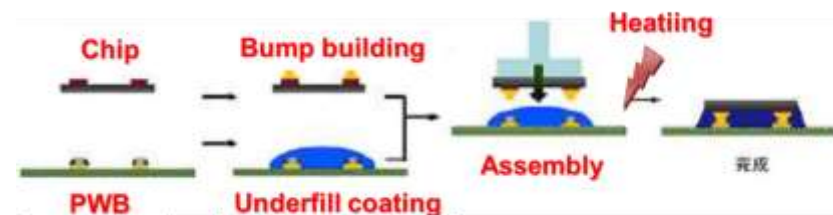
- ✓ JAXA started the evaluation of radiation tolerance of this switch as the first step of feasibility last year. (Results indicated excellent tolerance.)

High-density surface mount technology

- ✓ JAXA is studying and developing System In a Package (SIP) technology for space devices with high-density Surface Mount Technology (SMT).
- ✓ Flip Chip(FC) would reduce CPU mounting area by 83.70%, which is expected to give a drastic miniaturization of space devices.
- ✓ Now element technology evaluations are on-going.
Stud bump, Build-up PWB for FC, Epoxy-encapsulated solder connection.



Au Stud bump



<http://www.panasonic.com/jp/company/pfsc/technology/dj200701.html>

Summary

- ✓ Updated status of JAXA's EEE components R&D activities has been reported.
- ✓ New research activities for extending the possibility of space activities have also been introduced.
- ✓ Although the state-of-the-art component technology is very attractive, sufficient characterization is required to identify potential failure mechanisms.