The latest activities related to the passive components in JAXA

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INTRODUCTION

In the present day, there are 129 models of passive and active components in Japan which meet the requirement of space components. They are qualified as JAXA qualified components by JAXA. Some of JAXA qualified components which have been gone through the review by ESA and met the criteria are included in the European Preferred Parts List (EPPL). These components contribute to the realization of rockets and space satellites, including commercial and government satellites. In recent years, the satellites which require lower cost and have shorter life time, called "New Space" satellites, are rapidly increasing. Although the high quality and high cost components may not be required for such new space satellites, we believe the needs for space satellites are becoming polarized. The satellites will become larger as the space missions become more complex and more difficult. Such satellites should be accepting even fewer failures than the current satellites. Therefore, high-spec and high quality components will be required even more.

In addition to the components which are qualified for space use, 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, we have started a space tolerance evaluation activity to prepare the evaluation guidelines for space use of passive COTS components.

In this paper, we show the JAXA qualified passive components and the evaluation activity for the tolerance to the space environment of the passive COTS components.

Note that what they call "component" in Europe is called "part" in Japan ("Component" indicates "subsystem" in Japan). However, in this paper "component" is used for the same meaning as "part."

JAXA QUALIFIED PASSIVE COMPONENTS

There is a total of 129 models of JAXA qualified components, of which 104 models are passive components. Note that the PCBs and materials such as thermal control films are also included in JAXA qualified components. A list of JAXA qualified passive components and EPPL listed components are shown in Table 1.

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

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. In Table 1, components indicated in red are currently listed in EPPL. These components can be used for European space mission because their quality and the reliability have been already verified. Recently, JAXA-qualified rectangular microminiature connectors were included in the EPPL in January 2022. More information about JAXA qualified components can be found in the JAXA EEE parts database [1]. The detail specifications and the applicable documents for all JAXA qualified components are available therein.

COMPARISON OF JAXA/ESCC QUALIFICATION TEST SPECIFICATION OF THE PASSIVE COTS COMPONENTS

JAXA qualified components are examined in the qualification test which are described in the generic and detail specification documents. As described in last SPCD presentation [2], there are three kinds of specification documents in JAXA; General / basic specification called "JAXA-QTS-2000 [3]" defines basic requirements that are common for all component families. The generic specification defines common requirements for each component family. Detail requirements for each component family are defined in its detail specification. It has been verified that JAXA qualification system based on the above documents is similar to the ESCC (European Space Components Coordination) qualification system in the previous JAXA-ESA cooperation framework. The summary of the comparison results is shown in Table 2. The document tree of JAXA qualification system compared with that of ESCC qualification system is shown in Fig.1.

Table 2. Summary of JAXA and ESA qualified system comparison results

System	JAXA	ESCC
Basic document	JAXA-QTS-2000	-ESCC 20100 (component qualification) -ESCC 25400 (technology flow)
Subject	Manufacturing line	-Components (component qualification) -Manufacturing technology (technology flow)
Duration	3 years	2 years
Manufacturing line	Commercial lines may be used	Same as JAXA-QML system
Change control of QA program	Decision is made by TRB	-Review and approved by ESCC (component qualification) -Same as JAXA-QML system (technology flow)
Test optimization	Decision is made by TRB Change must be described in the detail specification with rationale	-Restricted. Review / approval required by ESCC (component qualification) -Same as JAXA-QML system (technology flow)

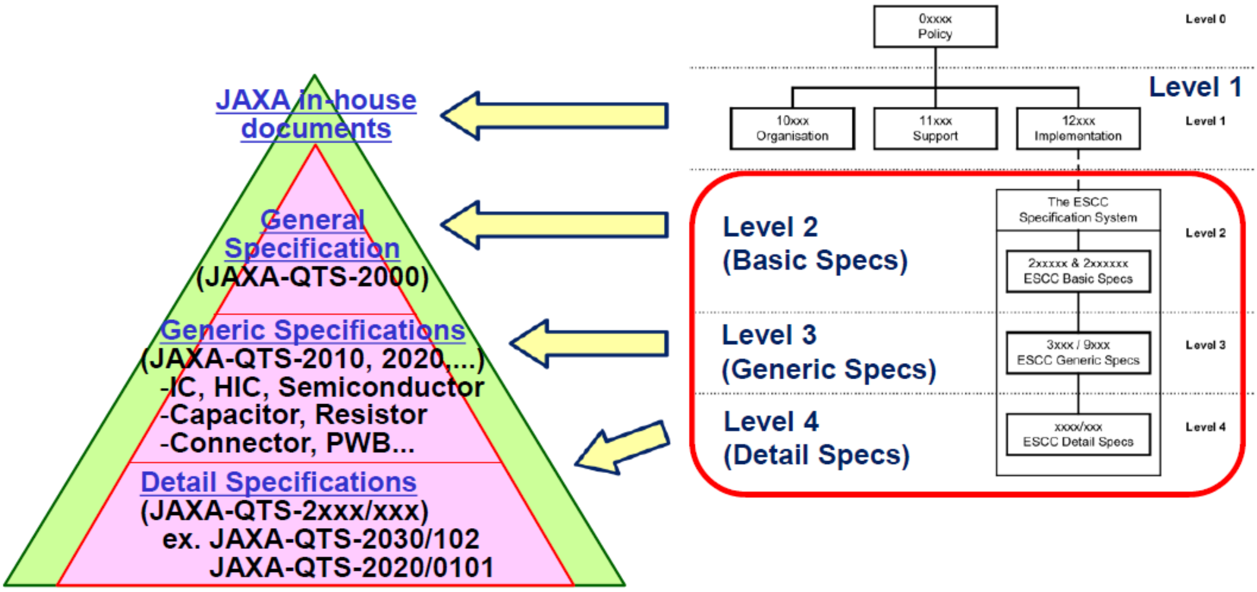


Fig. 1. Document tree of JAXA qualification system and ESCC qualification system

One major difference between the qualification system of JAXA and ESCC is that the basic requirements that are common for all component families are defined in one document (general specification (JAXA-QTS-2000)) [3] in JAXA qualification system. Another difference is that JAXA doesn't have its own specifications for test methods. The common requirements for each component family are defined in a generic specification. Detail requirements for each component are defined in its detail specification. Approval procedure for component qualification is defined in JAXA in-house documents. All the specifications are available through JAXA EEE parts database [1]. Duration of the certification is also different between JAXA/ESCC qualification systems. The certification is valid for 3 years in JAXA qualification system whereas it is valid for 2 years in ESCC system. There is no other major difference when compared JAXA system with ESCC system.

Same comparison activity has been performing among the specification of DLA (Defence Logistics Agency) and the specification of JAXA and ESCC. Although there are some differences that come from the different background ideas, the equivalence was confirmed among the specification of DLA, ESCC and JAXA QTS.

EVALUATION OF COTS COMPONENTS FOR TOLERANCE TO SPACE ENVIRONMENT

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.

Construction Analysis by DPA

To evaluate the tolerance to the space environment of passive COTS components such as polymer tantalum capacitor, voltage-controlled crystal oscillator, solid state battery and stacked metallized film chip capacitor, we prepared one product from each part type. The specifications of the parts are shown in Table 3.

Table 3. The specifications of the parts

Part type	Manufacture	Characteristic
Polymer tantalum capacitor	Manufacture A	-Rated voltage: 10V -Nominal capacitance: 150μF -Operating temperature range: - 55°C ~ +105°C
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°C ~ +80°C
Stacked metallized film chip capacitor	Manufacture C	-Rated voltage: 100V -Nominal capacitance: 0.018μF -Capacitance tolerance: ±10 % -Operating temperature range: - 55°C ~ +125°C
Voltage-controlled crystal oscillator	Manufacture D	-Nominal frequency: 100, 122.8, 125MHz -Rated voltage: 3.3V -Operating temperature range: 0°C ~ +70°C, -40°C ~ +85°C

As the construction analysis method, external visual examination, radiographic examination, cross-section observation, and SEM(Scanning Electron Microscope) observation and EDX(Energy-dispersive X-ray spectroscopy) analysis were adopted. The analysis results for each component are shown below.

The construction analysis result of polymer tantalum capacitor

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.

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

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

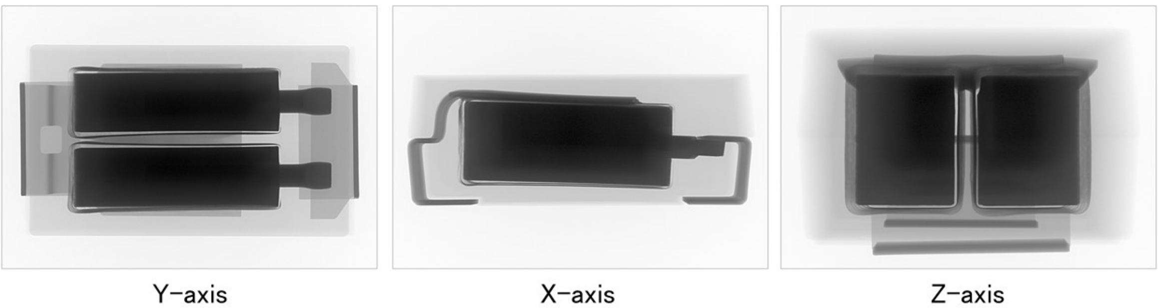


Fig. 3. The result of radiographic examination of polymer tantalum capacitor

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

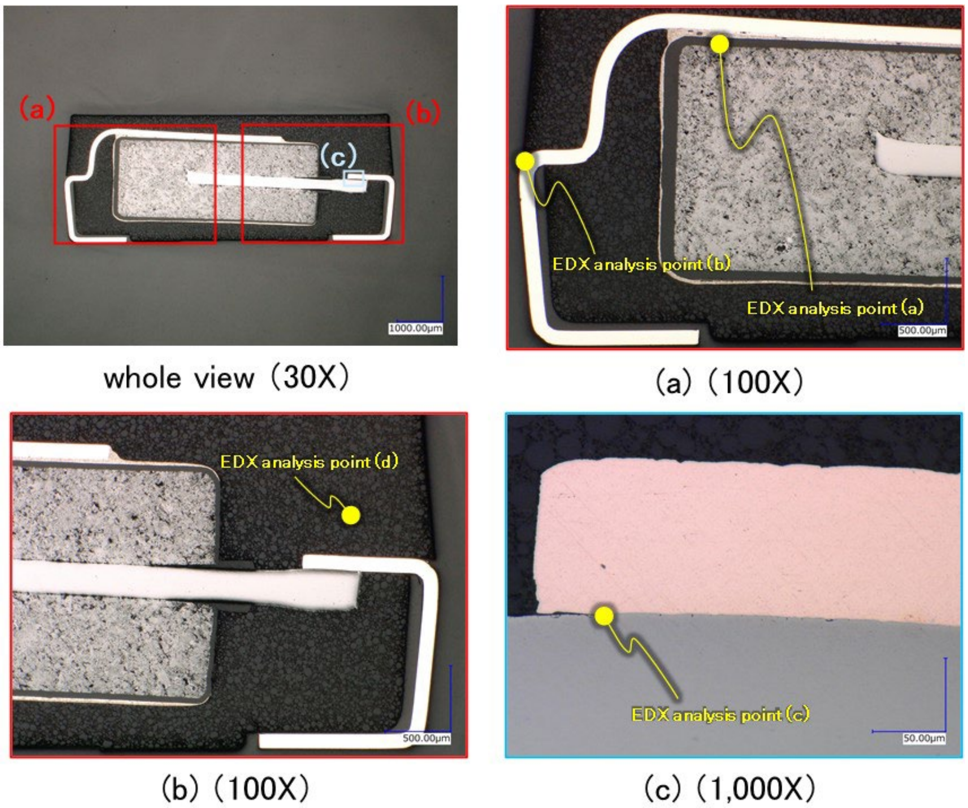
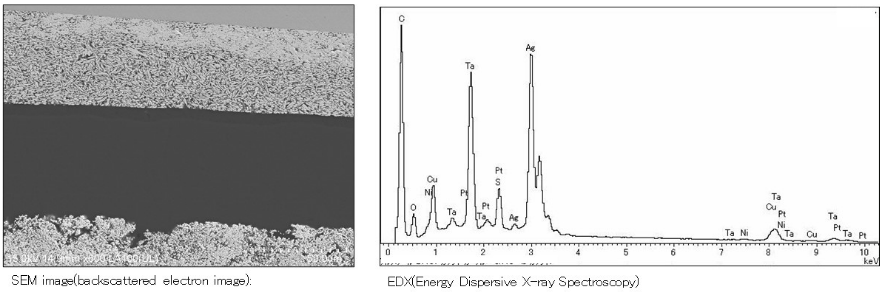
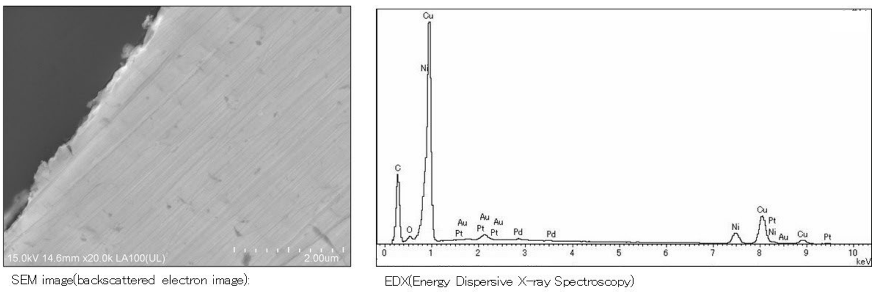


Fig. 4. The result of cross-section observation of polymer tantalum capacitor

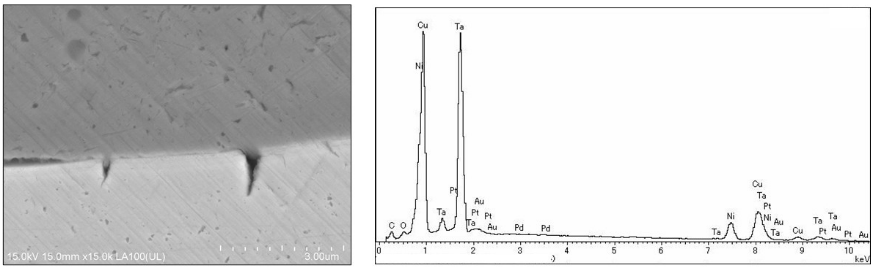
The result of SEM / EDX analysis is shown in Fig. 5. There are concerns about the degradation of conductive polymer materials due to radiation exposure and the effects of outgassing from mold resin.



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

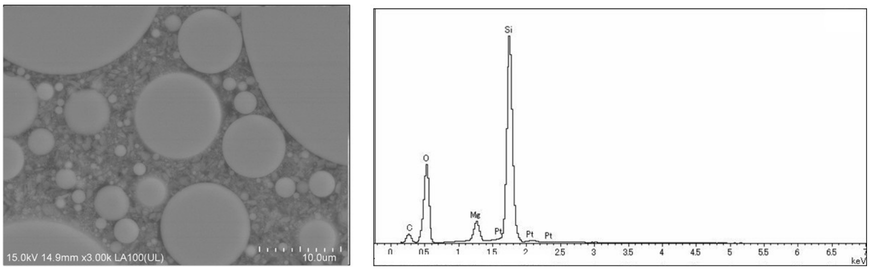


EDX point (b): electrode



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

EDX point (c): electrode, tantalum wire



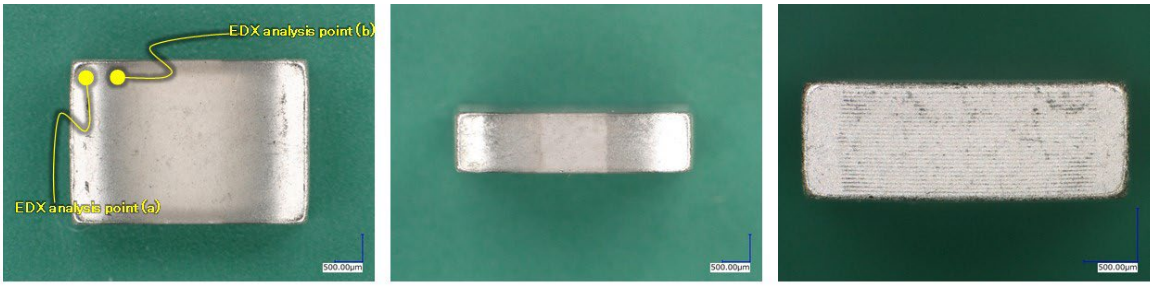
SEM image(backscattered electron image)　　EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (d): mold resin

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

The construction analysis result of solid state battery

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 the external visual examination of solid state battery

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

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

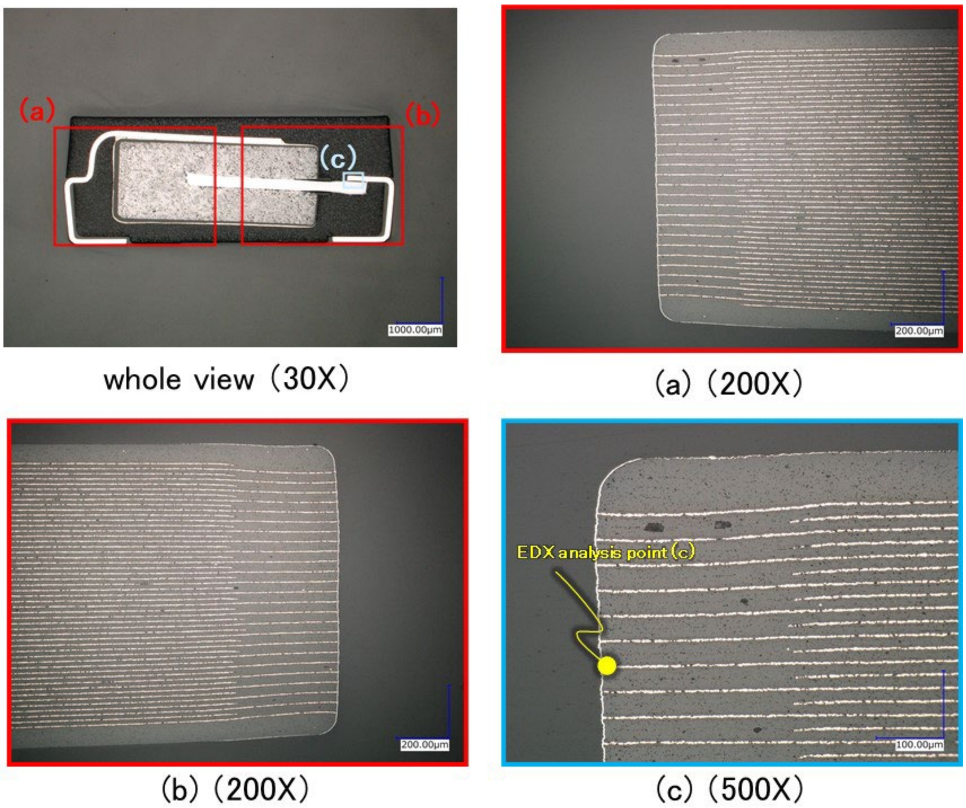
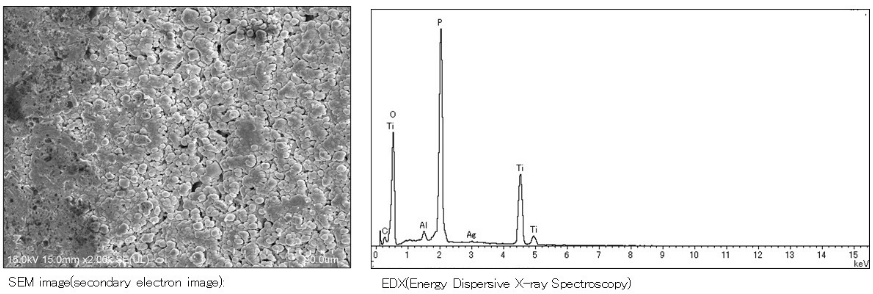
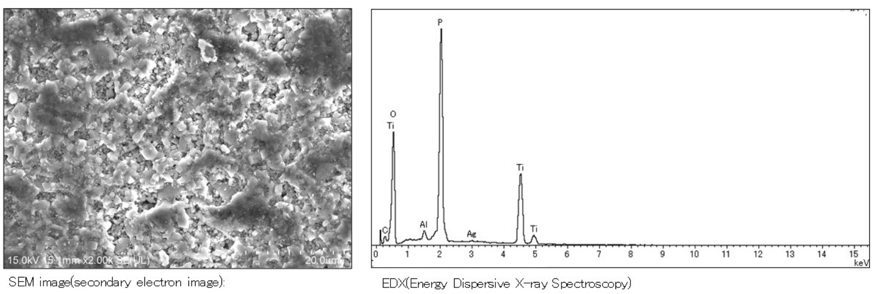


Fig. 8. The result of cross-section observation of solid state battery

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.



EDX point (a): external electrode, Ceramic body



EDX point (b): external electrode, ceramic body

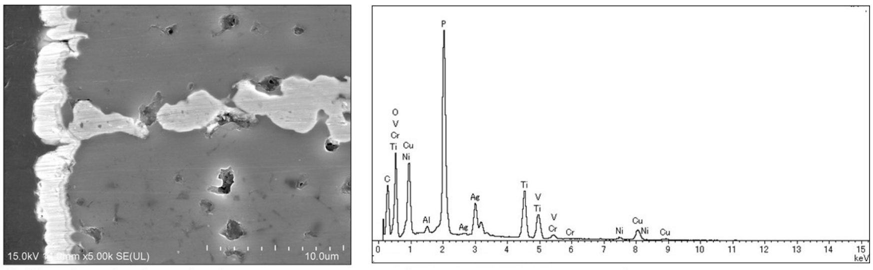


Fig. 9. The result of SEM / EDX analysis of solid state battery

The construction analysis result of stacked metallized film chip capacitor

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

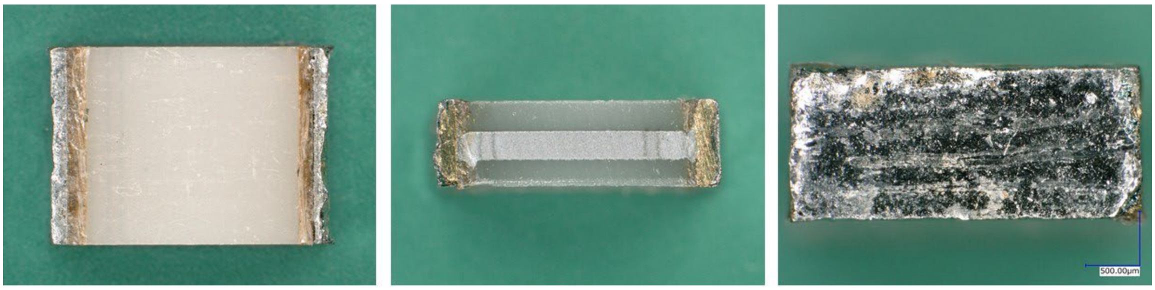


Fig. 10. The result of the external visual examination of stacked metallized film chip capacitor

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

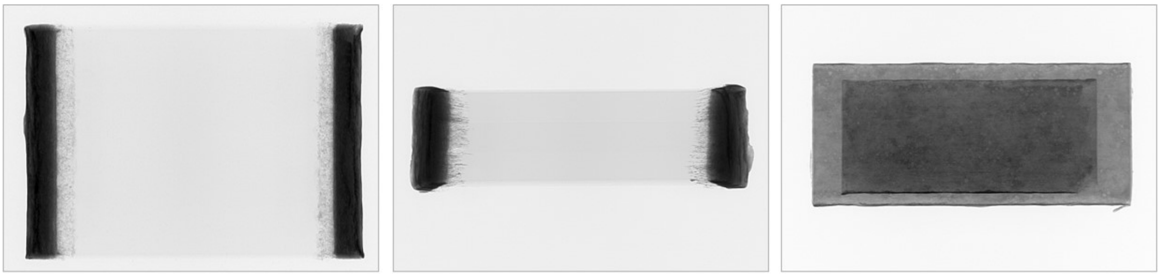


Fig. 11. The result of radiographic examination of stacked metallized film chip capacitor

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

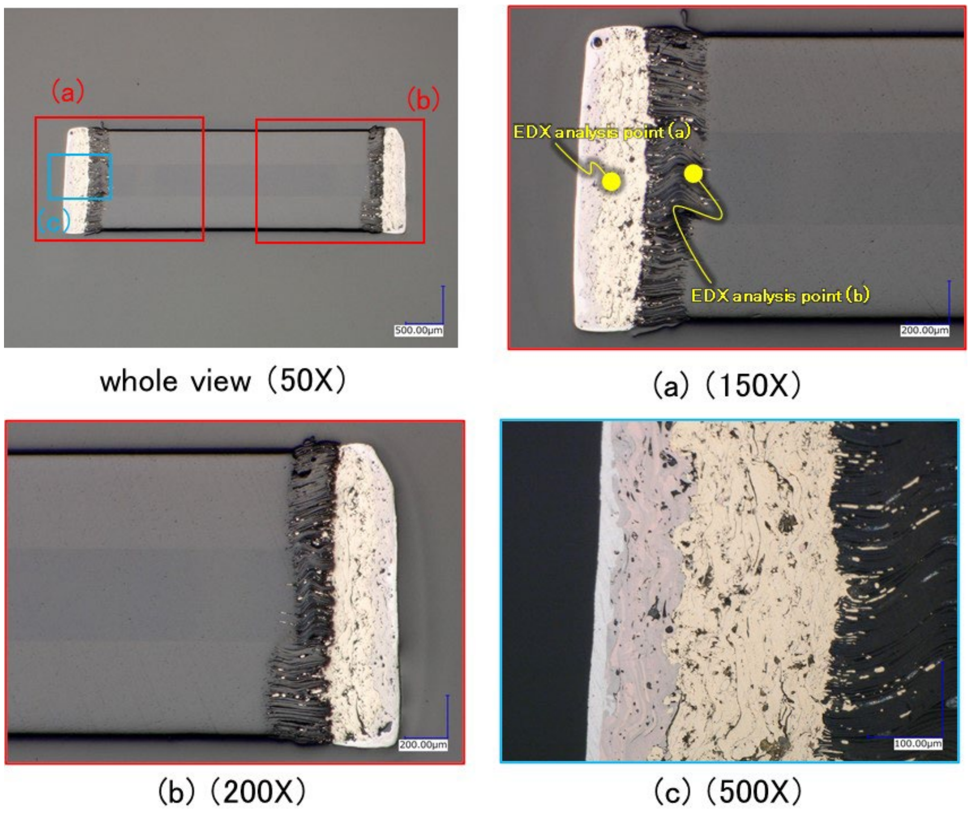


Fig. 12. The result of cross-section observation of stacked metallized film chip capacitor

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.

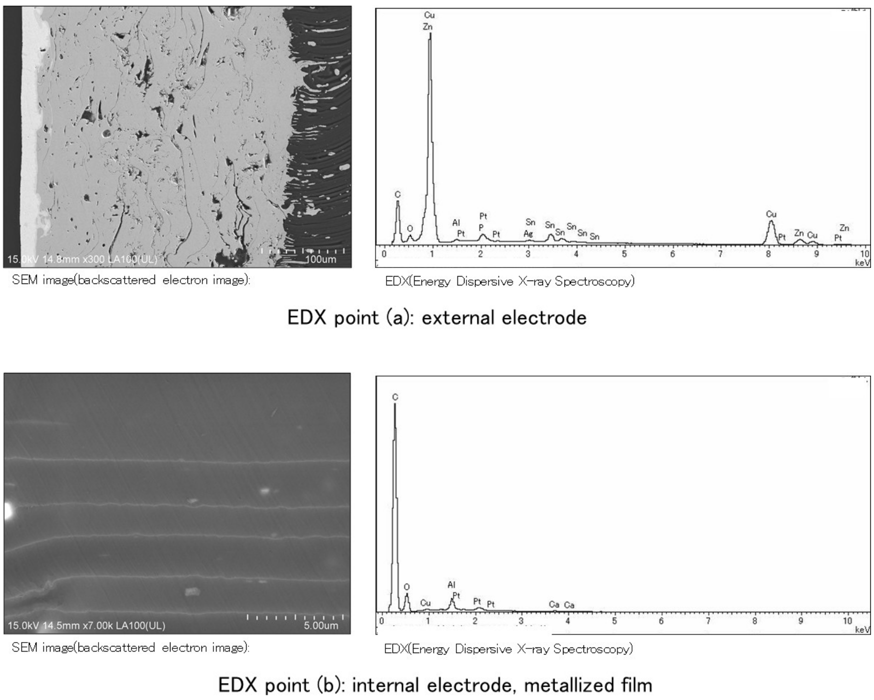


Fig. 13. The result of SEM / EDX analysis of stacked metallized film chip capacitor

The construction analysis result of voltage-controlled crystal oscillator

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)

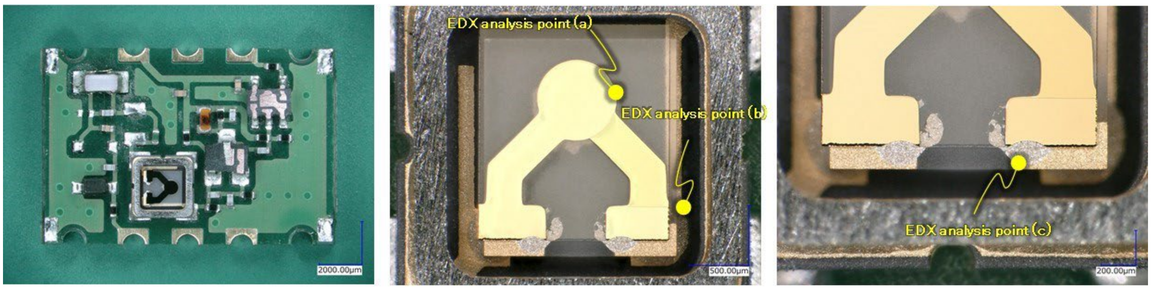
Fig. 14. The result of the external visual examination of voltage-controlled crystal oscillator

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

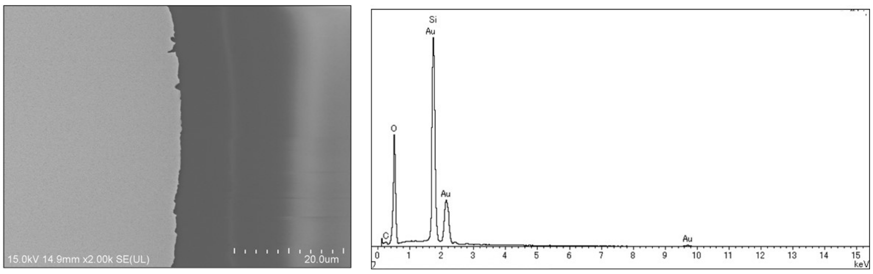
The result of the internal visual examination is shown in Fig. 16. Uneven coating of the conductive adhesive for mounting the crystal element was confirmed.



whole view(50X) crystal element(100X) wiring(150X)

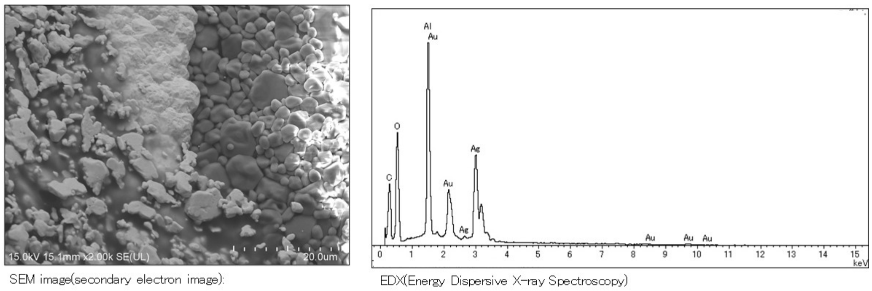
Fig. 16. The result of the internal visual examination of voltage-controlled crystal oscillator

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.

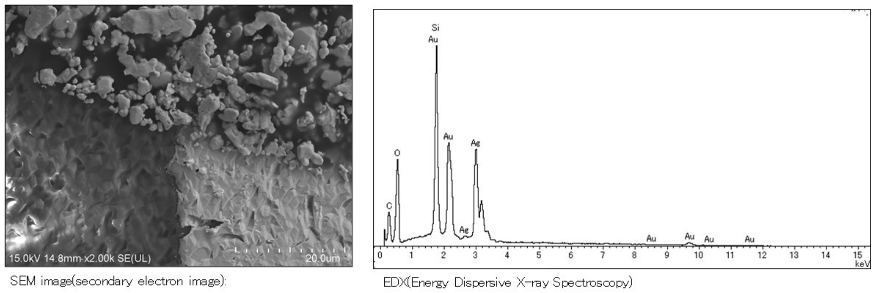


SEM image(secondary electron image) EDX(Energy Dispersive X-ray Spectroscopy)

EDX point (a): electrode, crystal element



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



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

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

As a result of material and structural analysis of polymer tantalum capacitor, voltage-controlled crystal oscillator, solid state battery and stacked metallized film chip capacitor, 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

An overview of JAXA qualified passive components and their qualification requirement was introduced. Currently there are 104 JAXA qualified passive components and 20 of them are listed in EPPL. Most of them are qualified using JAXA-QML system, which is similar to the technology flow qualification in ESCC system. The qualification system in JAXA is quite similar to that in ESCC and its general requirements are 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.

As a result of material and structural analysis of some passive COTS components, 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.

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