The latest activities related to the passive components in JAXA

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Japan Aerospace Exploration Agency (JAXA)

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- Introduction of JAXA qualified passive components
- Comparison of JAXA/ESCC qualification test specification
- Recent activity of passive components
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Introduction of JAXA qualified passive components

- **JAXA has the components qualification system for components applied to the space application.**

Main purpose of this system

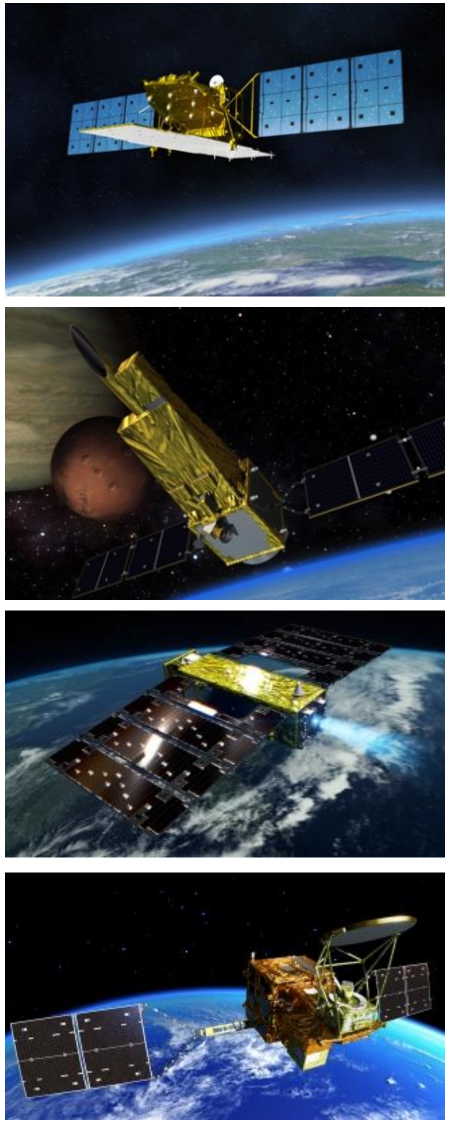
✓ **Components applied in common for many satellites are treated as standard components.**

➡ Quality and reliability of standard components are totally confirmed by this system in advance.

Qualification test (QT), Screening test, Stability of Manufacture product line

➡ Projects which plan to use such a standard components do not need any test before using.

- **ESA and NASA have similar qualification system.**



Introduction of JAXA qualified passive components

- There are total of 129 models of JAXA qualified components, of which 104 models are passive components.
  ※ PCBs and materials such as thermal control films are also included in JAXA qualified components.
- As of July 2022, there are 14 passive component manufacturers whose abilities to manufacture the products to satisfy the requirements for space application defined by JAXA.

Table 1. List of JAXA qualified passive components.

Comp. family	Description	Detail spec.	Manufacturer
Capacitors	MLCC EPPL	3 (*1)	Murata
	Chip, Solid, Electrolytic, Tantalum EPPL	1	Matsuo Electric
Resistors	Chip, Thick Film EPPL	1	Tateyama Kagaku
		2	Hokuriku Electric Seiden
	Wire-Wound (Power Type)	2	Techno
		1	Sanada KOA
	Film	3	Sanada KOA
	Networks, Film	1	Sanada KOA
	Chip, Thin Film EPPL	1	Sanada KOA
Thermistors	Chip, Negative Temperature Coefficient EPPL	1	Tateyama Kagaku
	Lead, Negative Temperature Coefficient EPPL	1	Tateyama Kagaku
Fuses	Subminiature, Current-Limiting EPPL	1	Tateyama Kagaku
	Surface Mount, Miniature, Current-Limiting EPPL	1	Tateyama Kagaku
Temp. Sensors	Platinum EPPL	3	MHI (*2)
Osc. Crystals	Quartz Crystal Units	3	Nihon Dempa Kogyo
	Crystal Controlled Oscillators EPPL	1	Nihon Dempa Kogyo
Transformers and Inductors	Power	2	Tamura
	Others	6	Tamura
Wires and Cables	Differential Transmission Cables EPPL	2	Junkosha
Connectors	Rectangular, Miniature	1	JAE (*3)
		1	Nihon Maruko
	Rectangular, Miniature, High Density	1	JAE (*3)
		1	Nihon Maruko
	Rectangular, Microminiature EPPL	1	ITT Cannon
		1	Nihon Maruko
	Rectangular Miniature Mixed	1	Nihon Maruko
	Coaxial, RF	3	Waka Manufacturing

(*1) NASDA2040/L104(X7R)type and JAXA2040/M105(X7R) type only
(*2) MHI = Mitsubishi Heavy Industries
(*3) JAE = Japan Aviation Electronics Industry

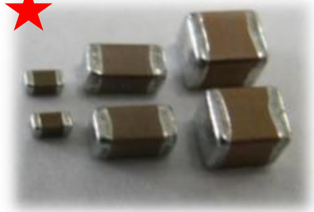
JAXA qualified components listed in EPPL

➢ **19 models of JAXA qualified components are listed in EPPL.**

Passive Components

★ Chip Tantalum Capacitors (Matsuo Electric)

★ Chip, Fine Ceramic (Fukui Murata)



★ Miniature, High-Capacity, Fine Ceramic (Fukui Murata)

★ Chip Film Resistors (Hokuriku Electric)

★ Chip Film Resistors (Hokuriku Electric)

★ Chip Film Resistors (Tateyama Kagaku)

★ Chip Metal Film Resistors (Sanada KOA)

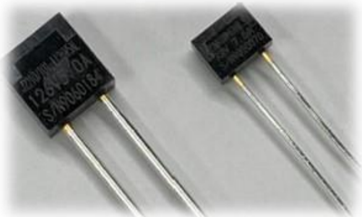
★ Connectors, Rectangular, Microminiature(ITT Cannon)

Platinum Temperature Sensors (MHI) : 3 models

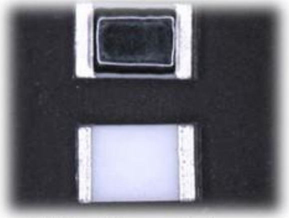
Differential Transmission Cables (Junkosha) : 2 models

★ Crystals Controlled Oscillators (Nihon Dempa Kogyo)

SMD Fuses (Tateyama Kagaku)



Leaded Fuses (Tateyama Kagaku)



Chip Thermistors (Tateyama Kagaku)

Lead, Negative Temperature Coeff. Thermistors (Tateyama Kagaku)

Active Components

POL DC/DC Converter (Avionics Fukushima)

★ Parts listed on EPPL since SPCD2018

Comparison of JAXA/ESCC qualification specification

- Like example of JAXA qualified components listed in EPPL, JAXA and ESA conducted the activity related to the Cooperation Agreement on EEE Components for mutual usage of each component.
- Mutual usage of Japanese components in Europe / European components in Japan has been promoted by JAXA and ESA:
  - To avoid duplicated development of similar components in Europe / Japan
  - To ensure the availability of second source
- To remove the barrier of mutual usage, JAXA and ESA held joint work to compare JAXA specifications and ESCC specifications for component qualification.

Items to be compared

1. Overall difference in both qualification systems
2. Detail comparison of generic specifications

Comparison of JAXA/ESCC qualification specification

- **Comparison of document tree related to the qualification systems between JAXA and ESA is shown in Fig.1.**
- **Same document tree from Level 2 to Level 4**

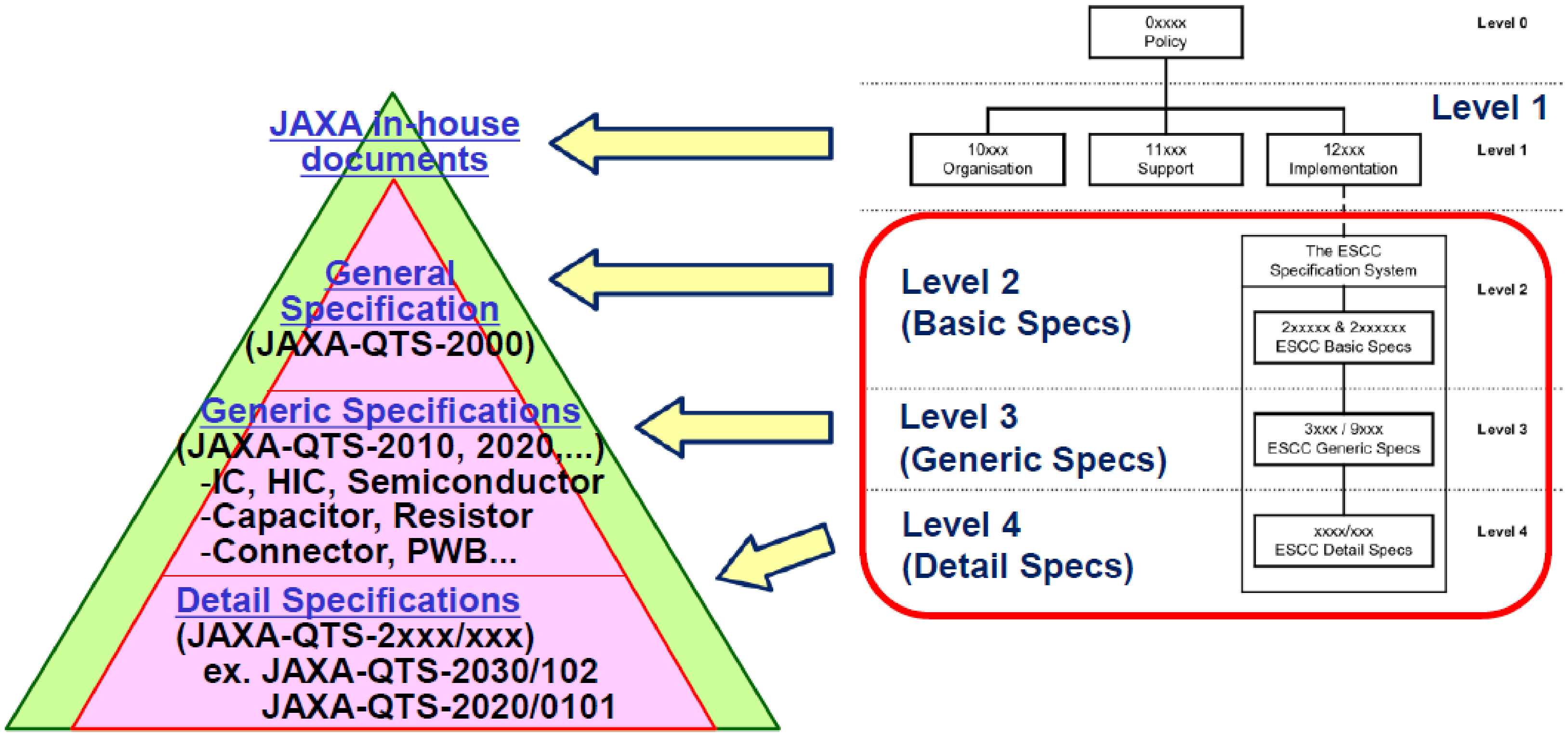


Fig.1 document tree of JAXA qualification system and ESCC qualification system

Comparison of JAXA/ESCC qualification specification

- Summary of the overall comparison each qualification system are listed in Table 2.
- There is no major difference when compared JAXA system with ESCC system.

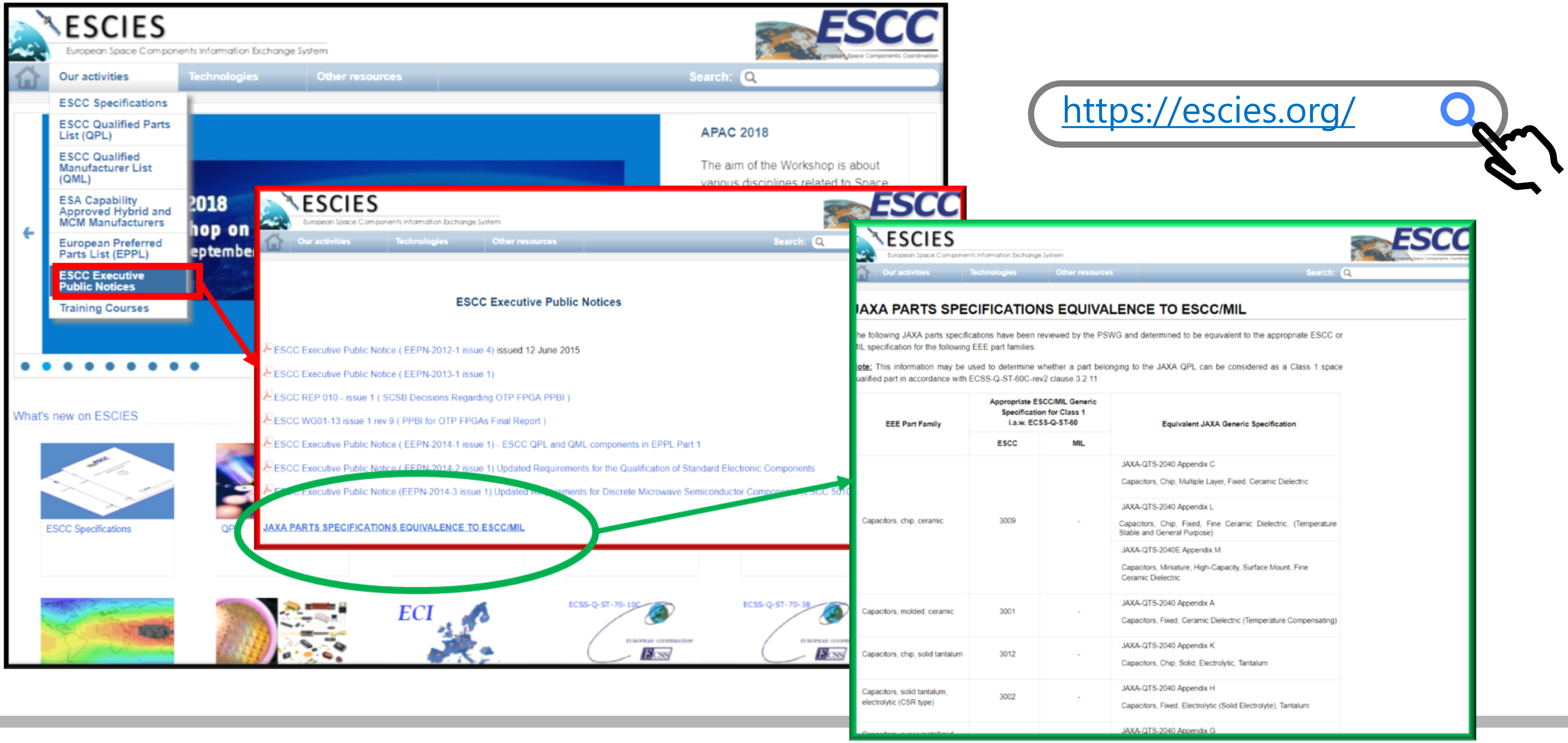
Table 2. comparison JAXA/ESCC qualification system

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)

MoQ=Maintenance of Qualification QMS=Quality Management System

Comparison of JAXA/ESCC qualification 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).**



Recent activities of passive components

<Background>

- Commercial Off-The-Shelf (COTS) components, especially for automotive or industrial, are expected to apply to the latest space applications due to its advantage of performance and cost.
- However, since COTS components don't conform to space standards, COTS components must be evaluated according to the reliability and quality assurance requirements.
- Currently, JAXA does not have the latest passive COTS component evaluation guidelines.
- Therefore, in order to prepare the evaluation guidelines for space use of passive COTS components such as polymer tantalum capacitor, solid state battery and stacked metallized film chip capacitor, voltage-controlled crystal oscillator, we have started evaluation activity for tolerance to space environment.

<Contents of evaluation>

- **Construction analysis such as external visual examination, radiographic examination, cross-section observation, and SEM(Scanning Electron Microscope) observation and EDX(Energy-dispersive X-ray spectroscopy) analysis was performed on the components shown in Table 3.**

Table 3. The list of the components

Component type	Manufacture	Characteristic
Polymer tantalum capacitor	Manufacture A	-Rated voltage: 10V -Nominal capacitance: 150μF -Operating temperature range: - 55℃ ~ +105℃
Solid state battery	Manufacture B	-Rated voltage: 1.5V -Capacity: 100μAh -Dimensions (L×W×H mm): 4.4 x 3.0 x 1.1 mm -Operating temperature range: - 20℃ ~ +80℃
Stacked metallized film chip capacitor	Manufacture C	-Rated voltage: 100V -Nominal capacitance: 0.018μF -Capacitance tolerance: ±10 % -Operating temperature range: - 55℃ ~ +125℃
Voltage-controlled crystal oscillator	Manufacture D	-Nominal frequency: 100, 122.8, 125MHz -Rated voltage: 3.3V -Operating temperature range: 0℃ ~ +70℃, -40℃ ~ +85℃

- **The evaluation results for each component are shown on the following pages.**

(1) The result of polymer tantalum capacitor

● external visual examination

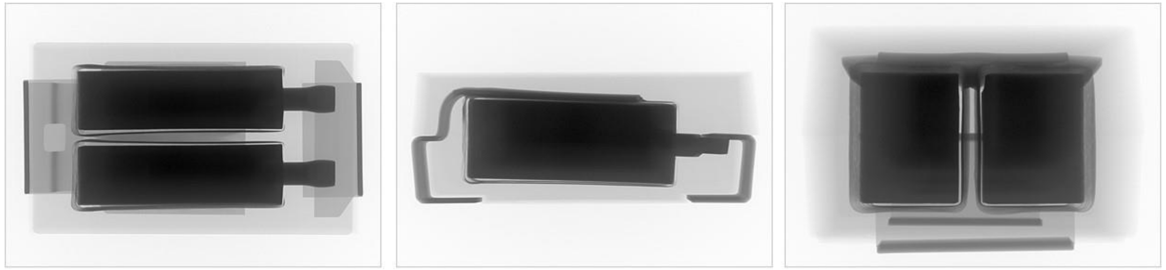
➢ **The result of the external visual examination is shown in Fig. 2. We performed at a magnification between 30X and 50X. No defects such as plating peelings or cracks were observed.**

top (30X) side (30X) electrode (50X)

Fig. 2. The result of external visual examination of polymer tantalum capacitor

● radiographic examination

➢ **The result of radiographic examination is shown in Fig. 3. No internal defects were observed.**



Y-axis X-axis Z-axis

Fig. 3. The result of radiographic examination of polymer tantalum capacitor

(1) The result of polymer tantalum capacitor

- **cross-section observation**

➢ **The result of cross-section observation is shown in Fig. 4. No defects were observed in the electrodes and internal elements.**

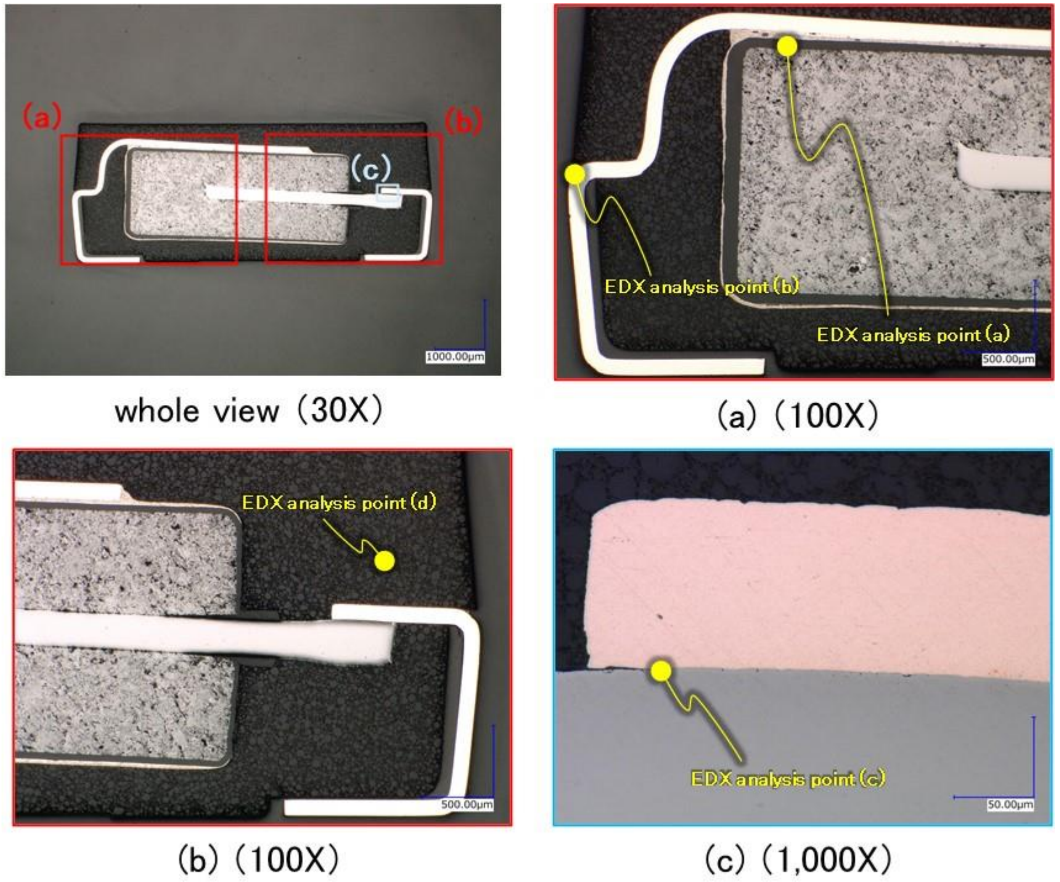
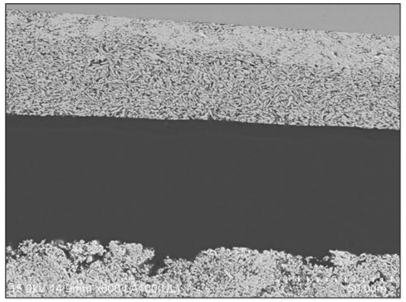


Fig. 4. The result of cross-section observation of polymer tantalum capacitor

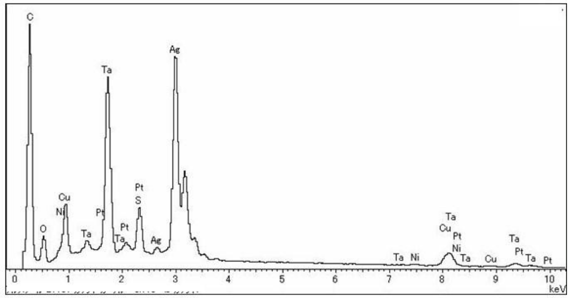
(1) The result of polymer tantalum capacitor

● SEM / EDX analysis

➢ **The result of SEM / EDX analysis is shown in Fig. 5. There are concerns about the degradation of conductive polymer materials due to radiation exposure and the effects of outgassing from mold resin.**

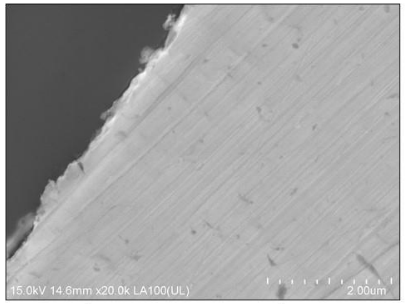


SEM image(backscattered electron image):

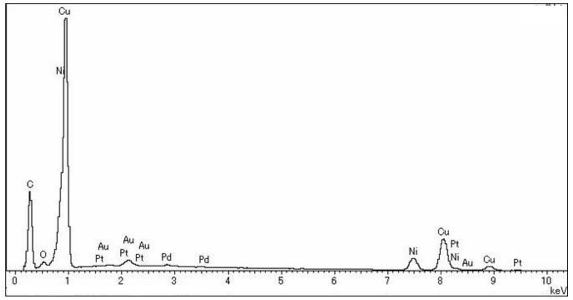


EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (a): electrode, conductive adhesive, tantalum element

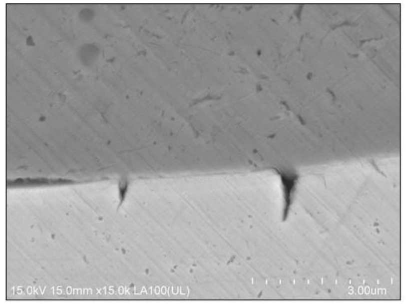


SEM image(backscattered electron image):

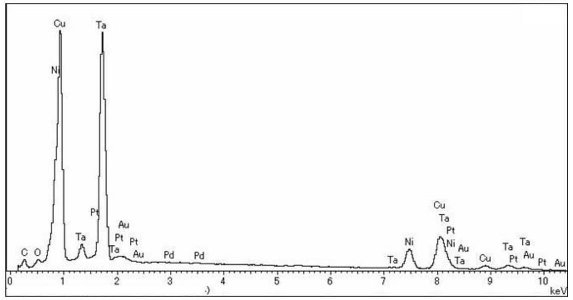


EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (b): electrode

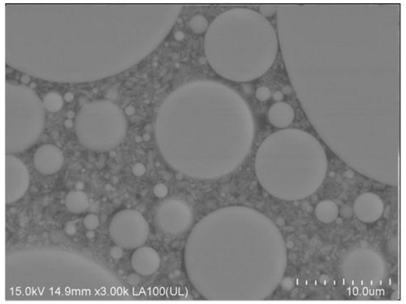


SEM image(backscattered electron image):

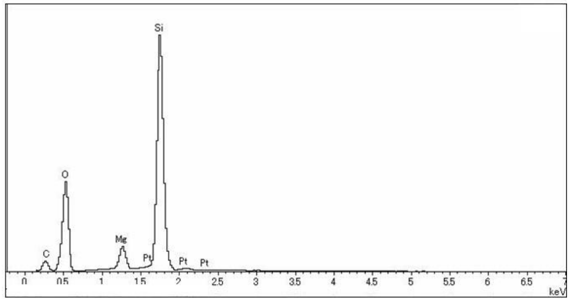


EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (c): electrode, tantalum wire



SEM image(backscattered electron image):



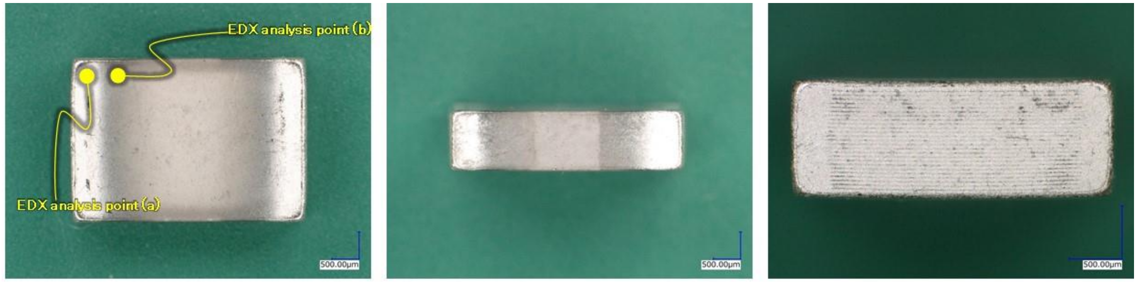
EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (d): mold resin

Fig. 5. The result of SEM / EDX analysis of polymer tantalum capacitor

● external visual examination

➢ The result of the external visual examination is shown in Fig. 6. We performed at a magnification between 50X and 100X. No defects such as plating peelings or cracks were observed.



top (50X) side (50X) Electrode(100X)

Fig. 6. The result of external visual examination of solid state battery

● radiographic examination

➢ The result of radiographic examination is shown in Fig. 7. No defects were observed in the electrodes and internal elements.

Y-axis X-axis Z-axis

Fig. 7. The result of radiographic examination of solid state battery

- **cross-section observation**
  - ➢ **The result of cross-section observation is shown in Fig. 8. Small voids were confirmed in the ceramic element, so there are concerns that leakage current will occur between the internal electrodes and the insulation resistance will decrease.**

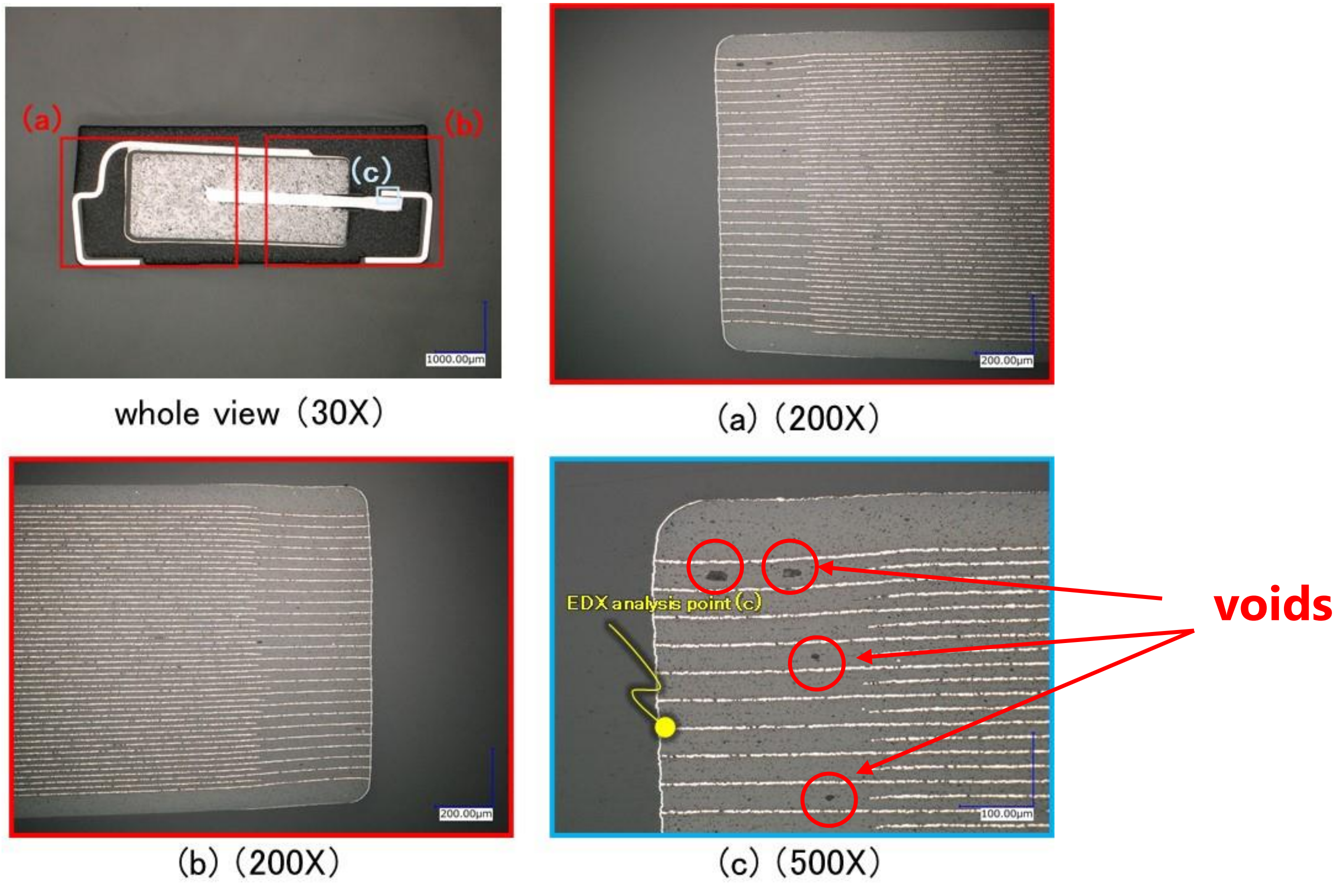
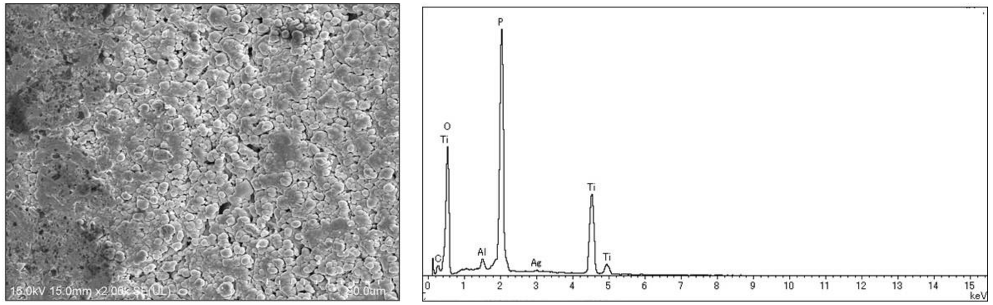


Fig. 8. The result of cross-section observation of solid state battery

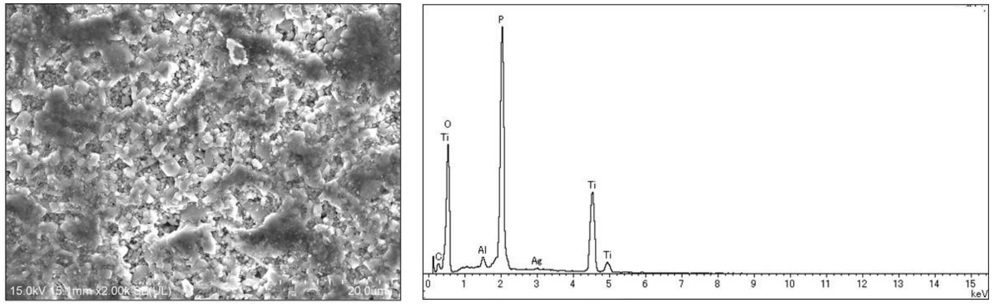
● SEM / EDX analysis

➢ **The result of SEM / EDX analysis is shown in Fig. 9. Since silver is used as the electrode material, there is concern about short circuits due to dendrites.**



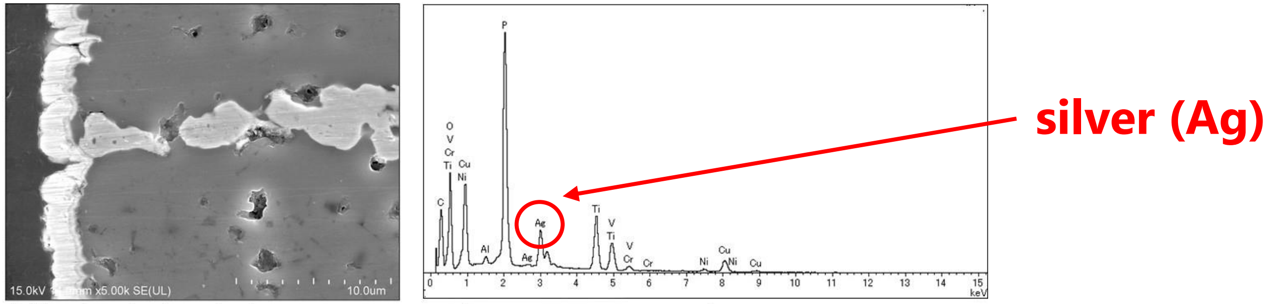
SEM image(secondary electron image): EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (a): external electrode, Ceramic body



SEM image(secondary electron image): EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (b): external electrode, ceramic body



SEM image(secondary electron image): EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (c): external and internal electrode, ceramic body

Fig. 9. The result of SEM / EDX analysis of solid state battery

(3) The result of stacked metallized film chip capacitor

● external visual examination

➢ The result of the external visual examination is shown in Fig. 10. No defects were observed in the electrodes and internal elements.

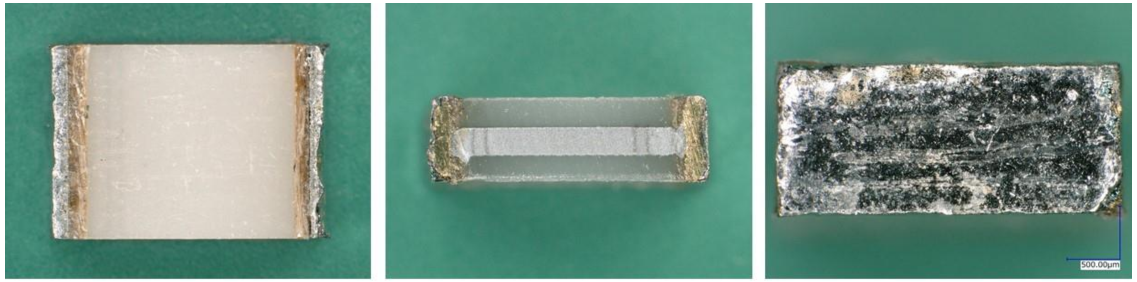


Fig. 10. The result of external visual examination of stacked metallized film chip capacitor

● radiographic examination

➢ The result of radiographic examination is shown in Fig. 11. No defects were observed in the electrodes and internal elements.

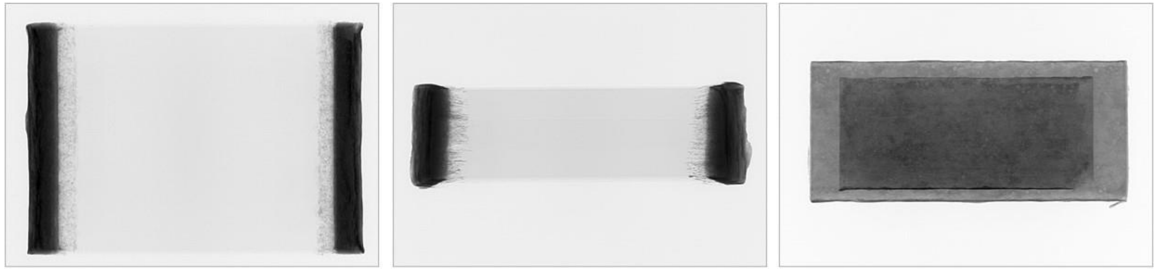


Fig. 11. The result of radiographic examination of stacked metallized film chip capacitor

● cross-section observation

- The result of cross-section observation is shown in Fig. 12. Since gaps were observed between the dielectric films, there are concerns that mechanical and thermal stress may widen the gaps and cause cracks.

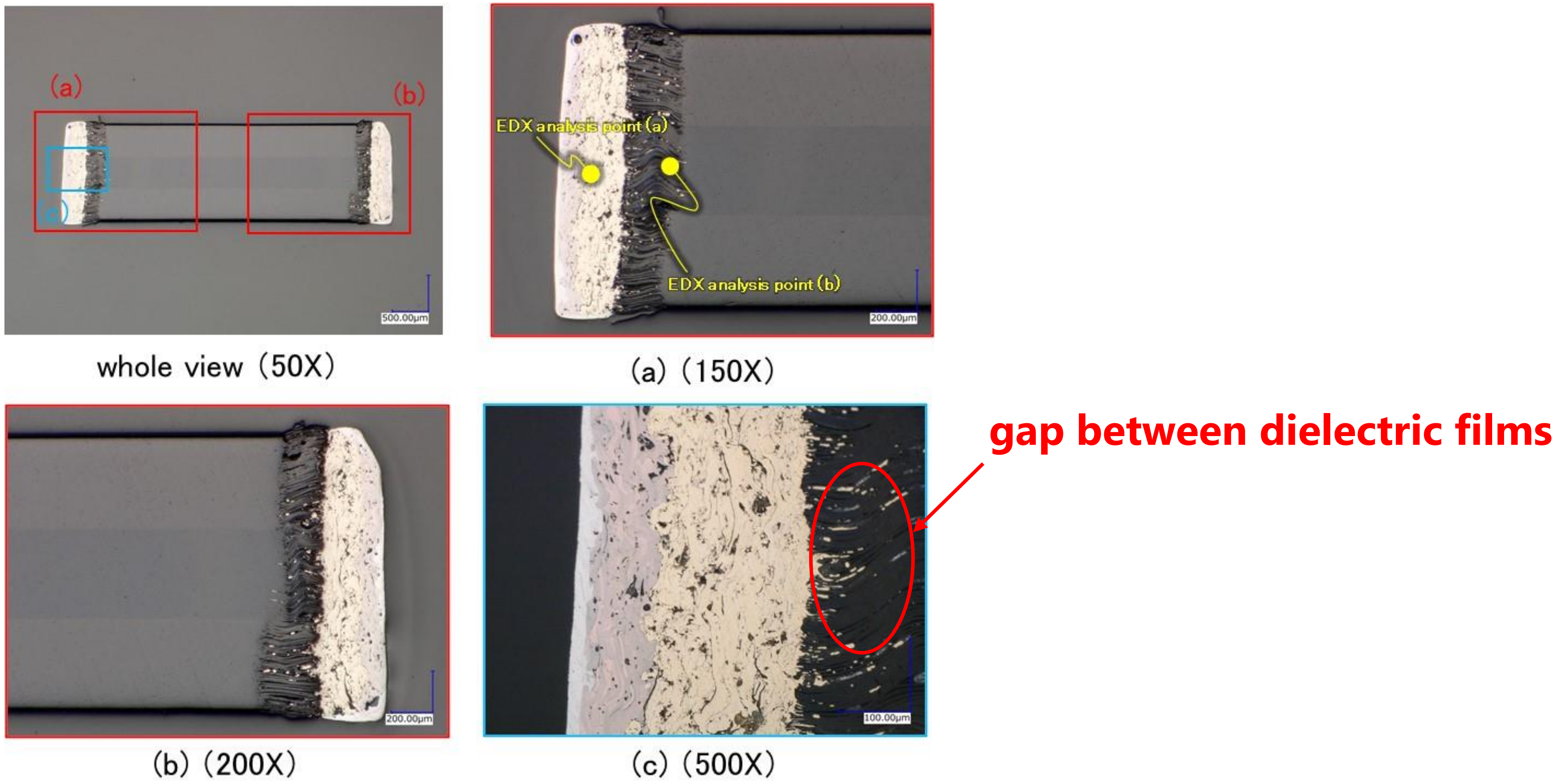
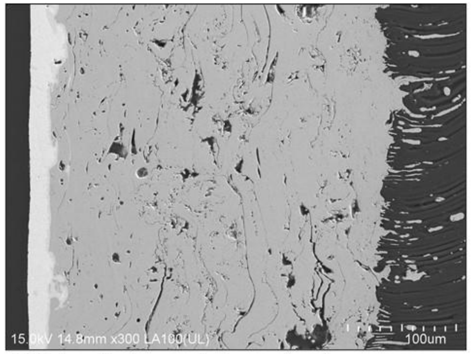


Fig. 12. The result of cross-section observation of stacked metallized film chip capacitor

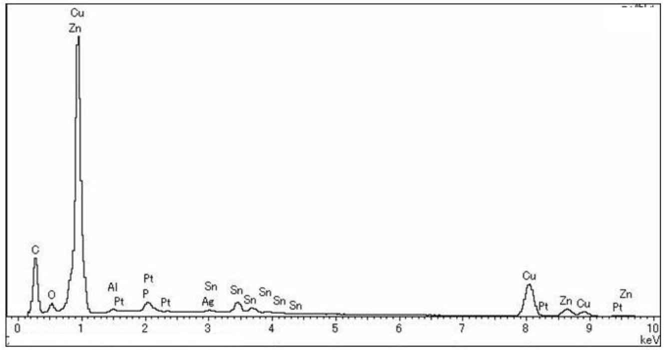
(3) The result of stacked metallized film chip capacitor

● SEM / EDX analysis

➢ **The result of SEM / EDX analysis is shown in Fig. 13. There are concerns about the degradation of the dielectric films due to radiation exposure.**

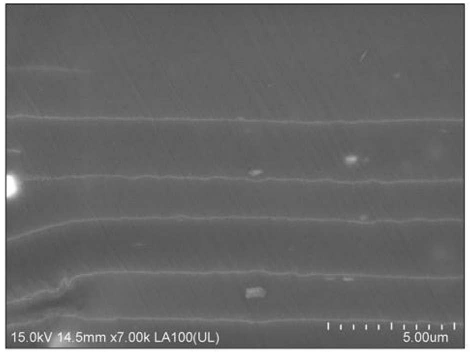


SEM image(backscattered electron image):

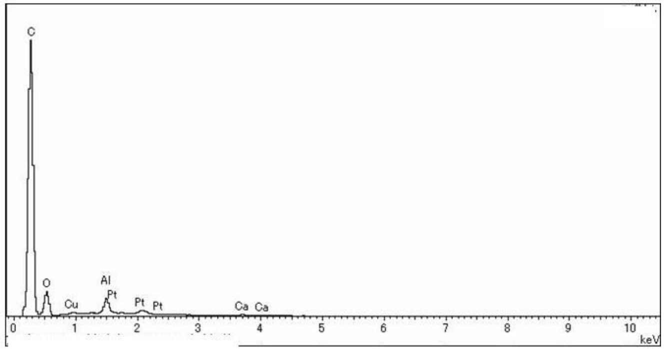


EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (a): external electrode



SEM image(backscattered electron image):



EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (b): internal electrode, metallized film

Fig. 13. The result of SEM / EDX analysis of stacked metallized film chip capacitor

(4) The result of voltage-controlled crystal oscillator

- **external visual examination**
  - **The result of the external visual examination is shown in Fig. 14. No defects were observed.**

top (20X) side(X-axis) (20X) Side(Z-axis) (30X)

Fig. 14. The result of external visual examination of voltage-controlled crystal oscillator

- **radiographic examination**
  - **The result of radiographic examination is shown in Fig. 15. No defects were observed in internal elements.**

Y-axis X-axis Z-axis

Fig. 15. The result of radiographic examination of voltage-controlled crystal oscillator

● internal visual examination

➢ **The result of the internal visual examination is shown in Fig. 16. Uneven coating of the conductive adhesive for mounting the crystal element was confirmed.**

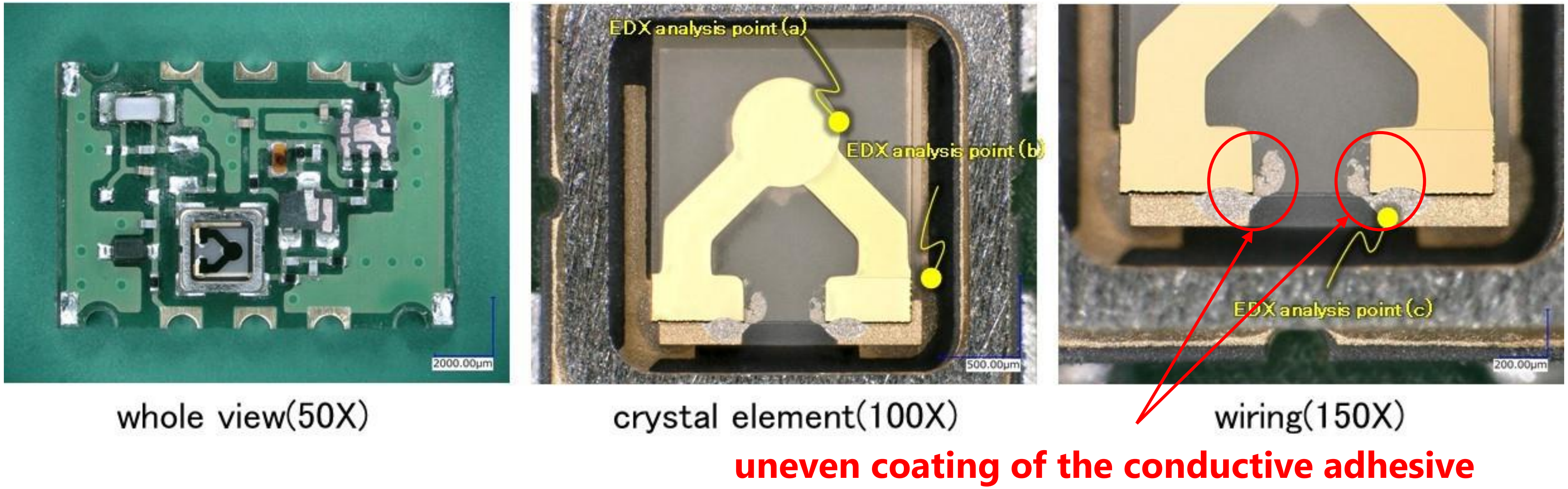
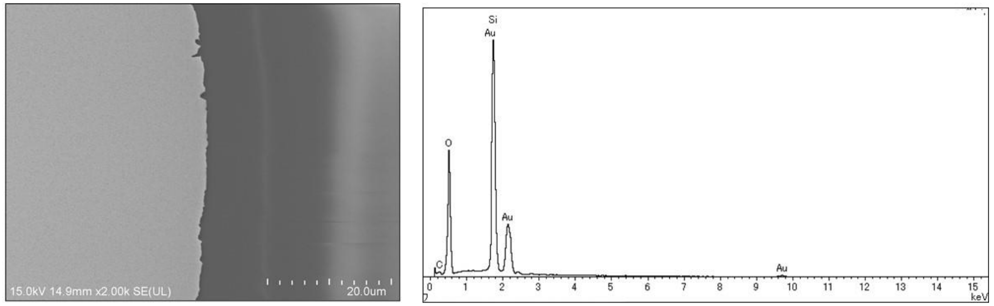


Fig. 16. The result of internal visual examination of voltage-controlled crystal oscillator

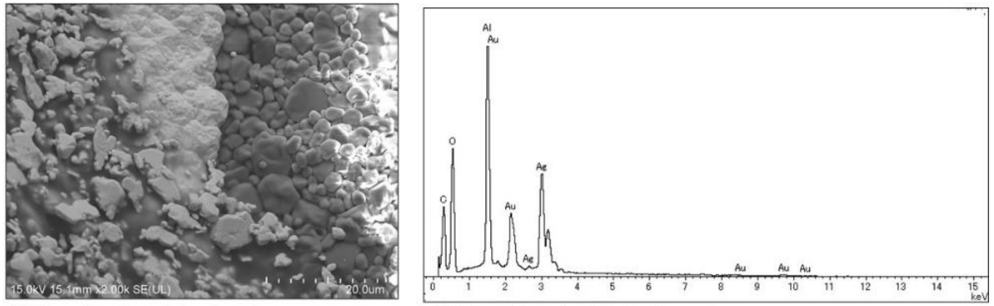
● SEM / EDX analysis

➢ **The result of SEM / EDX analysis is shown in Fig. 17. Since silver is used as the conductive adhesive for the crystal element, there is concern about short circuits due to dendrites.**



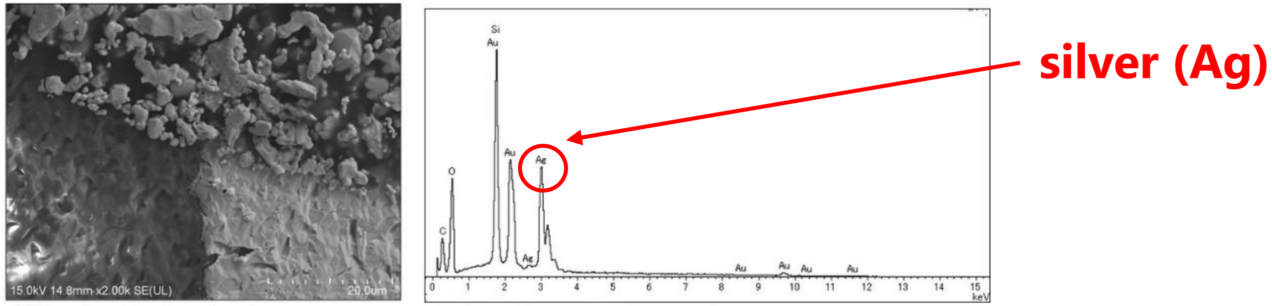
SEM image(secondary electron image) EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (a): electrode, crystal element



SEM image(secondary electron image) EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (b): ceramics, conductive adhesive, wiring



SEM image(secondary electron image) EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (c): crystal element, conductive adhesive, wiring

Fig. 17. The result of SEM / EDX analysis of voltage-controlled crystal oscillator

Summary of evaluation results

- As a result of material and structural analysis of polymer tantalum capacitor, solid state battery, stacked metallized film chip capacitor, and voltage-controlled crystal oscillator, we confirmed concerns about radiation, thermal, and mechanical weakness.
- In the future, we will perform radiation tests, heat resistance tests and mechanical strength tests and prepare the evaluation guidelines for space use of passive COTS components.

Summary

- **We introduced an overview of JAXA qualified passive components and their qualification requirement.**
  - ✓ Currently there are 104 JAXA qualified passive components and 19 of them are listed in EPPL.
  - ✓ The qualification system in JAXA is quite similar to that in ESCC and its general requirements were outlined in comparison with those in ESCC system.
  - ✓ As the result of comparison, the qualification test requirements of JAXA qualification system are verified to be equivalent to that of ESCC system.

- **We also introduced the evaluation activity for the tolerance to the space environment of the passive COTS components.**
  - ✓ As a result of material and structural analysis of some passive COTS components, and voltage-controlled crystal oscillator, we confirmed concerns about radiation, thermal, and mechanical weakness.
  - ✓ In the future, we will perform radiation tests, heat resistance tests and mechanical strength tests and prepare the evaluation guidelines for space use of passive COTS components.

Thank you for your attention.

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