JAXA update on EEE components development and qualification

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Japan Aerospace Exploration Agency (JAXA)

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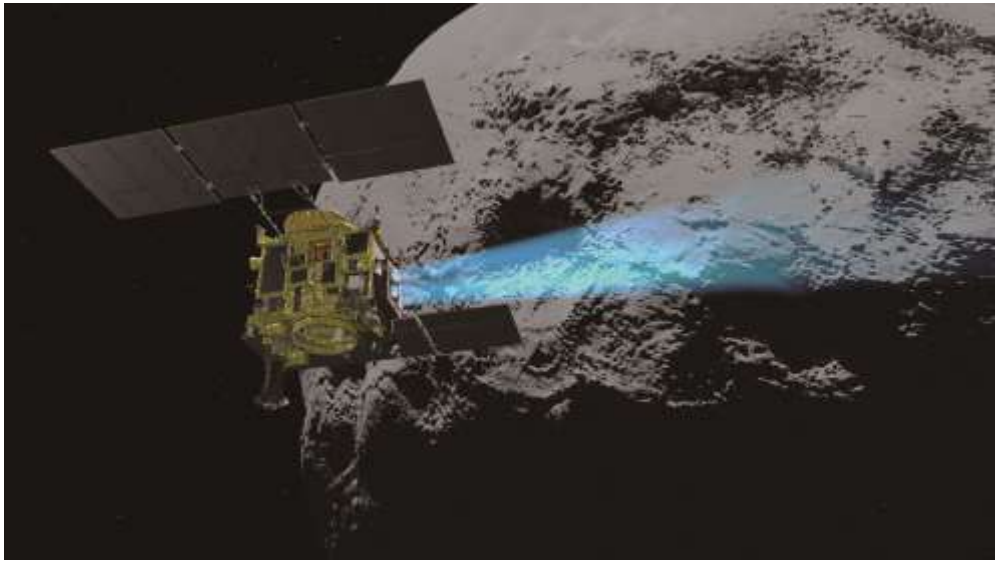
Introduction

Hot Topics!!

The asteroid explore “Hayabusa-2” successfully touch downed to the “Ryugu” surface in Feb. 22nd!!

After the sample capturing, Hayabusa-2 will make 300 million kilometers long journey and will come back in 2020.



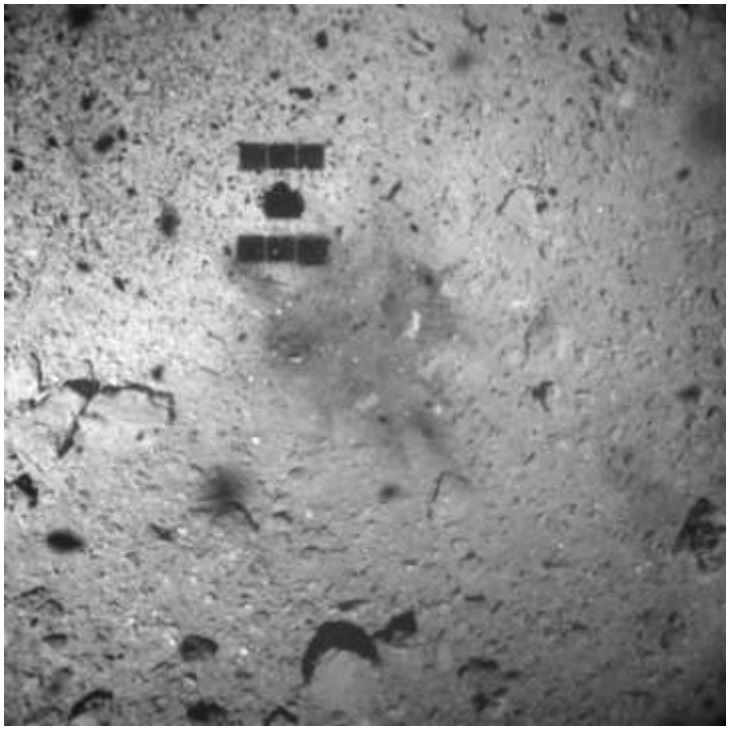


Image immediately after touch down, taken with ONC - W 1
Shooting time: around 01/29/2002 07:30 (on-machine time)
Altitude: 30 m or less
Image credit: JAXA, Tokyo Univ., Kochi Univ., Rikkyo Univ., Nagoya Univ., Chiba Institute of Technology, Meiji Univ., Aizu Univ., AIST

It is said in Japanese proverb that
“Picnic isn’t over until you get back home”.

I wish it’s careful and safety journey.

Introduction

- JAXA has a total of 147 models of JAXA qualified components.
  ※ Hayabusa-2 also used many kinds of JAXA qualified components.
  (ex. Capacitors, Trans, Resistors, ASIC etc.)

Table 1. List of JAXA qualified components.

Comp. family	Description	Manufacturer
ICs	-64bit MPU (HR5000) -64bit MPU (HR5000S) -4Mbit EEPROM -36Mbit Burst SRAM	HIREC
HICs	-DC/DC converter -POL DC/DC converter -Command driver -Hybrids (Class II)	Avionics Fukushima
Transistors	-Power MOSFET (n-ch and p-ch) -Power MOSFET (SJ250 and SJ600)	Fuji Electric
Solar Cells	-Triple-Junction Compound Semiconductor -High Efficiency Triple-Junction Compound Semiconductor	Sharp

Red: Listed to EPPL

Comp. family	Description	Manufacturer
Capacitors	Mica	Soshin Electric
	MLCC	Murata
	Chip, Solid, Electrolytic, Tantalum	Matsuo Electric
Resistors	Chip, Thick Film	Tateyama Kagaku
		Hokuriku Electric
	Wire-Wound (Power Type)	Seiden Techno
		Sanada KOA
	Film	Sanada KOA
	Networks, Film	Sanada KOA
	Chip, Thin Film	Sanada KOA
Thermistors	Chip, Negative Temperature Coefficient	Tateyama Kagaku
	Lead, Negative Temperature Coefficient	Tateyama Kagaku
Fuses	Subminiature, Current-Limiting	Tateyama Kagaku
Temp. Sensors	Platinum	MHI*
Osc. Crystals	Quartz Crystal Units	Nihon Dempa Kogyo
Transformers and Inductors	Power	Tamura
	Others	Tamura
Wires and Cables	Fluoroplastic, Polyimide Insulated Wires	Hitachi Metals
	Differential Transmission Cables	Junkosha
Connectors	Rectangular, Miniature	JAE**
		Nihon Maruko
	Rectangular, Miniature, High Density	JAE**
		Nihon Maruko
	Rectangular, Microminiature	Nihon Maruko
	Rectangular Miniature Mixed	Nihon Maruko
	Coaxial, RF	Waka Manufacturing

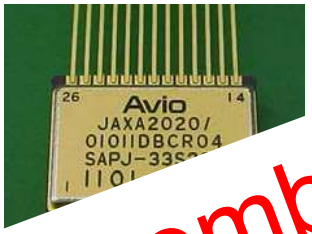
JAXA qualified components listed in EPPL

Active Components

Power MOSFET (Fuji Electric)

1) n-ch, TO254, 100-250V
2) n-ch SMD, 100-250V
3) n-ch TO-254/SMD, 500V
4) p-ch, TO-254/SMD, 100/200V
5) n-ch , Super Junction, TO-254/257/SMD, 250V
6) n-ch , Super Junction, TO-254/257/SMD, 600V

POL DC/DC converter
(Fukushima Avio)

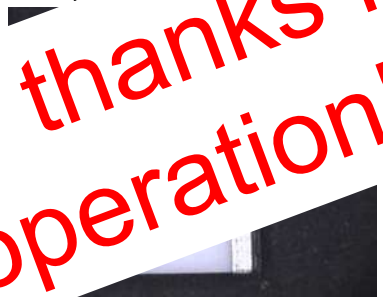


So many thanks for ESA member's kind cooperation!!

Passive Co

Platinum temp. sensors(MHI)

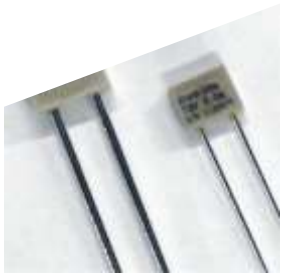
Chip Ta



Chip re
(Sanada

Current-limiting fuses, SMD
(Tateyama kagaku)

Differential transmission cables
(Junkosha)



Chip Tantalum capacitors
(Matsuo Electric)

Leaded Thermistor
(Tateyama kagaku)

Red: Newly appointed after 2006

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- **Revision of JAXA qualification documents**
- Latest News of JAXA development components
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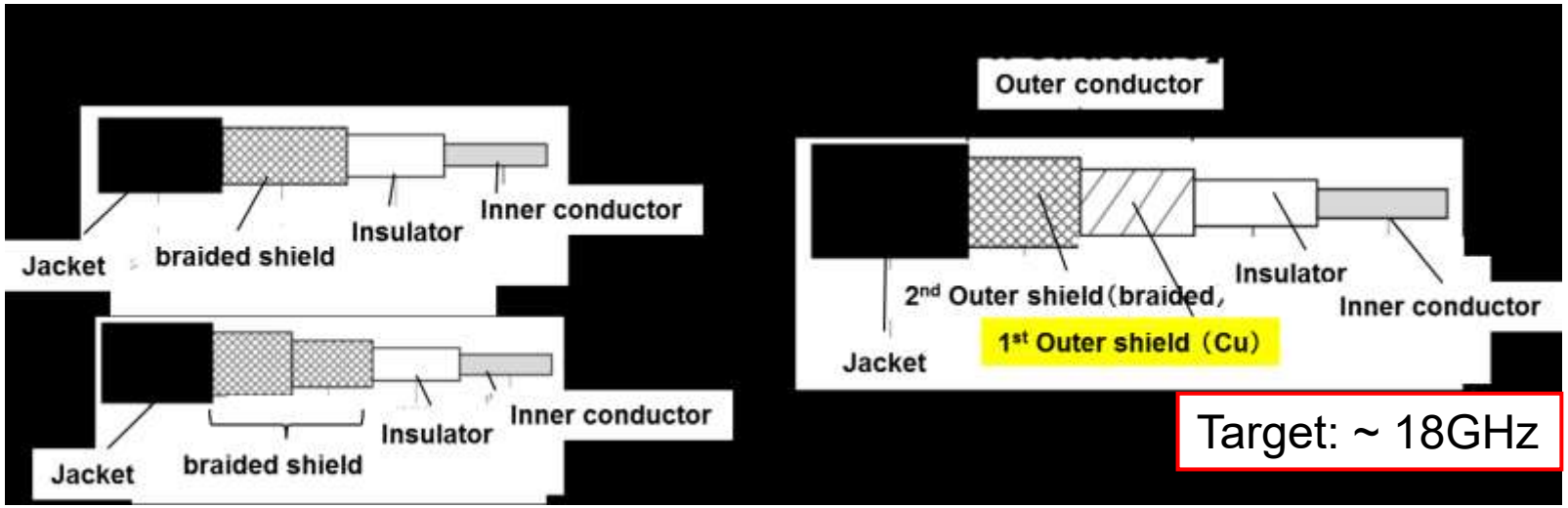
Revision of JAXA qualification documents

- JAXA qualification components are qualified based on JAXA generic specification documents (JAXA-QTS).
- JAXA has started to revise two of JAXA generic specification documents in this JFY.

(1) JAXA-QTS-2120 : Qualification document for cables

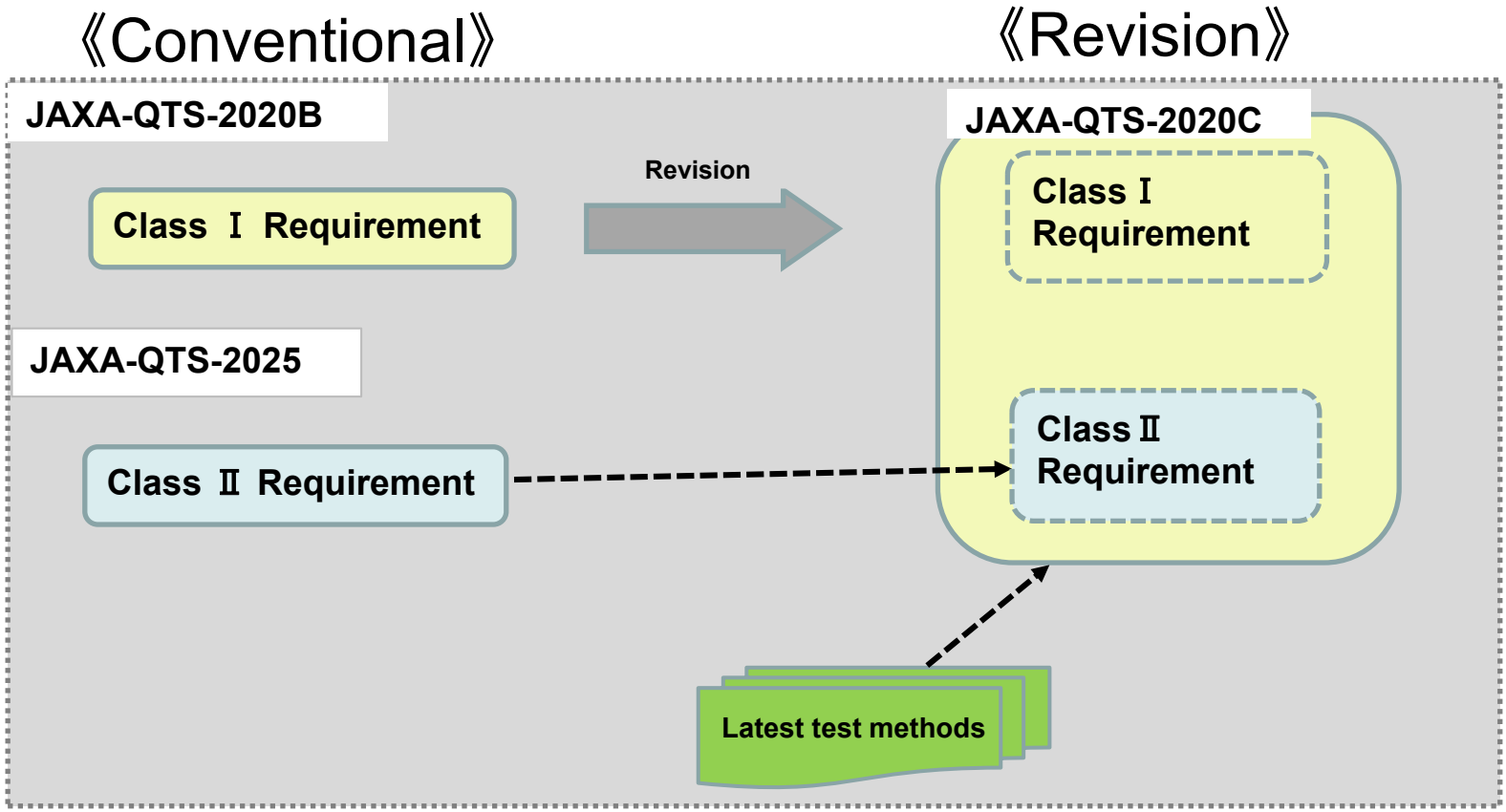
Points of revision: - To add the new structure “radio frequency coaxial cable”
- To add the test required by ESCC 3902 and MIL-DTL-17
(Insulation resistance, Solderability, Anthony and Brown test)



Revision of JAXA qualification documents

(2) JAXA-QTS-2020 : Qualification document for hybrid ICs

Points of revision: - To include the requirement of JAXA-QTS-2025 which is the qualification document for Class II Hybrid IC.
- To apply the latest test methods described in applicable documents.



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Latest News of JAXA development components

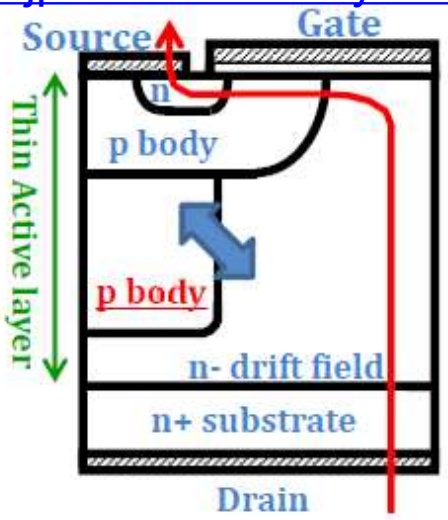
Rad-Hard SJ power MOSFET

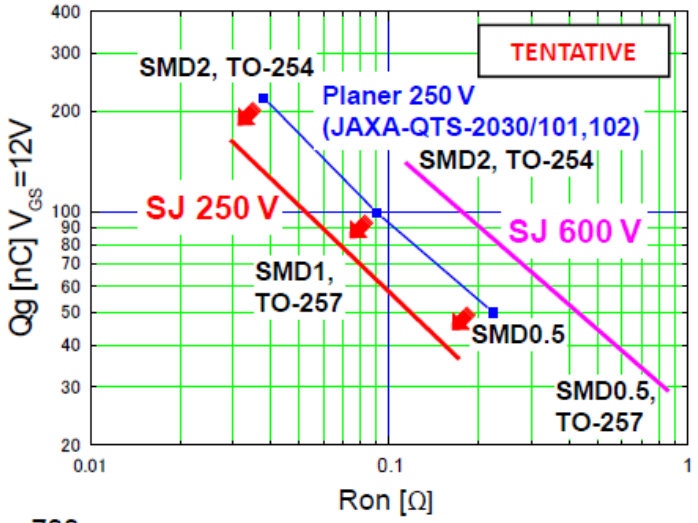
- **Low R_{ON} x Q_g (compared to planer type)**
  - **– 45 % reduction (250 V type)**
  - **– 75 % reduction (600 V type)**

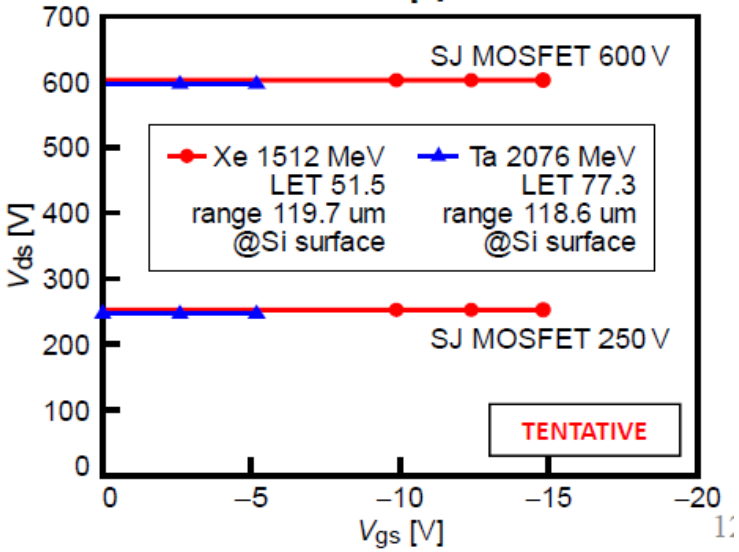
- **High SEGR / SEB tolerance**
  - **– SEGR / SEB FREE**
    up to LET of 75 MeV/(mg/cm2)

These are listed in EPPL NOW!!

Detail spec. ↓
https://eeepitnl.tksc.jaxa.jp/en/info/history.htm



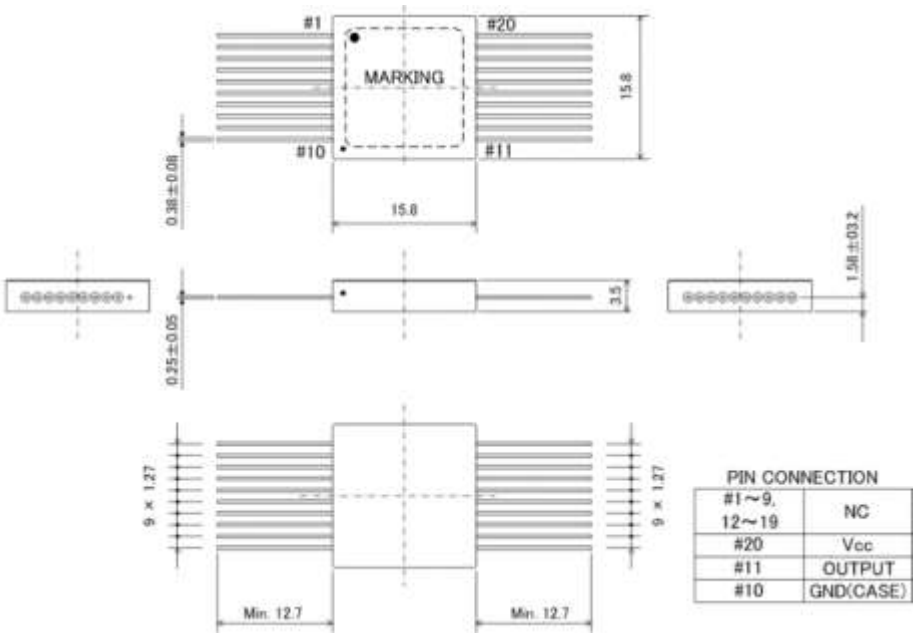




Latest News of JAXA development components

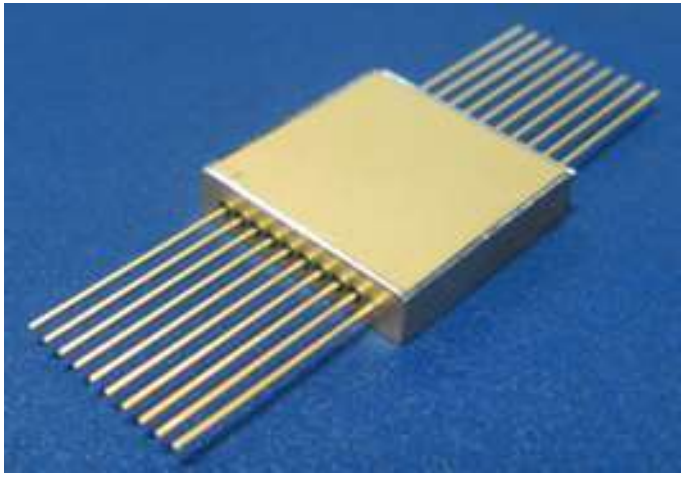
Crystal Oscillator (XO) for space application

- Manufacturer : NIHON DEMPA KOGYO CO., LTD.
- Qualification test completed at the end of September 2018.
- Completion of qualification activities is expected the 4th quarter of JFY2018.
- The lead time of this XO is approximate 10 ~ 11 months for domestic.



PIN CONNECTION

#1～9, 12～19	NC
#20	Vcc
#11	OUTPUT
#10	GND(CASE)



Electrical characteristics of XO

Item	Symbol	Condition	Min.	Max.	Unit
Output frequency range	fc	----	41	100	MHz
Consumption current	Icc	----	-	40	mA
Initial accuracy	Δf/fo	Vcc = +3.3V, Tc = +25℃, CL = 15pF	-	±15	ppm
Frequency-temperature tolerance	Δf/f	Tc = -45℃ to +125℃	-	±50	ppm
Long-term frequency - temperature tolerance (Frequency aging)	Δf/f	----	-	±3 (Year 1) ±1.5 (Year thereafter)	ppm / year
Output waveform	-	----	Symmetrical square wave, ACMOS compatible		-
Output voltage	V_{OL}	----	-	0.1 x Vcc	V
	V_{OH}	----	0.9 x Vcc	-	V
Duty cycle		----	35	65	%
Rise time	tr	10% x Vcc to 90% x Vcc	-	5	ns
Fall time	tf	90% x Vcc to 10% x Vcc	5	-	ns

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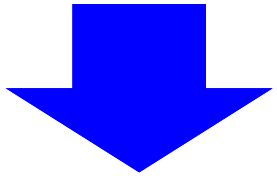
Background of WHISKER mission

- Due to the demands for applying COTs components to space application, we need to know whether lead-free components applicable for in-orbit environment.
- To apply the lead-free components for space, “whisker” is the most important and biggest barrier.

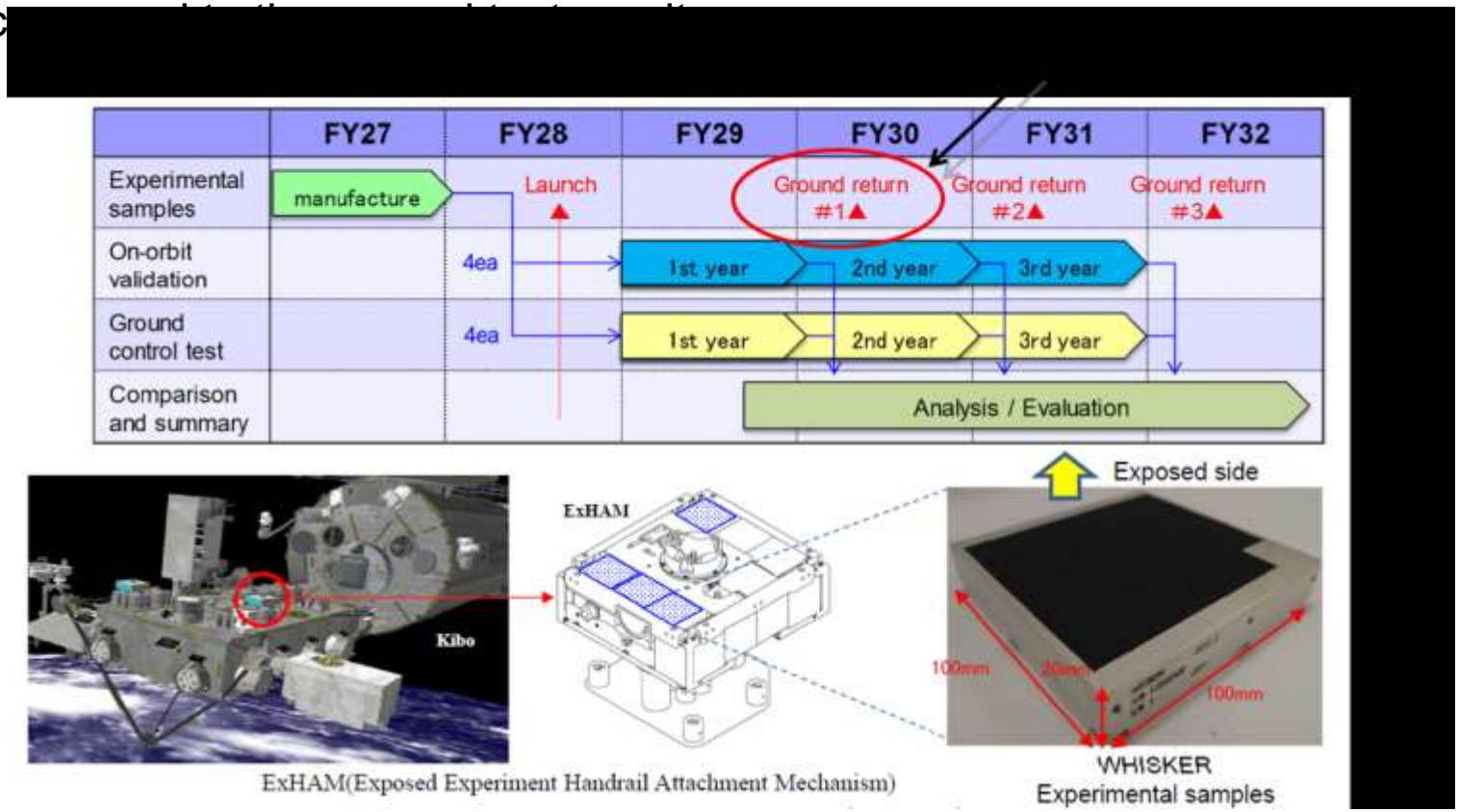


JAXA started the in-orbit demonstration calls “**WHISKER mission**“.

- To verify the effectiveness of conformal coating for tin whisker suppression in-orbit environment.
- To identify the different of whisker growth between on-ground and in-orbit environment.

Interim report of WHISKER mission

- JAXA is planning to 3 years WSHISKER mission for in-orbit demonstration.
- This demonstration is performed by ExHAM platform equipped on Kibo module in ISS.
- 1st year sample was back in last year. The results of exposure were analyzed and c



ExHAM(Exposed Experiment Handrail Attachment Mechanism)

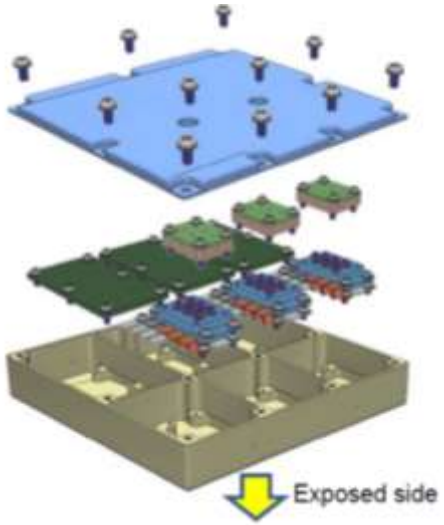
Interim report of WHISKER mission

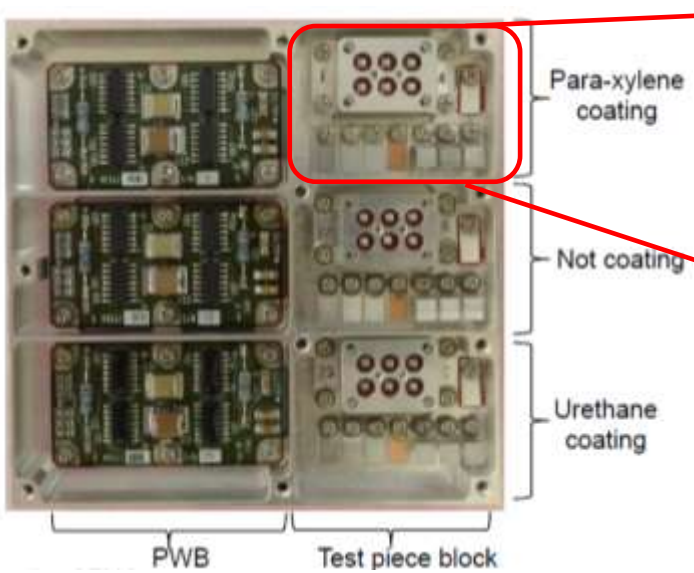
We have two objectives of WHISKER mission

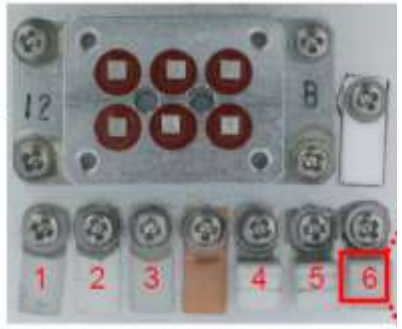
1）To verify the effectiveness of conformal coatings which may mitigate whisker growth.

2）To compare whisker growth on the ground and on-orbit using the same sample.

To achieve above objective, we prepared test samples of PWB and Test pieces which different of coating condition.



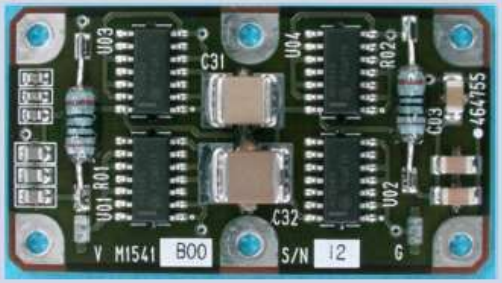
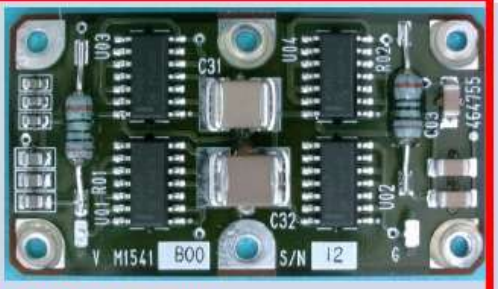
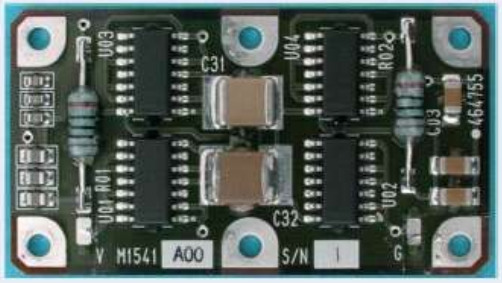
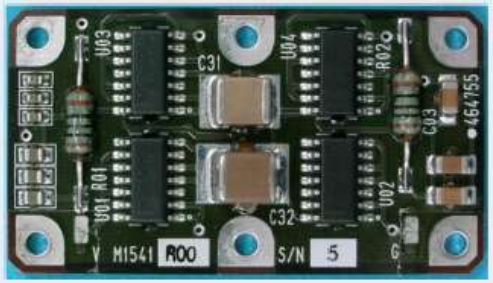
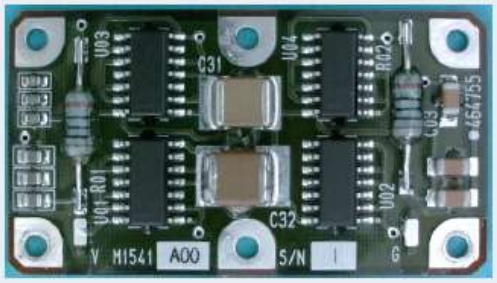
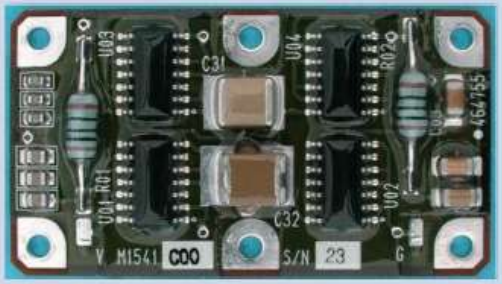
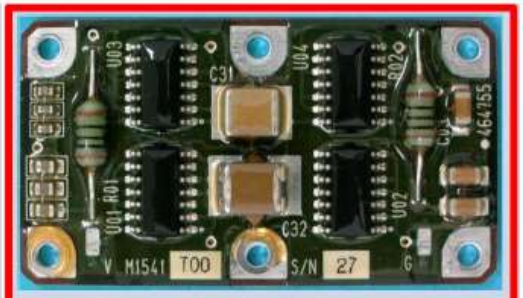
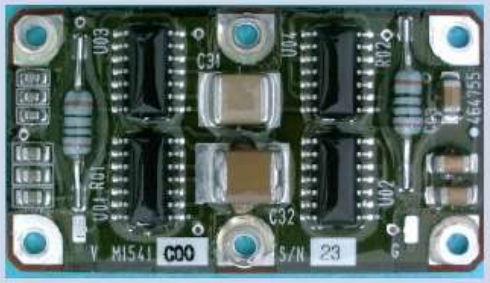




Test piece1(Flat plate) / Test piece4(Bent plate)
Base :Cu, Foundation :Ni=2μm, Tin plating(a*)=3μm
Test piece2(Flat plate) / Test piece5(Bent plate)
Base :Cu, Foundation :Ni=2μm, Tin plating(b**)=8μm
Test piece3(Flat plate) / Test piece6(Bent plate)
Base : 42alloy, Foundation :None, Tin plating(b**)=8μm
(*; Plating hard to grow / **; Plating easy to grow)

Summary of results (PWB)

Microscope inspection (PWB)

	Initial	Ground 1st year	On-orbit 1st year
No coating		 (b)Whisker growth, Solder crack	 (b)Whisker growth
Para-xylene coating			
Urethane coating		 (f) Change to yellow, Solder crack	

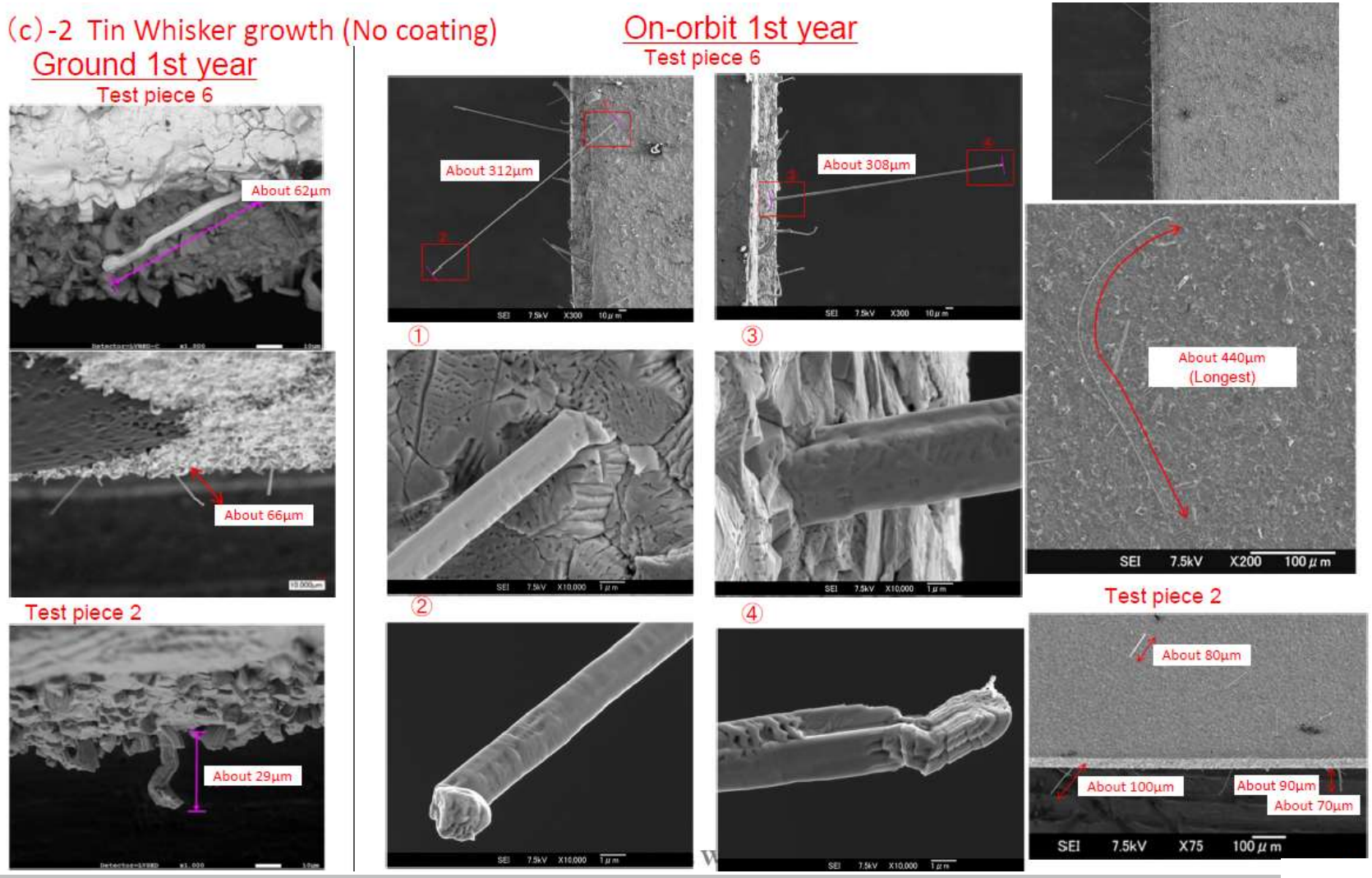
Summary of results (Test pieces)

Microscope inspection (Test piece block)

	Initial	On Ground 1st year	On-orbit 1st year
No coating		 (c)Whisker growth, Discoloration of Cu plate	 (a)(c)Long whisker growth
Para-xylene coating		 Discoloration of Cu plate	
Urethane coating		 (d) Whisker growth, (f) Change to yellow	 (d) Whisker growth in the edge of sample.

Results of Surface observation by SEM (Test piece block)

- Different to the whisker observed in ground test sample, which length was less than 100um, the longest whisker was about 440um length in in-orbit sample.

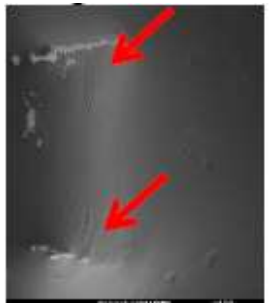


Effectiveness of conformal coating

- Para-xylene coating: There is no growth of whiskers in either case.
  (surface unchanged)

- Urethane coating: There is no growth of whiskers in thick coated area.
  - It was found that there is the winkles and thinner coating around the edge of samples.

    ➡ It should be monitored carefully whether whisker will be growth on 2nd and 3rd year.

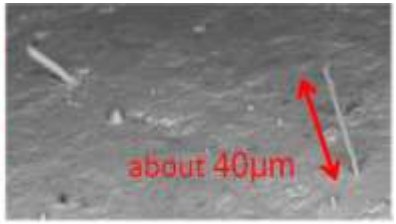


On-orbit (1st year)
SOP IC (U02)
Gullwing lead

- No coating: There is growth of whiskers in both cases.(Different shape and length)

Ground (1st year)
5750 size
chip capacitor
(C31) Electrode
plating part

On-orbit (1st year)
5750 size
chip capacitor
(C31) Electrode
plating part



Based on the 1st year test sample evaluation results, tin whisker suppression effect was confirmed both Para-xylene and Urethane coating.

➡ We continue the analytical evaluation to verify the effectiveness of conformal coating.

Summary

- JAXA is starting to revise the qualification documents JAXA-QTS-2120 and JAXA-QTS-2020
  - New revision of JAXA-QTS-2120 will appropriate for radio frequency cable.
  - JAXA-QTS-2020 will be added the policy of Class Ⅱ.
- SJ power MOSFET and XO for space application were developed.
  - 250V and 600V type of SJ power MOSFET was listed to EPPL
  - XO qualification process is currently progress.
- Interim report of in-orbit demonstration of WHISKER mission was reported.
  - Based on the 1st year test sample evaluation results, tin whisker suppression effect was confirmed both Para-xylene and Urethane coating.
  - There is the difference of whisker growth, shape and length, between ground test sample and in-orbit test sample. (Longest one is about 440μm length)
  - We continue the analytical evaluation to verify the effectiveness of conformal coating.

Thank you for your attention!!

APPENDIX

Comparison of JAXA/ESCC qualification test specification

- Document tree has been compared between JAXA and ESA qualification system.
- Same document tree from Level 2 to Level 4

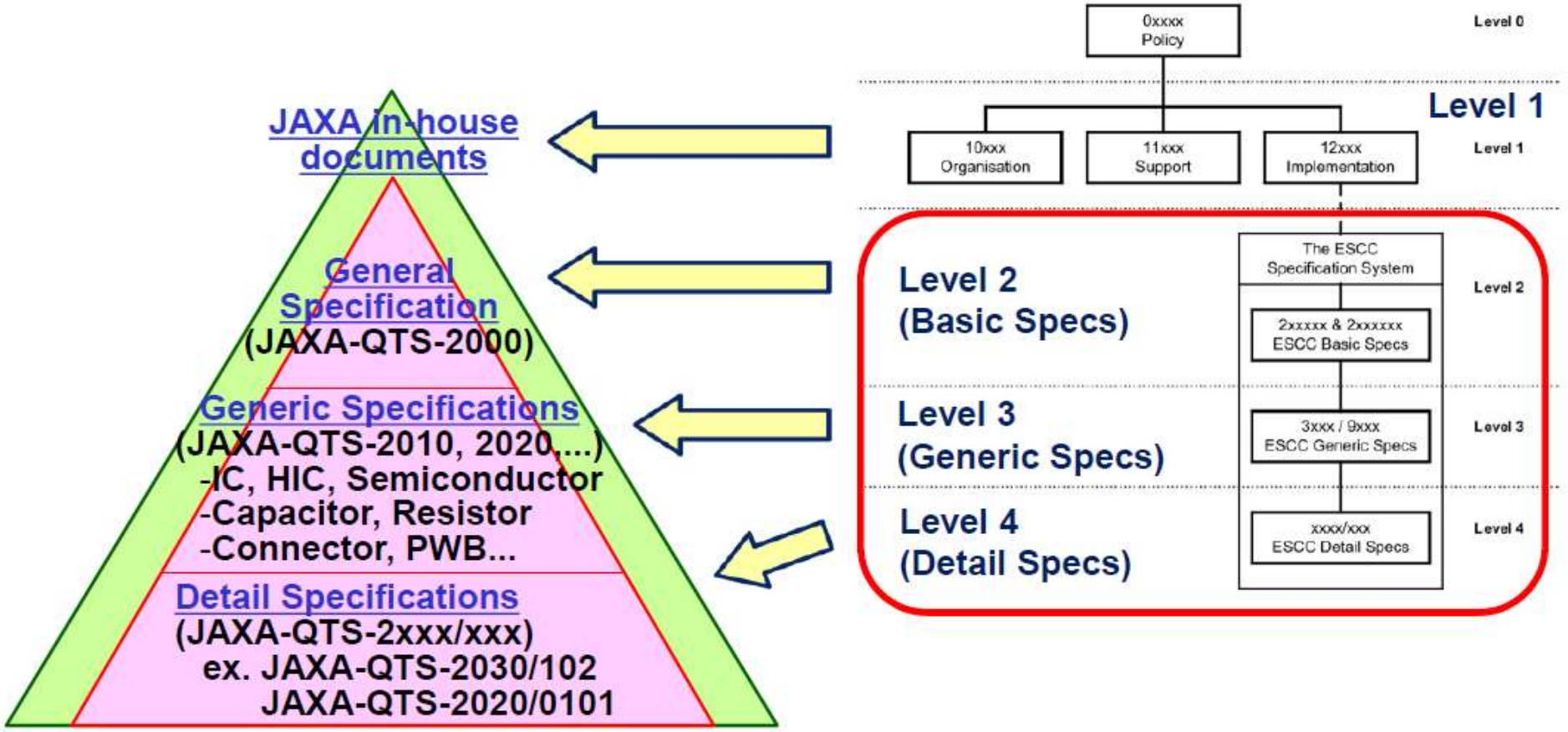


Fig. 1. Document tree of JAXA qualification system and ESCC qualification system

Comparison of JAXA/ESCC qualification test specification

- Summary of the overall comparison each qualification system are listed below.

There is no major difference when compared JAXA system with ESCC system.

System	ESCC	JAXA
Type of qualification	- Component Qualification - Technology Flow (TF) - Capability Approval (- Process Capability Approval)	- QML (qualification of manuf. lines) - QPL (qualification of parts)
Duration	2 years	3 years (QML)
Quality management	Process Identification Document (PID) + QMS	Quality Assurance Program Plan (QAPP)
Manufacturing line	Commercial lines may be used (processes, materials and technology shall be frozen by PID)	Commercial lines may be used (processes, materials and technology shall be frozen by QAPP)
Change control of QA program	- Review / approval required by ESCC Executive - Decision can be made by TRB with limitation (TF)	Decision can be made by TRB with limitation (QML)
Required tests for MoQ / procurement	- In-process control - Screening test - Periodic tests (every 24 or 12 months) - Environmental / mechanical subgroup - Endurance subgroup - Electrical subgroup - Assembly / capability subgroup	- In-process inspection - Screening test (active parts) - Quality Conformance Inspection (test interval differ from test group) passive parts : Group A-C basic characteristics ,life test etc. active parts : Group A-E electrical tests, die related tests, package related tests, radiation test etc.
Available Docs. after certification	- Detail specification	- Detail specification - Application Data Sheet (ADS)

Comparison of JAXA/ESCC qualification test specification

- Generic specification documents of all JAXA qualified components were compared with ESCC's specification. (26 items' equivalence has been confirmed)

  Comparison results are indicated in ESCIES.org (ESCC Public domain website).