The latest activities related to the passive components in JAXA

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Kensuke Shiba(1) and Koichi Suzuki(1)

(1) Japan Aerospace Exploration Agency (JAXA) Safety & Mission Assurance department
Email: shiba.kensuke@jaxa.jp

INTRODUCTION

In the present day, there are 121 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 lifetime, 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 do not 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 121 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 Chip, Solid, Electrolytic, Tantalum EPPL	3(*1) 1	Murata Matsuo Electric
Resistors	Chip, Thick Film EPPL Wire-Wound (Power Type) Film Networks, Film Chip, Thin Film EPPL	1 2 2 1 3 1 1	Tateyama Kagaku Hokuriku Electric Seiden Techno Sanada KOA Sanada KOA Sanada KOA Sanada KOA
Thermistors	Chip, Negative Temperature Coefficient EPPL Lead, Negative Temperature Coefficient EPPL	1 1	Tateyama Kagaku Tateyama Kagaku
Fuses	Subminiature, Current-Limiting EPPL Surface Mount, Miniature, Current-Limiting EPPL	1 1	Tateyama Kagaku Tateyama Kagaku
Temp. Sensors	Platinum EPPL	3	MHI(*2)
Osc. Crystals	Quartz Crystal Units Crystal Controlled Oscillators EPPL	3 1	Nihon Dempa Kogyo Nihon Dempa Kogyo
Transformers and Inductors	Power Others	2 6	Tamura Tamura
Wires and Cables	Differential Transmission Cables EPPL	2	Junkosha
Connectors	Rectangular, Miniature Rectangular, Miniature, High Density Rectangular, Microminiature EPPL Rectangular Miniature Mixed Coaxial, RF	1 1 1 1 1 1 1 3	JAE(*3) Nihon Maruko JAE(*3) Nihon Maruko ITT Cannon Nihon Maruko Nihon Maruko Waka Manufacturing
Printed Wiring Boards	Fine Pitch Printed Wiring Boards, Glass Base Woven Epoxy Resin Base Material	1 1 1	EIGHT KOUGYO CMK OKI Circuit Technology
	Fine Pitch Printed Wiring Boards, Glass Base Woven Polyimide Resin or Glass Base Woven Epoxy Resin Base Material	1	OKI Circuit Technology
	Flexible, Polyimide Film Base Material	1	OKI Circuit Technology
	Rigid-Flexible	1	OKI Circuit Technology
	Glass Base Woven Polyimide Resin or Glass Base Woven Epoxy Resin Base Material	1	OKI Circuit Technology
	CIC Controlled Thermal Expansion, Glass Base Woven Polyimide Resin Base Material	1	OKI Circuit Technology
	Area Array Packaging	1	OKI Circuit Technology
	For High-speed Signals	1	OKI Circuit Technology

(*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 2024, 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 (Technology Review Board)	-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)

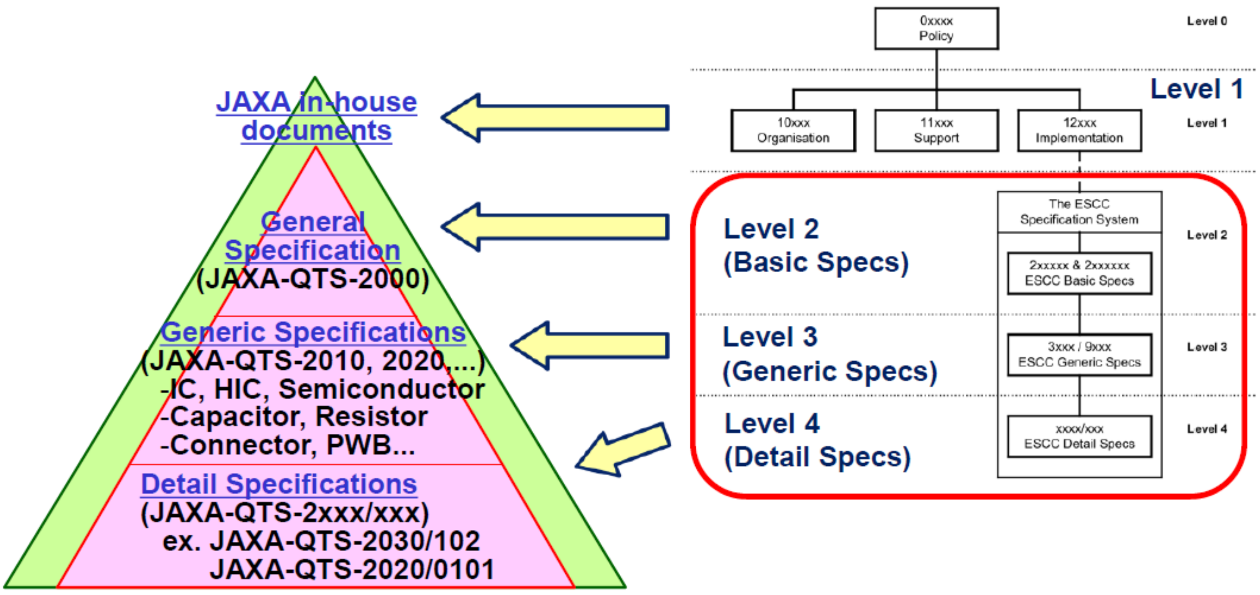


Fig. 1. Document tree of JAXA qualification system and ESCC qualification system

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. We presented the results of the DPA tests we conducted on these parts at the SPCD2022.We conducted TID tests, mechanical stress tests and thermal environment tests to evaluate the concerns we identified based on the internal structure and materials used in these components. Here, we will introduce the results of the environmental tests.

Samples under tests

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 components

Part type	Manufacture	Characteristic	Sample size
Polymer tantalum capacitor	Manufacture A	-Rated voltage: 10V -Nominal capacitance: 150μF -Operating temperature range: - 55℃ ~ +105℃	3ea
Stacked metallized film chip capacitor	Manufacture C	-Rated voltage: 100V -Nominal capacitance: 0.018μF -Capacitance tolerance: ±10% -Operating temperature range: - 55℃ ~ +125℃	3ea
Voltage-controlled crystal oscillator	Manufacture D	-Nominal frequency: 100, 122.8, 125MHz -Rated voltage: 3.3V -Operating temperature range: 0℃ ~ +70℃, -40℃ ~ +85℃	3ea
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℃	3ea

The thermal environment tests, the mechanical stress tests, and the TID tests were performed on the components shown in Table 3. The results are shown below.

The result of TID tests

We conducted TID tests under the test conditions shown in Table 4. The test facility was the National Institutes for Quantum Science and Technology, the radiation source was cobalt 60, and the dose rate was set at approximately 20k rads(Si)/hour.

Table 4. TID tests conditions

Part type	Conditions	Characteristic evaluation items	Criteria
Polymer tantalum capacitor	-Source: Cobalt 60 -Dose Rate: approximately 20k rads (Si) /hour -Dose: 100k rads (Si) -Characterization: Pre-irradiation, 0.1, 0.3, 0.5, 1.0 (Si) [kGy] -Bias of during irradiation	-Capacitance (Cap.) -Dissipation factor (tanδ) -leakage current	-Capacitance: within ±10% of initial value -Dissipation factor: 0.15 or less -leakage current: 450µA or less
Stacked metallized film chip capacitor		-Capacitance (Cap.) -Dissipation factor (tanδ) -Insulation resistance (IR)	-Capacitance: within ±5% of initial value -Dissipation factor: 0.012 or less - Insulation resistance: 1000MΩ or more
Voltage-controlled crystal oscillator		-Output frequency -Current consumption	-Output Frequency (Δf/f): ±50 ppm -Current consumption: Maximum 2x the nominal value
Solid-state battery	-Source: Cobalt 60 -Dose Rate: approximately 20k rads (Si) /hour -Dose: 100k rads (Si) -Characterization: Pre-irradiation, 1.0 (Si) [kGy] -Bias of during irradiation	-discharge capacity	-discharge capacity: N/A(Charge/discharge characteristic data acquisition only)

a) Polymer tantalum capacitor

The results of the electrical characteristic measurements after the TID test on the polymer tantalum capacitor are shown in Fig. 2.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was 1.61% compared to the judgment criteria of ±10% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.04176, compared to the judgment criteria of 0.15 or less.

Regarding the leakage current measurement result, it was confirmed that there were no abnormalities as the maximum value was 5.9µA, compared to the judgment criteria of 450µA or less.

No significant changes or abnormalities in electrical characteristics due to irradiation were observed.

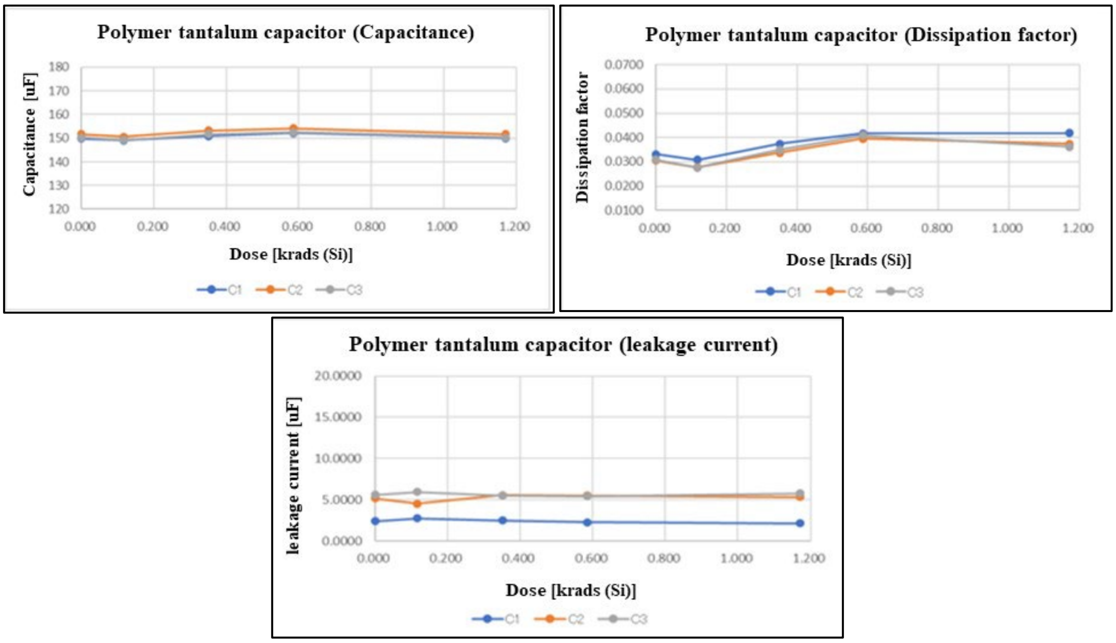


Fig. 2. The results of the electrical characteristic measurements after the TID test on the polymer tantalum capacitor

The results of the external visual examination after irradiation are shown in Fig. 3.

No significant changes or abnormalities were observed.

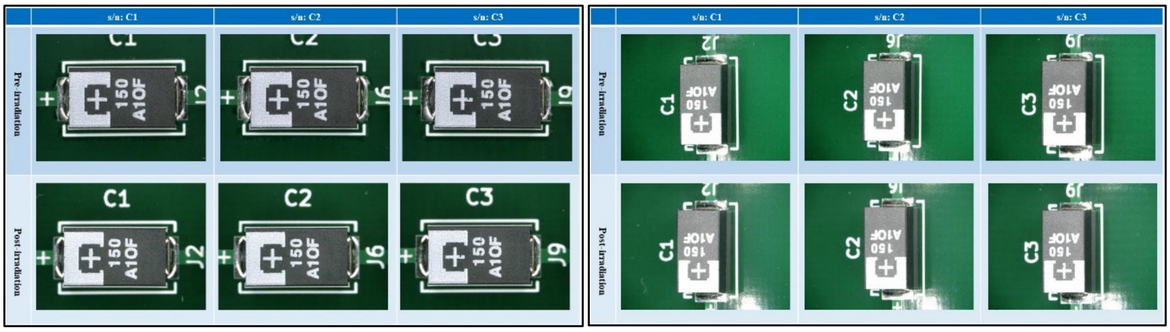


Fig. 3. the results of the external visual examination after irradiation on the polymer tantalum capacitor

b) Stacked metallized film chip capacitor

The results of the electrical characteristic measurements after the TID test on the stacked metallized film chip capacitor are shown in Fig. 4.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was -0.21% compared to the judgment criteria of ±5% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.0422, compared to the judgment criteria of 0.12 or less.

Regarding the insulation resistance measurement result, it was confirmed that there were no abnormalities as the minimum value was 61,000MΩ, compared to the judgment criteria of 1,000MΩ or more.

No significant changes or abnormalities in electrical characteristics due to irradiation were observed.

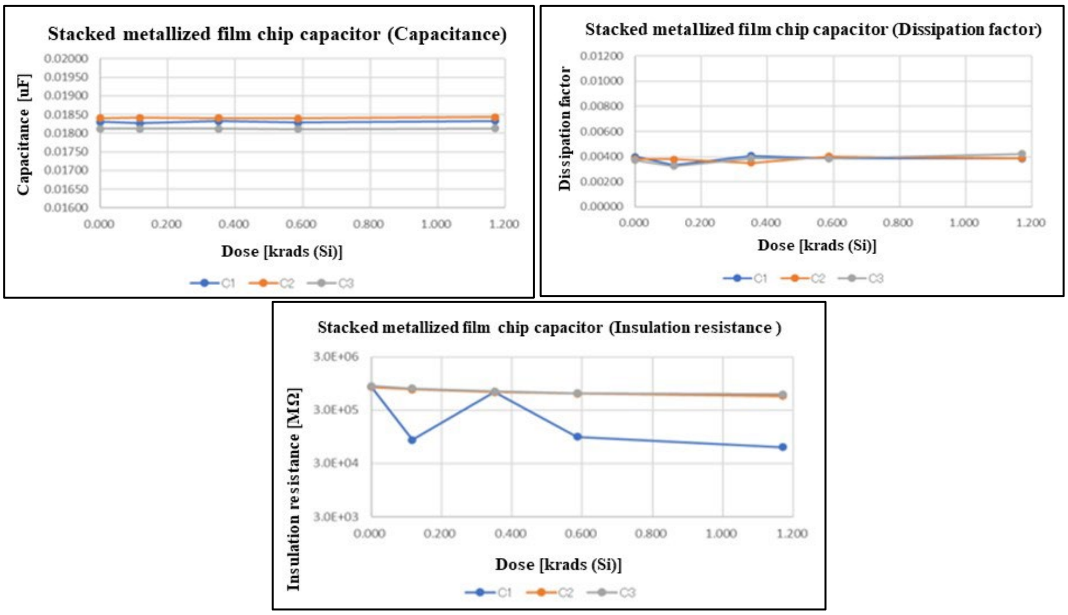


Fig. 4. The results of the electrical characteristic measurements after the TID test on the stacked metallized film chip capacitor

The results of the external visual examination after the TID test are shown in Fig. 5.

No significant changes or abnormalities were observed.

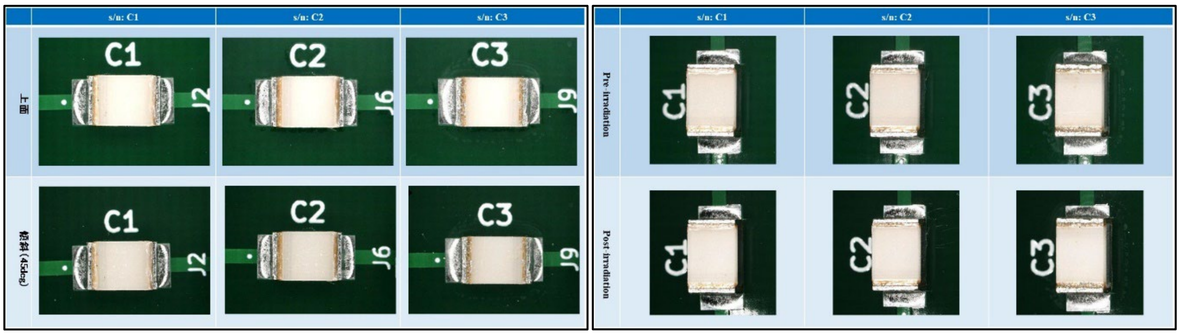


Fig. 5. The result of external visual examination after the TID test on the stacked metallized film chip capacitor

c) Voltage-controlled crystal oscillator

The results of the electrical characteristic measurements after the TID test on the voltage-controlled crystal oscillator are shown in Fig. 6.

Regarding the output frequency measurement result, it was confirmed that there were no abnormalities as the maximum change was 166Hz compared to the judgment criteria of 122.88MHz±6.144kHz.

No significant changes or abnormalities in electrical characteristics due to irradiation were observed.

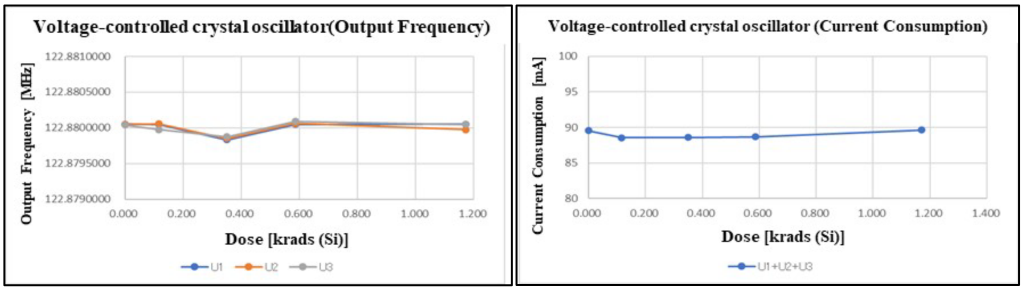


Fig. 6. The results of the electrical characteristic measurements after the TID test on the voltage-controlled crystal oscillator

The results of the external visual examination after the TID test are shown in Fig. 7.

No significant changes or abnormalities were observed.

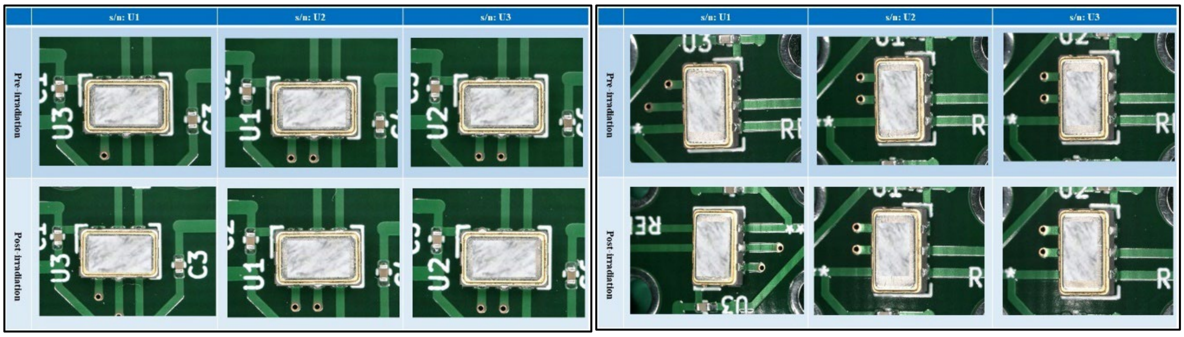


Fig. 7. The result of external visual examination after the TID test on the voltage-controlled crystal oscillator

d) Solid-state battery

The result of the electrical characteristic measurements after the TID test on the solid-state battery is shown in Fig. 8. Regarding the capacitance measurement result, it was confirmed that there were no significant changes.

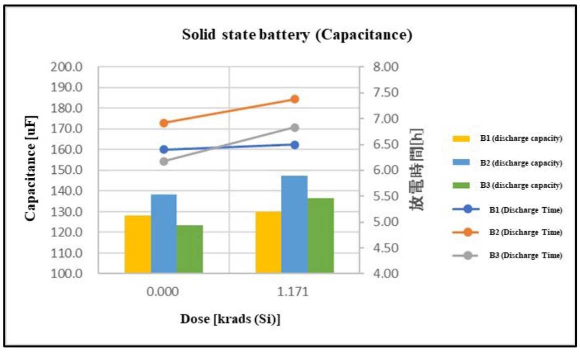


Fig. 8. The result of the electrical characteristic measurements after the TID test on the solid-state battery

The results of the external visual examination after the TID test are shown in Fig. 9.

During charging and discharging before irradiation, discoloration (brown) was confirmed in the negative electrode. The browned area is indicated by the yellow arrow in the figure.

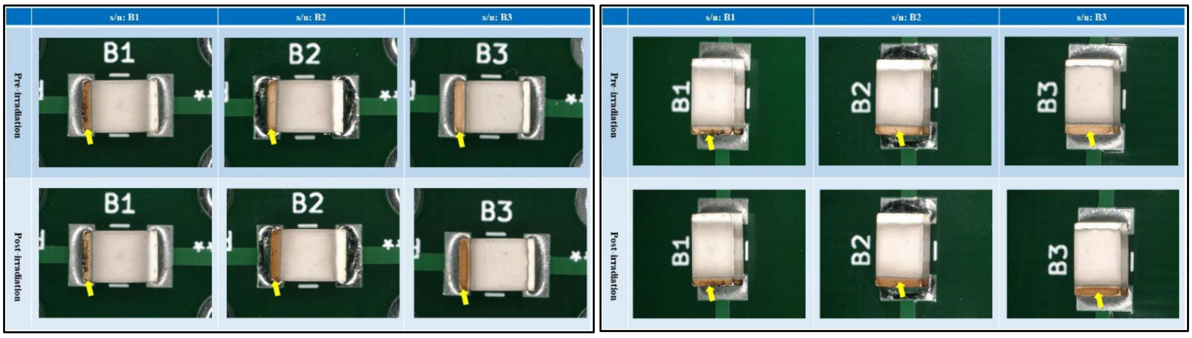


Fig. 9. The result of external visual examination after the TID test on solid-state battery

The result of mechanical stress tests

We conducted the mechanical stress tests under the test conditions shown in Table 5(Vibration tests) and Table 6(Shock tests).

Table 5. Vibration tests conditions

Part type	Conditions	Characteristic evaluation items	Criteria
Polymer tantalum capacitor	-Test method: MIL-STD-202, TM214 -Test condition: condition II, H (34.02Grms) -Frequency: 50Hz ~ 2,000Hz -Test time: 3 minutes for each on 3 axes, 9 minutes in total. -Characterization: Pre, Post-Vibration, Post-Shock	-Capacitance (Cap.) -Dissipation factor (tanδ) -leakage current	-Capacitance: within ±10% of initial value -Dissipation factor: 0.15 or less -leakage current: 450μA or less
Stacked metallized film chip capacitor		-Capacitance (Cap.) -Dissipation factor (tanδ) -Insulation resistance (IR)	-Capacitance: within ±3% of initial value -Dissipation factor: 0.011 or less - Insulation resistance: 3000MΩ or more
Solid-state battery		-discharge capacity	-discharge capacity: N/A (Charge/discharge characteristic data acquisition only)
Voltage-controlled crystal oscillator	-Test method: MIL-STD-883, TM2007 -Test condition: condition A (20G) -Frequency: 20Hz ~ 2,000Hz -Test time: 4 minutes for each on 3 axes, 4 times, 48 minutes in total. -Characterization: Pre, Post-Vibration, Post-Shock	-Output frequency -Current consumption	-Output Frequency (Δf/f): ±50 ppm -Current consumption: Maximum 2x the nominal value

Table 6. Shock tests conditions

Part type	Conditions	Characteristic evaluation items	Criteria
Polymer tantalum capacitor	-Test method: MIL-STD-202, TM213 -Test condition: condition C (100G) -Duration of pulse: 6 msec -Waveform: Half-sine shock pulse -Characterization: Pre, Post-Vibration, Post-Shock	-Capacitance (Cap.) -Dissipation factor (tanδ) -leakage current	-Capacitance: within ±10% of initial value -Dissipation factor: 0.15 or less -leakage current: 450μA or less
Stacked metallized film chip capacitor		-Capacitance (Cap.) -Dissipation factor (tanδ) -Insulation resistance (IR)	-Capacitance: within ±5% of initial value -Dissipation factor: 0.012 or less - Insulation resistance: 1000MΩ or more
Solid-state battery		-discharge capacity	-discharge capacity: N/A (Charge/discharge characteristic data acquisition only)
Voltage-controlled crystal oscillator	-Test method: MIL-STD-883, TM2007 -Test condition: condition A (20G) -Frequency: 20Hz ~ 2,000Hz -Test time: 4 minutes for each on 3 axes, 4 times, 48 minutes in total. -Characterization: Pre, Post-Vibration, Post-Shock	-Output frequency -Current consumption	-Output Frequency (Δf/f): ±50 ppm -Current consumption: Maximum 2x the nominal value

a) Polymer tantalum capacitor

1) Vibration tests and Shock tests

The results of the electrical characteristic measurements after the vibration test and shock test on the polymer tantalum capacitor are shown in Fig. 10.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as after the vibration test the maximum change was 3.57% compared to the judgment criteria of ±10% change rate from the initial value, and also as after the shock test the maximum change was 3.57% compared to the judgment criteria of ±10% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as after the vibration test the maximum change was 0.0343 compared to the judgment criteria of 0.15 or less, and also as after the shock test the maximum change was 0.0343 compared to the judgment criteria of 0.15 or less.

Regarding the leakage current measurement result, it was confirmed that there were no abnormalities as after the vibration test and the shock test the maximum value was 5.26μA, compared to the judgment criteria of 450μA or less.

No significant changes or abnormalities in electrical characteristics due to vibration and shock were observed.

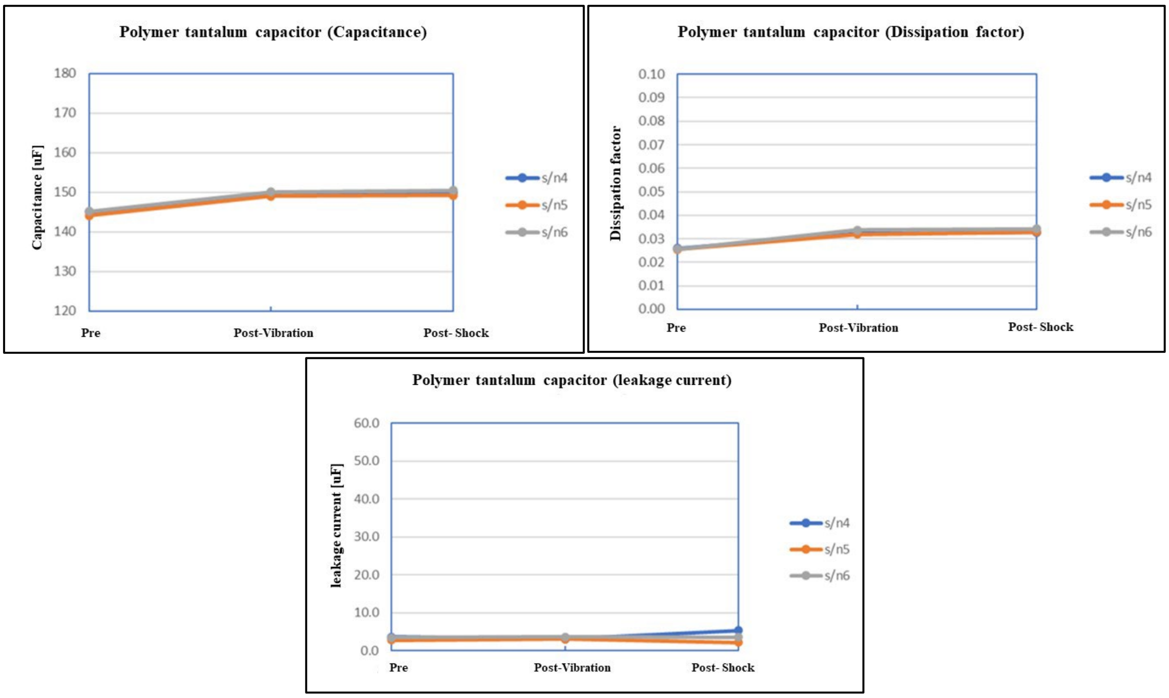


Fig. 10. The results of the electrical characteristic measurements after the vibration test and shock test on the polymer tantalum capacitor

The results of the external visual examination after the vibration test and the shock test are shown in Fig. 11. No significant changes or abnormalities were observed.

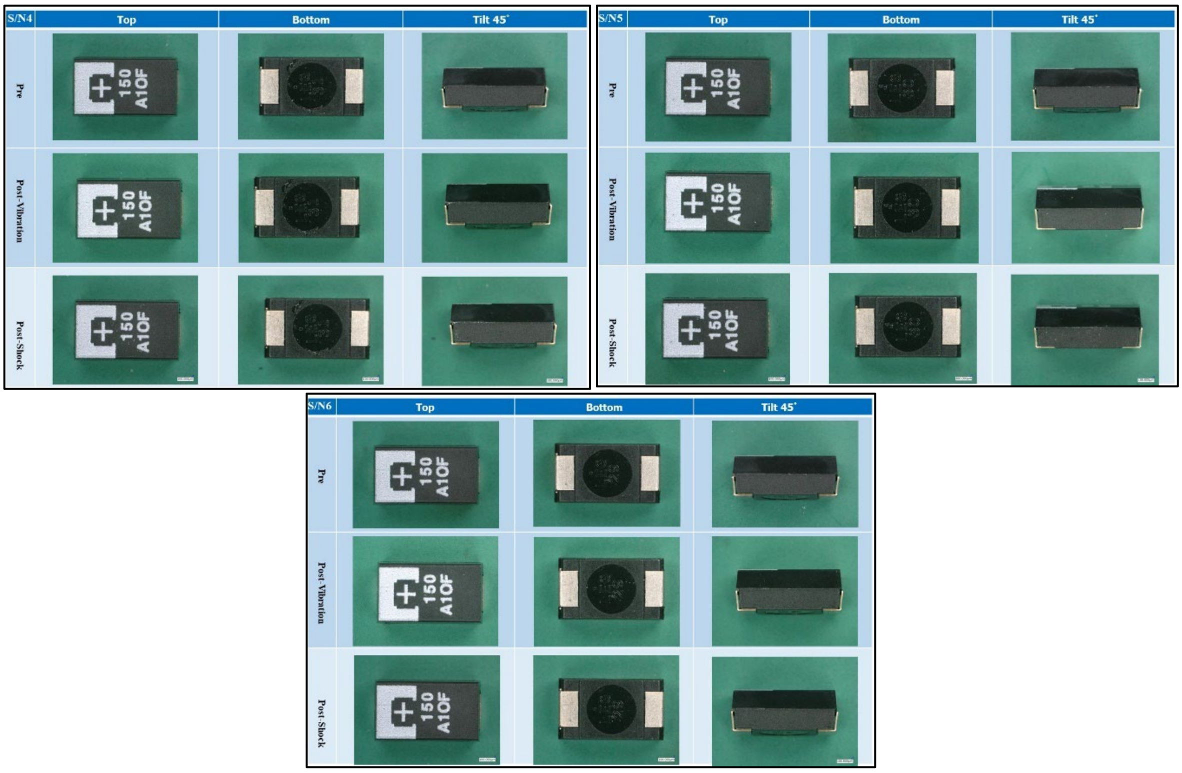


Fig. 11. The results of the external visual examination after the vibration test and the shock test on polymer tantalum capacitor

b) Stacked metallized film chip capacitor

The results of the electrical characteristic measurements after the vibration test and Shock test on the stacked metallized film chip capacitor are shown in Fig. 12.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was -0.21% compared to the judgment criteria of ±3% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.0422, compared to the judgment criteria of 0.12 or less.

Regarding the insulation resistance measurement result, it was confirmed that there were no abnormalities as the minimum value was 61,000MΩ, compared to the judgment criteria of 1,000MΩ or more.

No significant changes or abnormalities in electrical characteristics due to vibration and shock were observed.

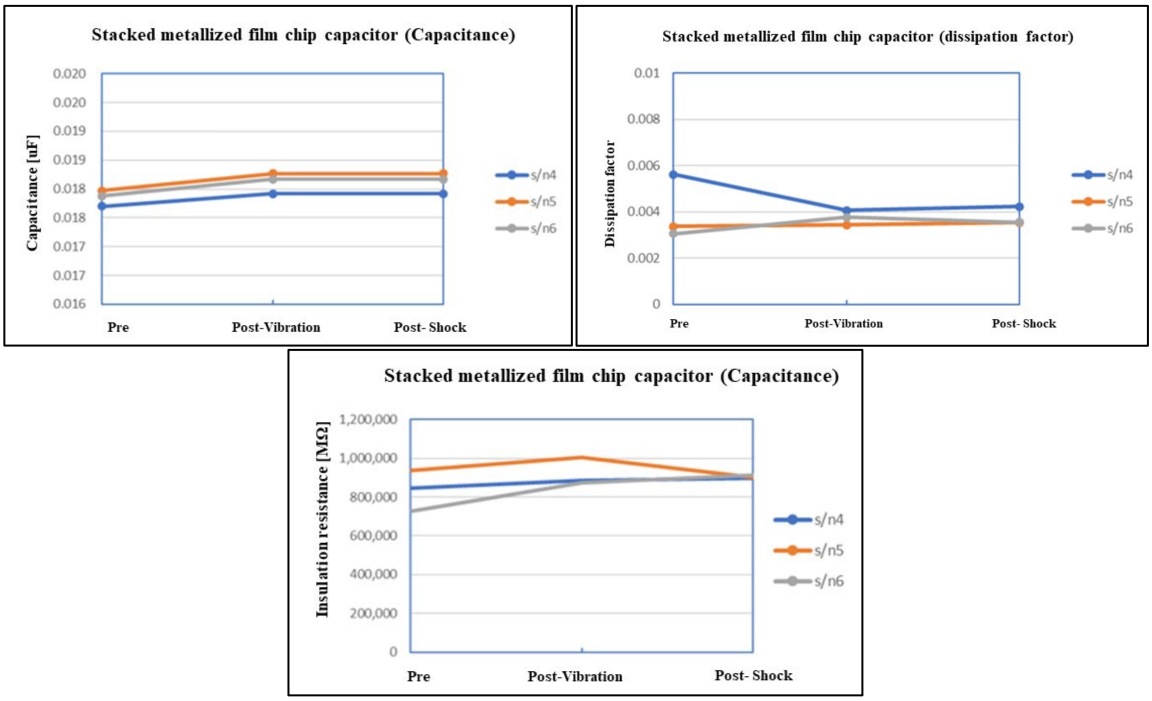


Fig. 12. The results of the electrical characteristic measurements after the vibration test and Shock test on the stacked metallized film chip capacitor

The results of the external visual examination after the vibration test and shock test are shown in Fig. 13. No significant changes or abnormalities were observed.

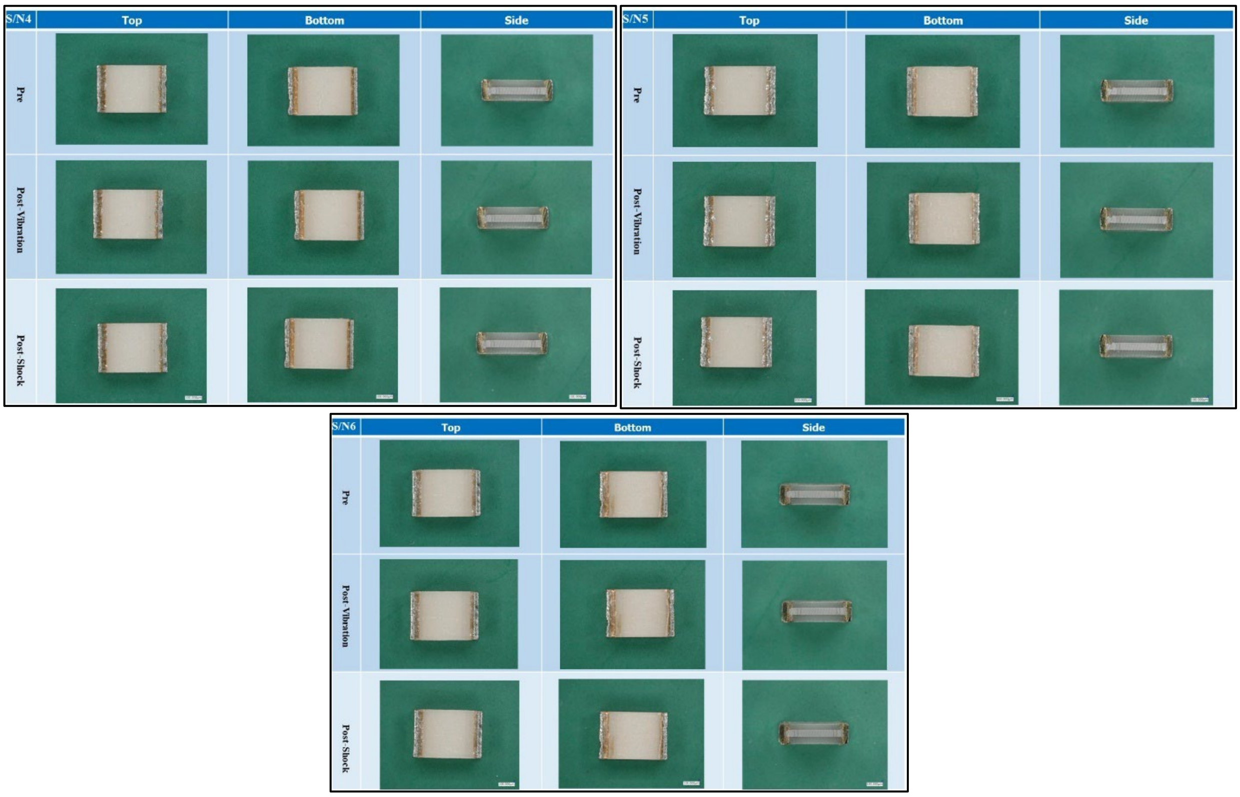


Fig. 13. The results of the external visual examination after the vibration test and shock test on the stacked metallized film chip capacitor

c) Voltage-controlled crystal oscillator

The results of the electrical characteristic measurements after the vibration test and shock test on the voltage-controlled crystal oscillator are shown in Fig. 14.

Regarding the output frequency measurement result, it was confirmed that there were no abnormalities as the maximum change was 137Hz compared to the judgment criteria of 122.88MHz±6.144kHz.

No significant changes or abnormalities in electrical characteristics due to vibration and shock were observed.

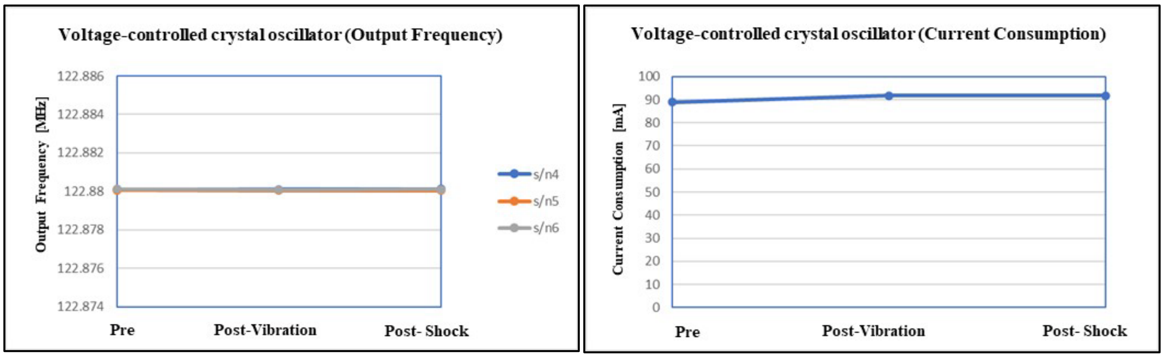


Fig. 14. The results of the electrical characteristic measurements after the vibration test and Shock test on the voltage-controlled crystal oscillator

The results of the external visual examination after the vibration test and the shock test are shown in Fig. 15. No significant changes or abnormalities were observed.

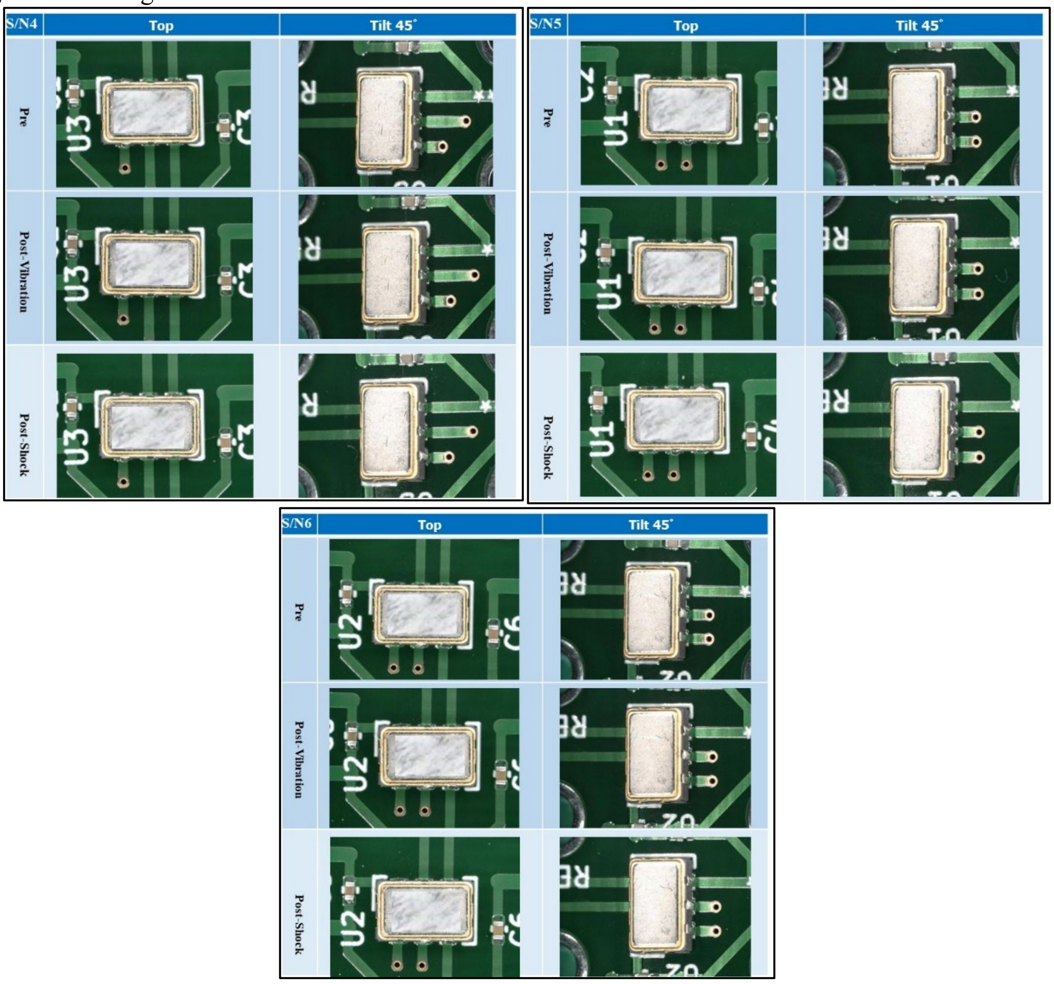


Fig. 15. The results of the external visual examination after the vibration test and the shock test on the voltage-controlled crystal oscillator

d) Solid-state battery

The result of the electrical characteristic measurements after the vibration test and shock test on the solid-state battery is shown in Fig. 16.

Regarding the capacitance measurement result, it was confirmed that there were no significant changes.

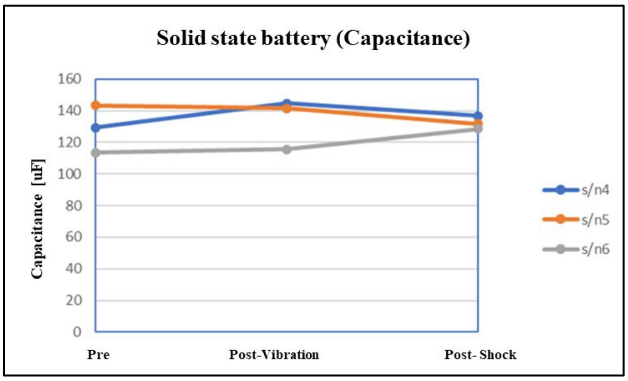


Fig. 16. The results of the mechanical stress tests on the solid-state battery

The results of the external visual examination after the vibration test and the shock test are shown in Fig. 17.

During charging and discharging before the vibration test, discoloration (brown) was confirmed in the negative electrode. The browned area is indicated by the yellow arrow and the crack area is indicated by the red arrow in the figure. Also, a close-up image of the area where cracks occurred in the S/N6 sample after the shock test is shown in Figure 18. Cracks occurred throughout the electrodes and the body.

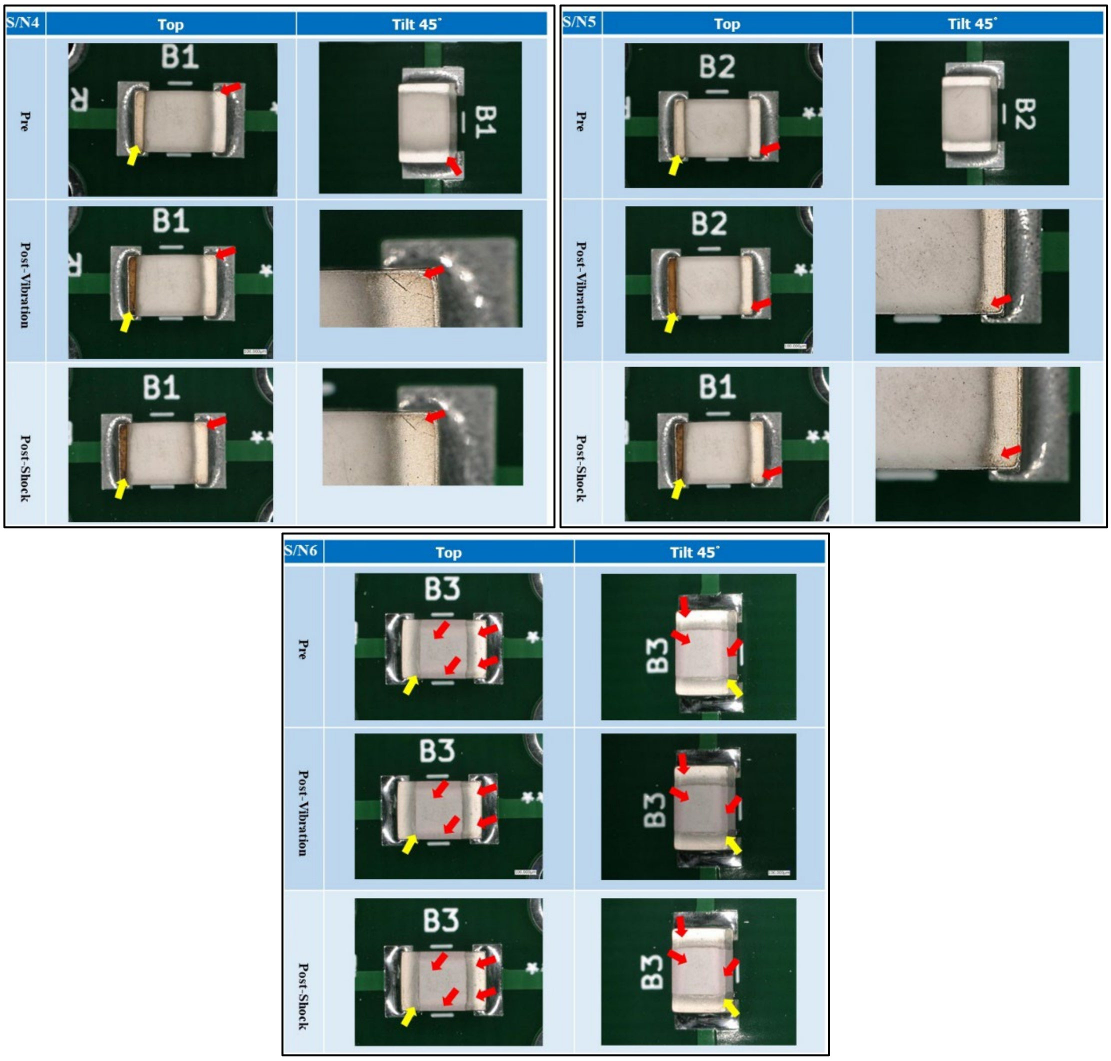


Fig. 17. The results of the external visual examination after the vibration test and the shock test on solid-state battery

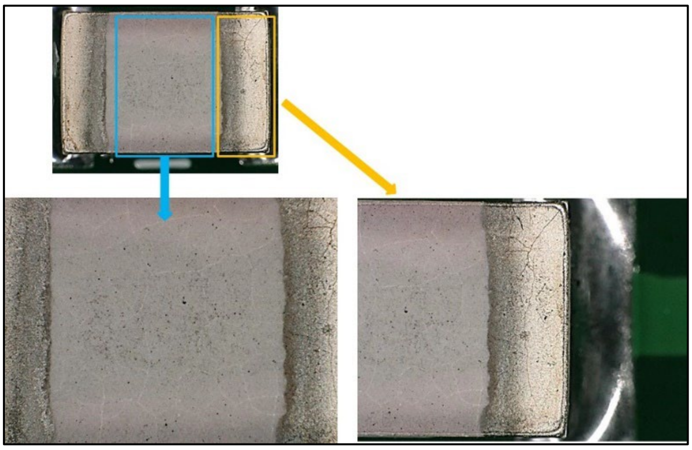


Fig. 18. Enlarged image of the solid-state battery sample(S/N:6) after shock test

The result of thermal environment tests

We conducted thermal environment tests under the test conditions shown in Table 7(Thermal shock tests) and Table 8(Ion migration tests).

Table 7. Thermal shock tests conditions

Part type	Conditions	Characteristic evaluation items	Criteria
Polymer tantalum capacitor	-Test method: MIL-STD-202, TM107 -Test cycles: -40°C(30min) → R.T.(5min) → +100°C(30min), 1000cycles -Characterization: Pre, 100, 300, 500, 1000cycles	-Capacitance (Cap.) -Dissipation factor (tanδ) -leakage current	-Capacitance: within ±10% of initial value -Dissipation factor: 0.15 or less -leakage current: 450μA or less
Stacked metallized film chip capacitor		-Capacitance (Cap.) -Dissipation factor (tanδ) -Insulation resistance (IR)	-Capacitance: within ±5% of initial value -Dissipation factor: 0.012 or less - Insulation resistance: 1500MΩ or more
Solid-state battery	-Test method: MIL-STD-202, TM107 -Test cycles: -20°C(30min) → R.T.(5min) → +80°C(30min), 1000cycles -Characterization: Pre, 100, 300, 500, 1000cycles	-discharge capacity	-discharge capacity: N/A(Charge/discharge characteristic data acquisition only)
Voltage-controlled crystal oscillator	-Test method: MIL-STD-202, TM107 -Test cycles: -40°C(30min) → R.T.(5min) → +100°C(30min), 1000cycles -Characterization: Pre, 100, 300, 500, 1000cycles	-Output frequency -Current consumption	-Output Frequency (Δf/f): ±50 ppm -Current consumption: Maximum 2x the nominal value

Table 8. Ion migration tests conditions

Part type	Conditions	Characteristic evaluation items	Criteria
Polymer tantalum capacitor	-Temperature: +85°C -Test Time: 2000hours -Vias: 10V(static) --Characterization: Pre, 240, 500, 1000, 2000hours	-Capacitance (Cap.) -Dissipation factor (tanδ) -leakage current	-Capacitance: within ±10% of initial value -Dissipation factor: 0.15 or less -leakage current: 450μA or less
Stacked metallized film chip capacitor		-Capacitance (Cap.) -Dissipation factor (tanδ) -Insulation resistance (IR)	-Capacitance: within ±5% of initial value -Dissipation factor: 0.012 or less - Insulation resistance: 1000MΩ or more
Solid-state battery	-Temperature: +80°C -Test Time: 2000hours -Vias: 100V(static) --Characterization: Pre, 240, 500, 1000, 2000hours	-discharge capacity	-discharge capacity: N/A (Charge/discharge characteristic data acquisition only)
Voltage-controlled crystal oscillator	-Temperature: +85°C -Test Time: 2000hours -Vias: 2V, -1.3V(static) --Characterization: Pre, 240, 500, 1000, 2000hours	-Output frequency -Current consumption	-Output Frequency (Δf/f): ±50 ppm -Current consumption: Maximum 2x the nominal value

a) Polymer tantalum capacitor

1) Thermal shock tests

The results of the electrical characteristic measurements after the thermal shock test on the polymer tantalum capacitor are shown in Fig. 19.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was 1.47% compared to the judgment criteria of ±10% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.0361, compared to the judgment criteria of 0.15 or less.

Regarding the leakage current measurement result, it was confirmed that there were no abnormalities as the maximum value was 20μA, compared to the judgment criteria of 450μA or less.

No significant changes or abnormalities in electrical characteristics due to thermal shock were observed.

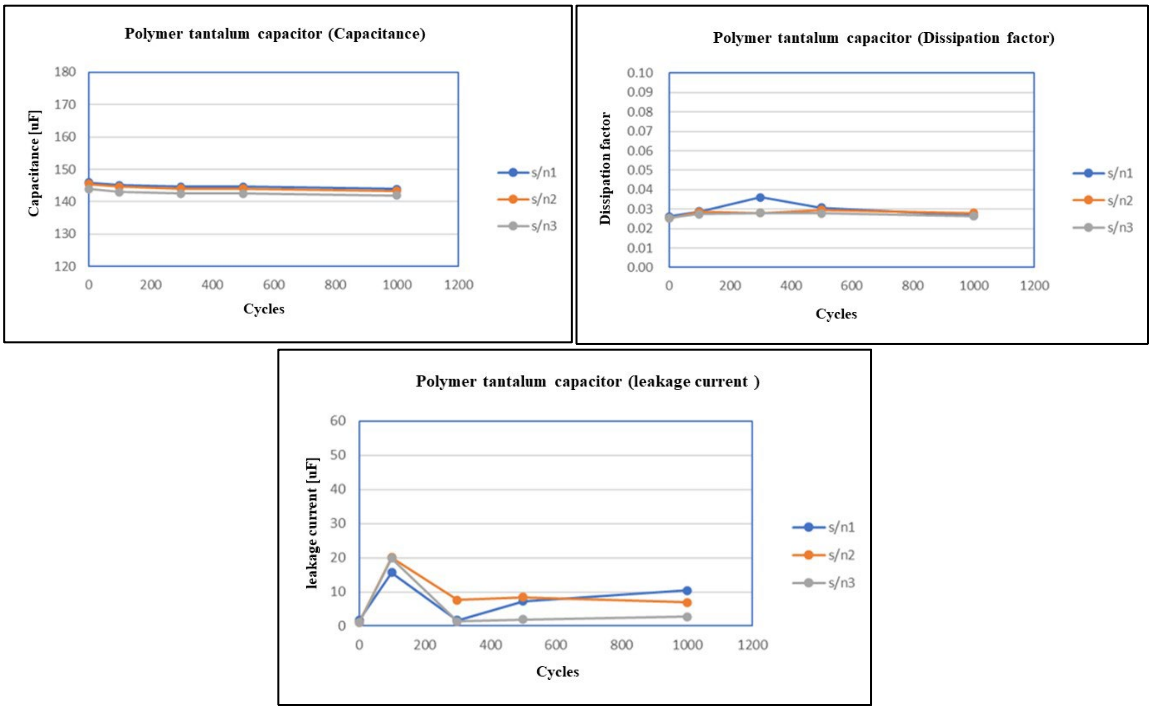


Fig. 19. The results of the electrical characteristic measurements after the thermal shock test on the polymer tantalum capacitor

The results of the external visual examination after the thermal shock test are shown in Fig. 20.

No significant changes or abnormalities were observed.

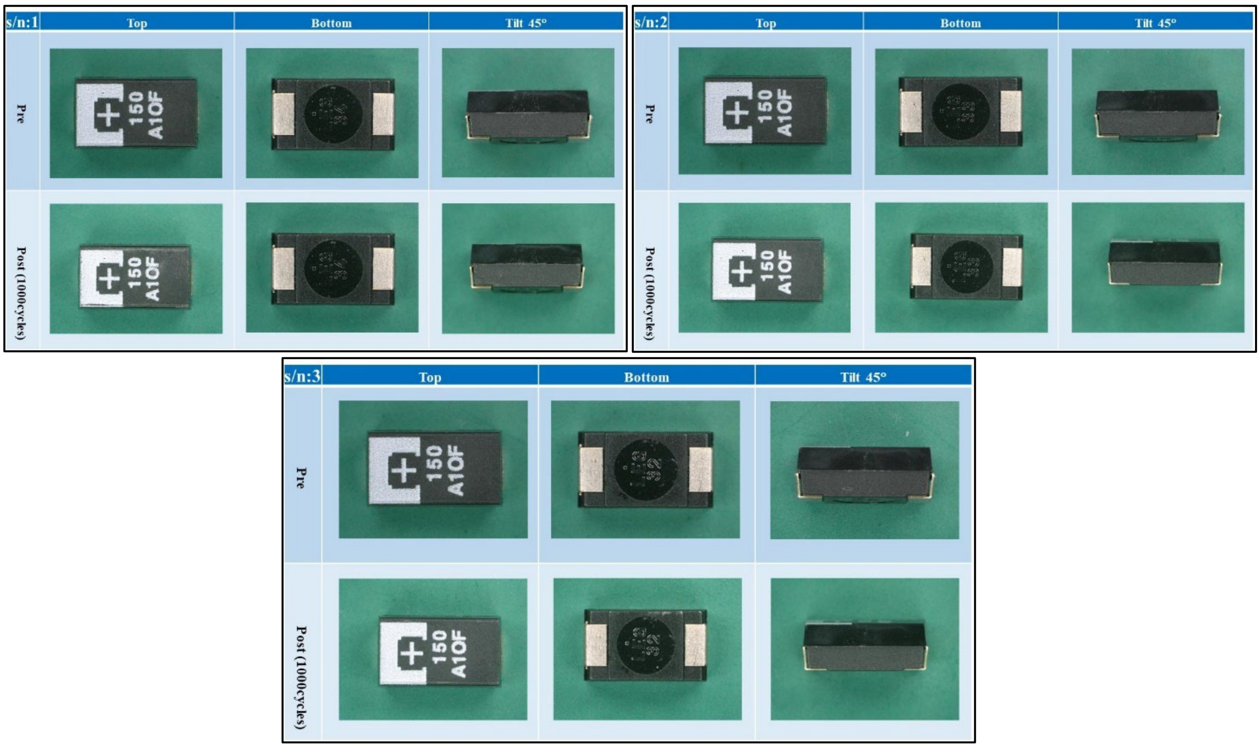


Fig. 20. The results of the external visual examination after the thermal shock test on the polymer tantalum capacitor

2) Ion migration tests

The result of the ion migration test on the polymer tantalum capacitor are shown in Fig. 21.

For S/N 7, a temporary increase of 0.5 μA was observed, but this did not result in ion migration. On the other hand, no significant fluctuations were observed for S/N 8 and 9, and no signs of the ion migration were observed.

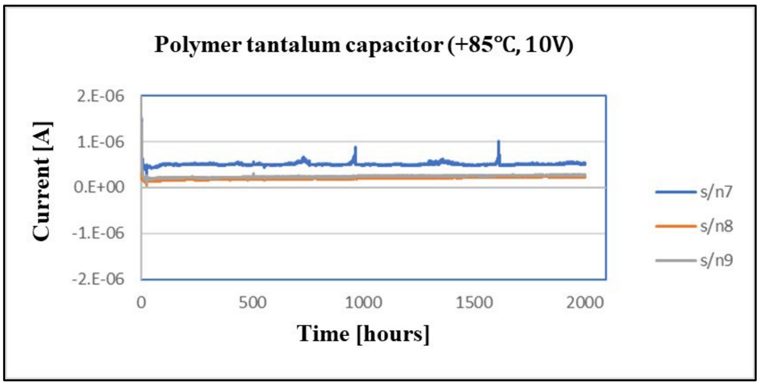


Fig. 21. The result of the ion migration test on the polymer tantalum capacitor

The results of the electrical characteristic measurements after the ion migration test are shown in Fig. 22.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was 2.35% compared to the judgment criteria of ±10% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.04, compared to the judgment criteria of 0.15 or less.

Regarding the leakage current measurement result, it was confirmed that there were no abnormalities as the maximum value was 17.346μA, compared to the judgment criteria of 450μA or less.

No significant changes or abnormalities in electrical characteristics were observed.

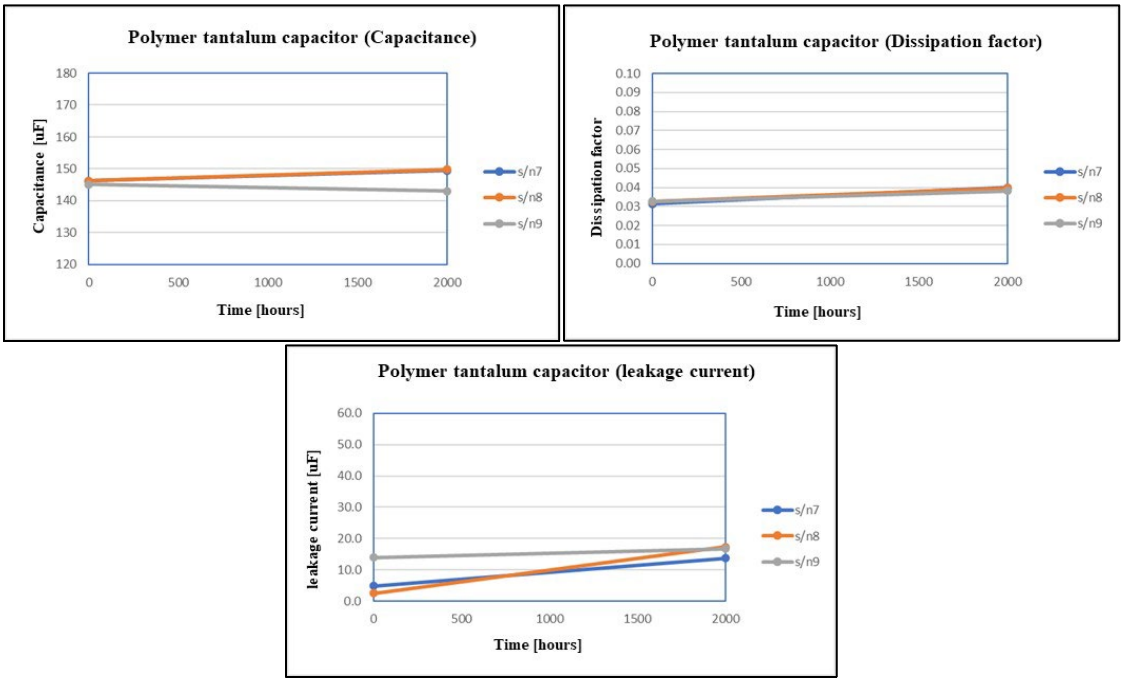


Fig. 22. The results of the electrical characteristic measurements after the ion migration test on polymer tantalum capacitor

The results of the external visual examination after the ion migration test are shown in Fig. 23.
No significant changes or abnormalities were observed.

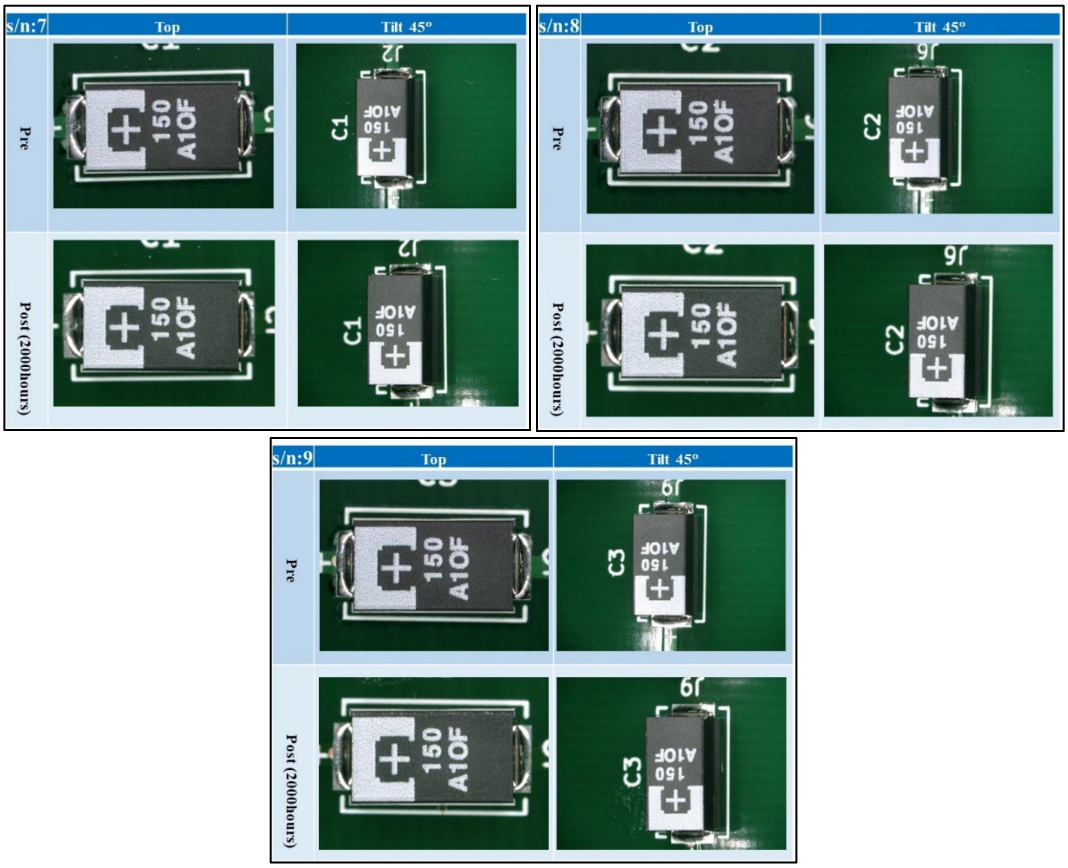


Fig. 23. The results of the external visual examination after the ion migration test on the polymer tantalum capacitor

b) Stacked metallized film chip capacitor

1) Thermal shock tests

The results of the electrical characteristic measurements after the thermal shock test on the stacked metallized film chip capacitor are shown in Fig. 24.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was 0.97% compared to the judgment criteria of ±5% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.033, compared to the judgment criteria of 0.12 or less.

Regarding the insulation resistance measurement result, it was confirmed that there were no abnormalities as the minimum value was 1,000,000MΩ, compared to the judgment criteria of 1,500MΩ or more.

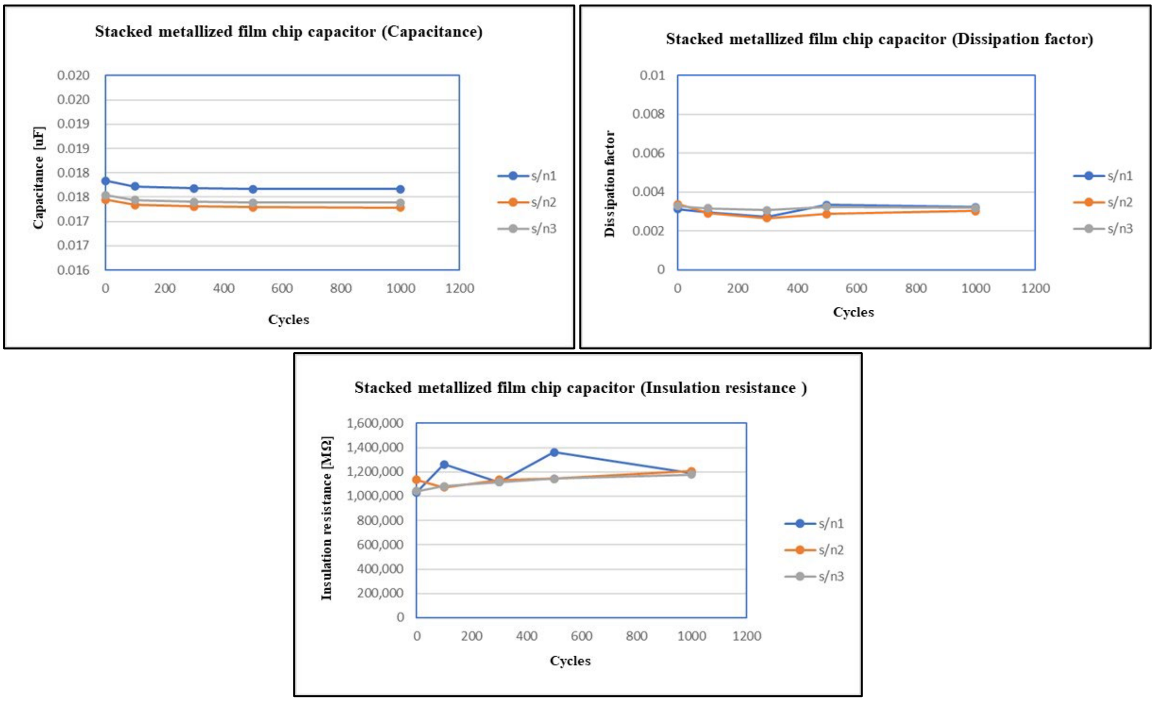


Fig. 24. The results of the electrical characteristic measurements after the thermal shock test on the stacked metallized film chip capacitor

The results of the external visual examination after the thermal shock test are shown in Fig. 25.

No significant changes or abnormalities were observed.

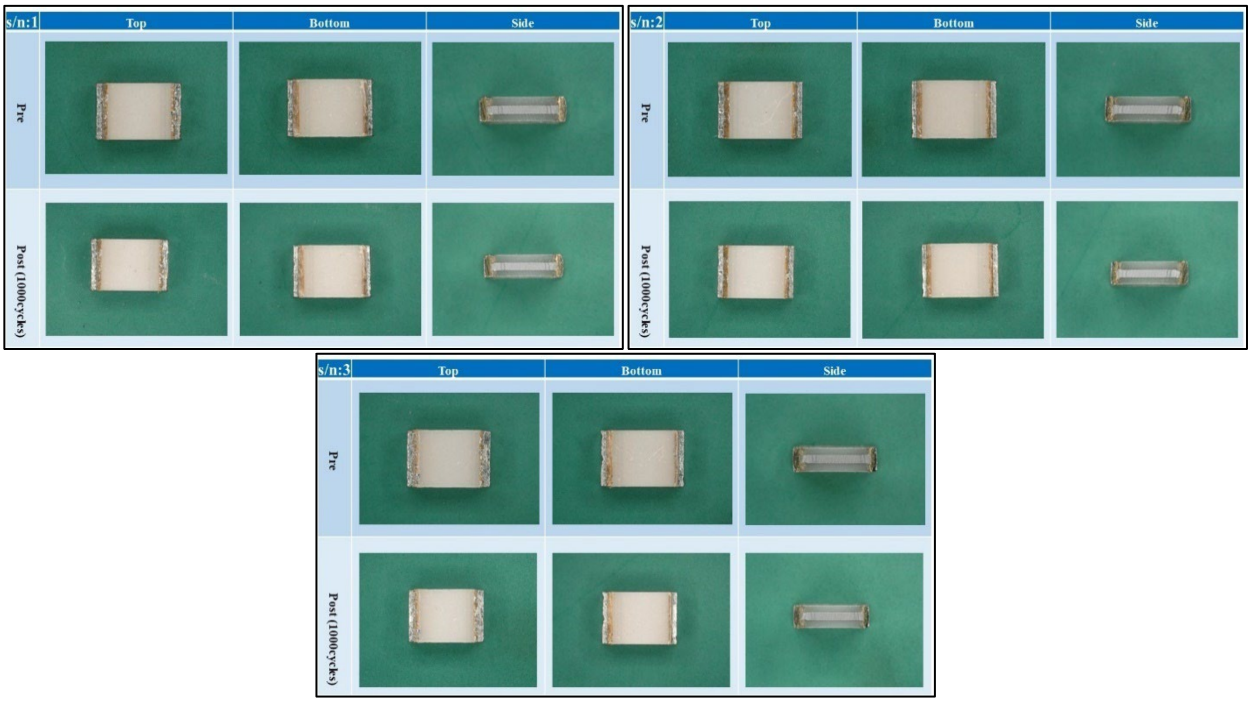


Fig. 25. The results of the external visual examination after the thermal shock test

2) Ion migration test

The results of the ion migration test on the stacked metallized film chip capacitor are shown in Fig. 26. No significant fluctuations were observed, and no signs of the ion migration were observed.

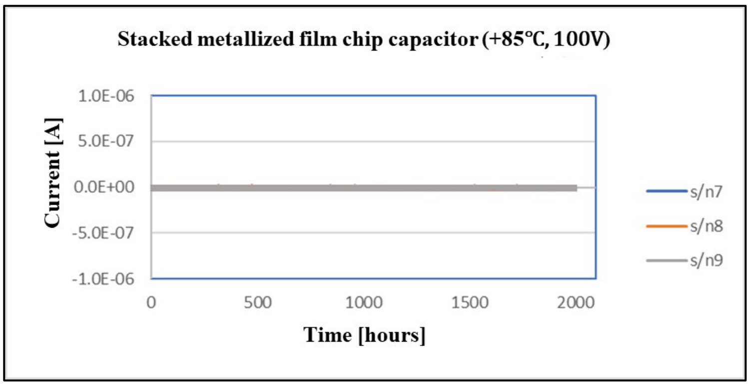


Fig. 26. The result of the ion migration test on stacked metallized film chip capacitor

The results of the electrical characteristic measurements after the ion migration test are shown in Fig. 27.

Regarding the capacitance measurement result, it was confirmed that there were no abnormalities as the maximum change was 1.88% compared to the judgment criteria of ±5% change rate from the initial value.

Regarding the dissipation factor measurement result, it was confirmed that there were no abnormalities as the maximum value was 0.00337, compared to the judgment criteria of 0.012 or less.

Regarding the insulation resistance measurement result, it was confirmed that there were no abnormalities as the minimum value was 1,750,000MΩ, compared to the judgment criteria of 1,000MΩ or more.

No significant changes or abnormalities in electrical characteristics due to the ion migration were observed.

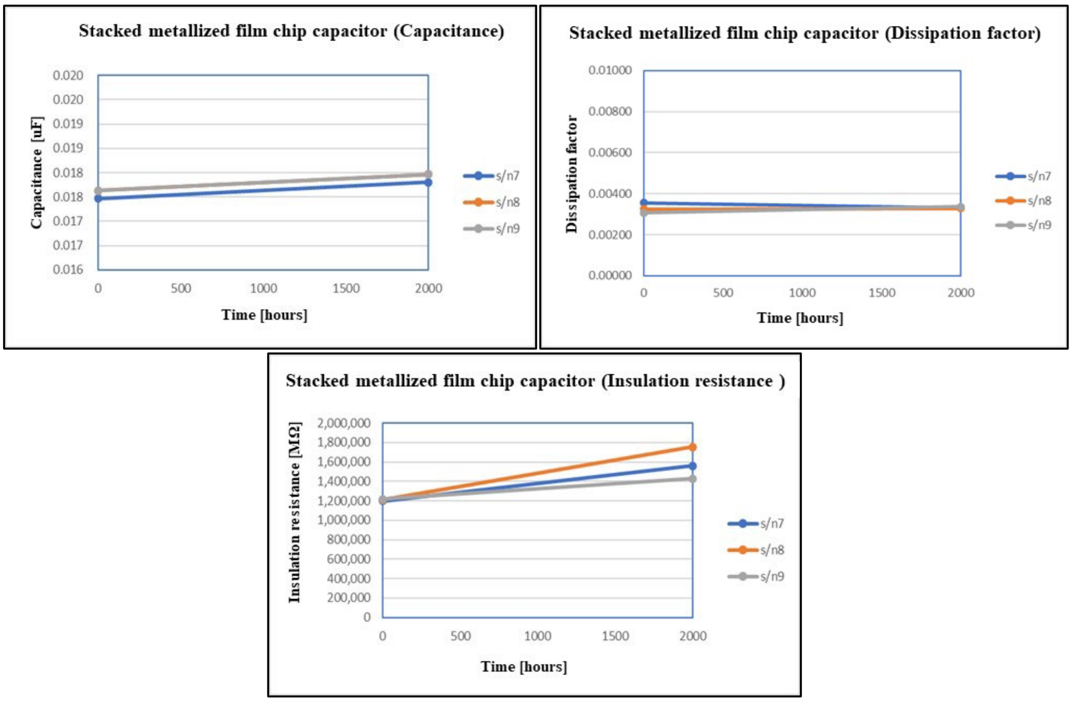


Fig. 27. The results of the electrical characteristic measurements after the ion migration test on stacked metallized film chip capacitor

The results of the external visual examination after the ion migration test are shown in Fig. 28.
No significant changes or abnormalities were observed.

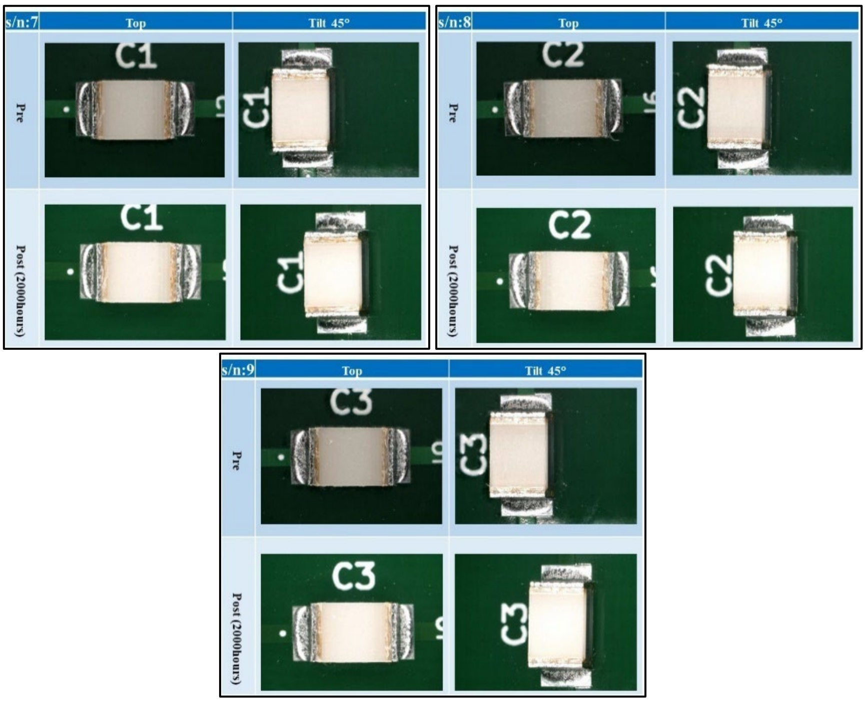


Fig. 28. The results of the external visual examination after the ion migration test on stacked metallized film chip capacitor

c) Voltage-controlled crystal oscillator

1) Thermal shock tests

The results of the electrical characteristic measurements after the thermal shock test on the voltage-controlled crystal oscillator are shown in Fig. 29.

No significant changes or abnormalities were observed.

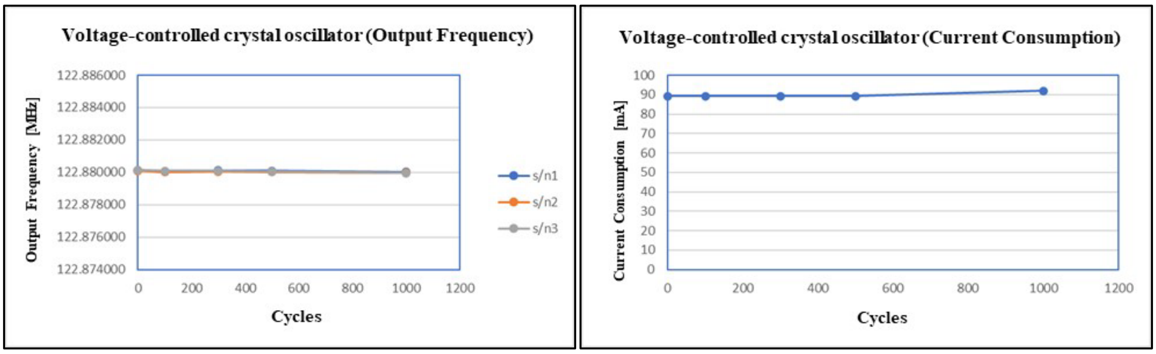


Fig. 29. The results of the electrical characteristic measurements after the thermal shock test on the voltage-controlled crystal oscillator

The results of the external visual examination after the thermal shock test are shown in Fig. 30.
No significant changes or abnormalities were observed.

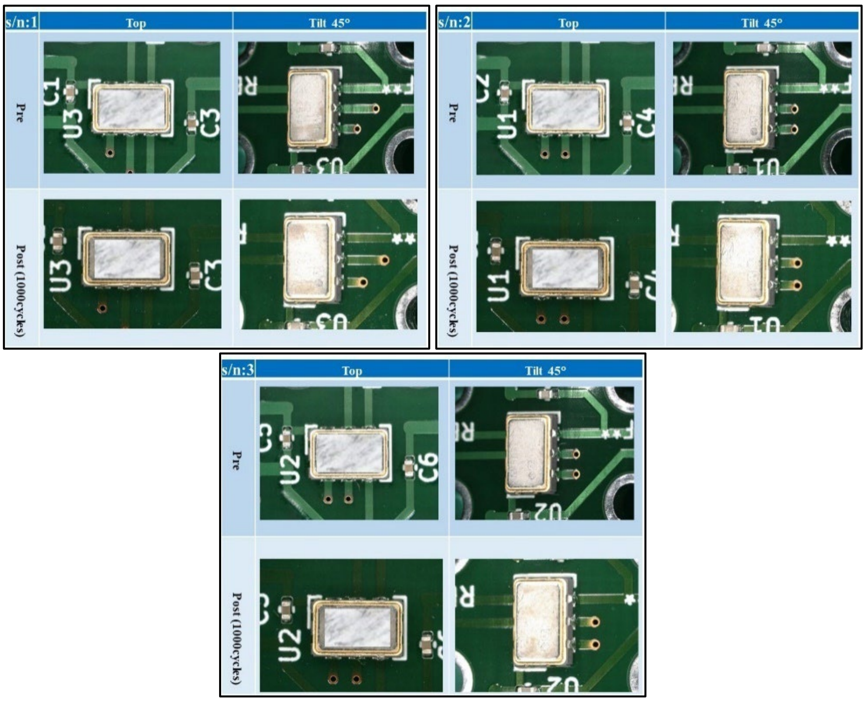


Fig. 30. The results of the external visual examination after the thermal shock test on voltage-controlled crystal oscillator

2) Ion migration tests

The results of the ion migration test on the voltage-controlled crystal oscillator are shown in Fig. 31.
No significant fluctuations were observed, and no signs of the ion migration were observed.

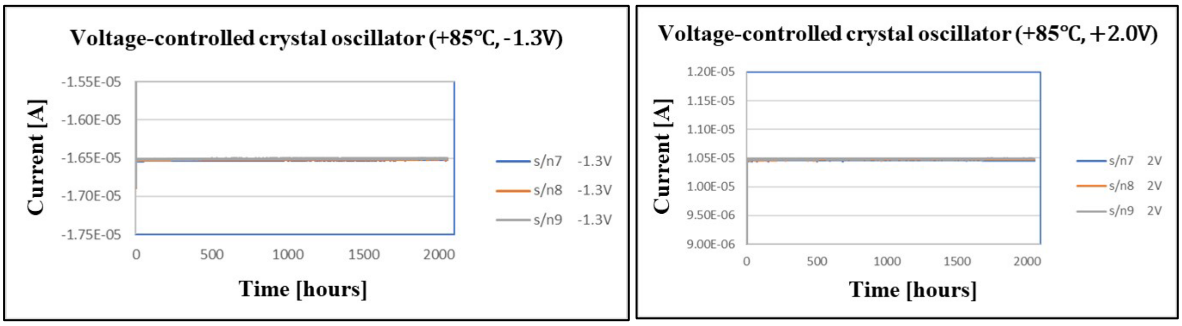


Fig. 31. The results of the ion migration test on the voltage-controlled crystal oscillator

The results of the electrical characteristic measurements after the ion migration test on the voltage-controlled crystal oscillator are shown in Fig. 32.

No significant changes or abnormalities in electrical characteristics due to the ion migration were observed.

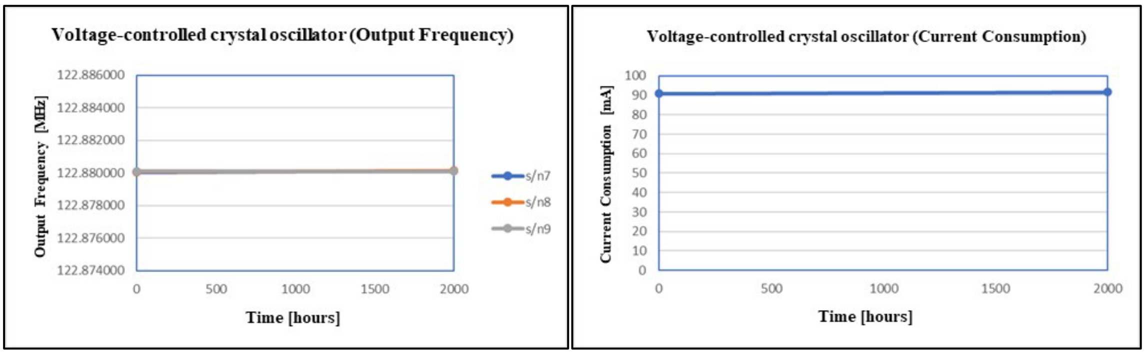


Fig. 32. The result of the electrical characteristic measurements after the ion migration test on voltage-controlled crystal oscillator

The results of the external visual examination after the ion migration test are shown in Fig. 33.
No significant changes or abnormalities were observed.

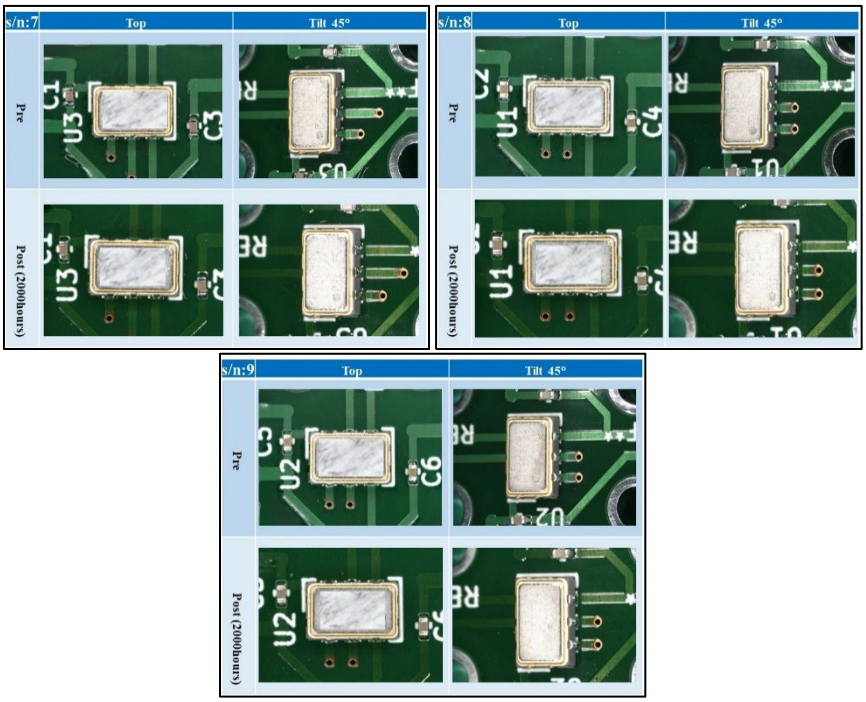


Fig. 33. The result of external visual examination after the ion migration test on voltage-controlled crystal oscillator

d) Solid-state battery

1) Thermal shock tests

The result of the electrical characteristic measurements after the thermal shock test on the solid-state battery is shown in Fig. 34.

Regarding the capacitance measurement result, after 300 cycles, the solid-state battery could no longer be charged or discharged, making it impossible to measure the capacitance.

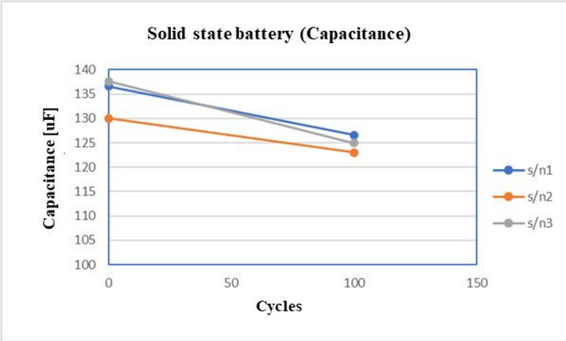
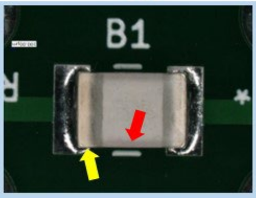
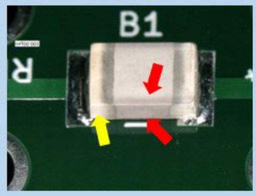
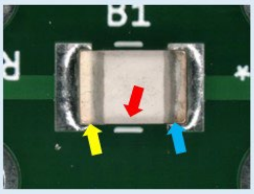
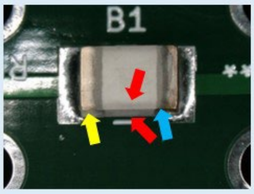
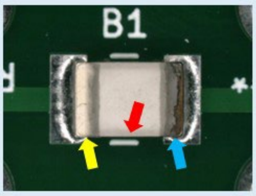
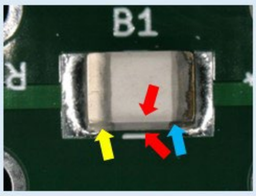
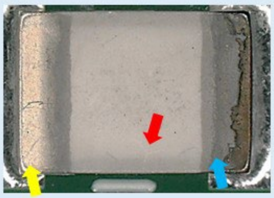
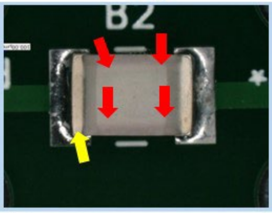
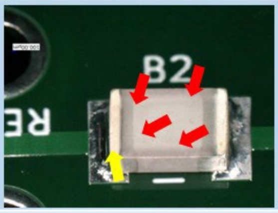
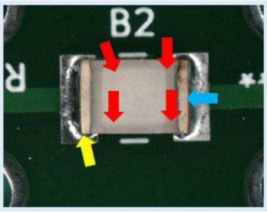
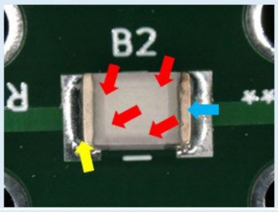
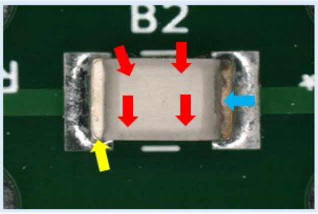
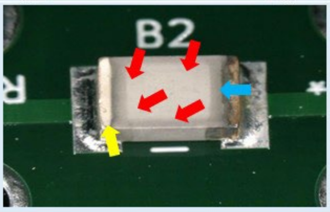
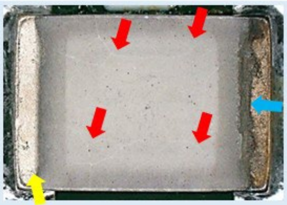


Fig. 34. The result of the electrical characteristic measurements after the thermal shock test on the solid-state battery

The results of the external visual examination after the thermal shock test are shown in Fig. 35. During charging and discharging before the thermal shock test, discoloration (brown) was confirmed in the negative electrode of all samples. After 100 cycles, peeling occurred on the positive electrode. The browned area is indicated by the yellow arrow, the crack area is indicated by the red arrow and the peeling area is indicated by the blue arrow in the figure.

s/n:1	Top	Tilt 45°
Pre		
100cycles		
300cycles		
300cycles (Enlarged image)		

s/n:2	Top	Tilt 45°
Pre		
100cycles		
300cycles		
300cycles (Enlarged image)		

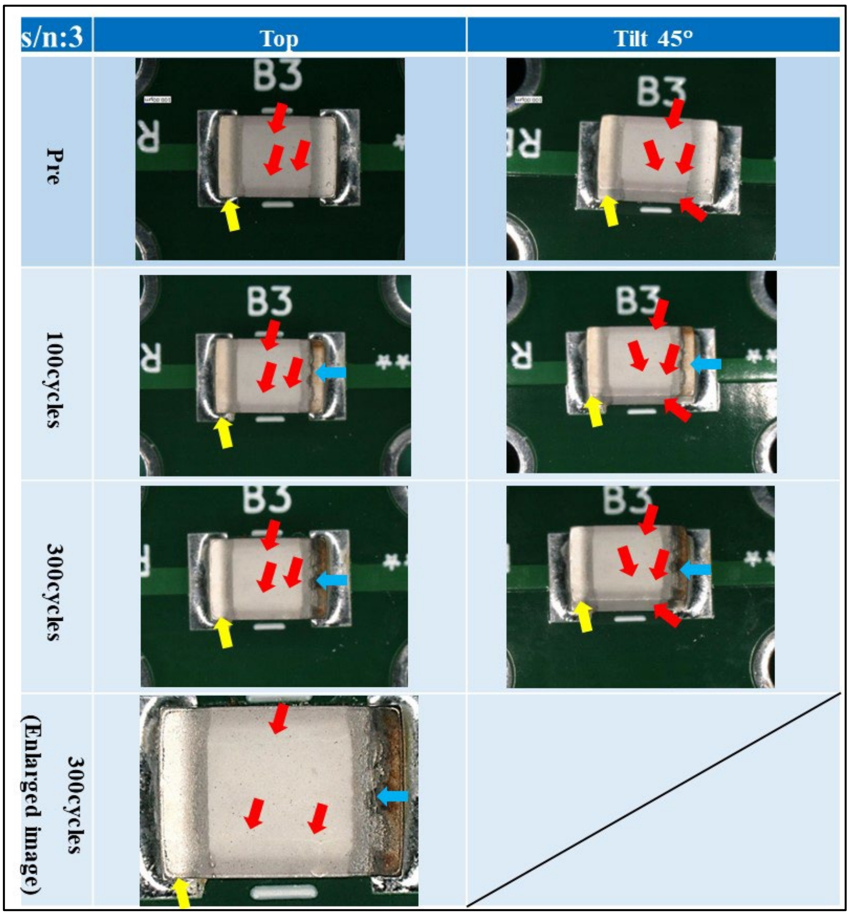


Fig. 35. The result of external visual examination after the thermal shock test on solid-state battery

2) Ion migration tests

The results of the ion migration test on the solid-state battery are shown in Fig. 36.
No significant fluctuations were observed, and no signs of ion migration were observed.

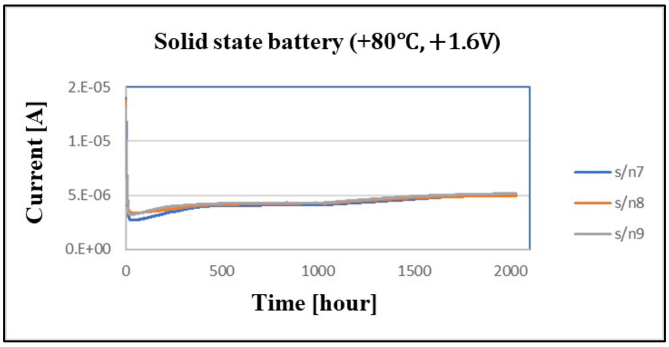


Fig. 36. The result of the ion migration test on solid-state battery

The result of the electrical characteristic measurement after the ion migration test on the solid-state battery is shown in Fig. 37.
In the measurement after 2000 hours, the capacitance of all samples was below the nominal capacitance of 100 µA, which was approximately 30% lower than the initial capacitance value.

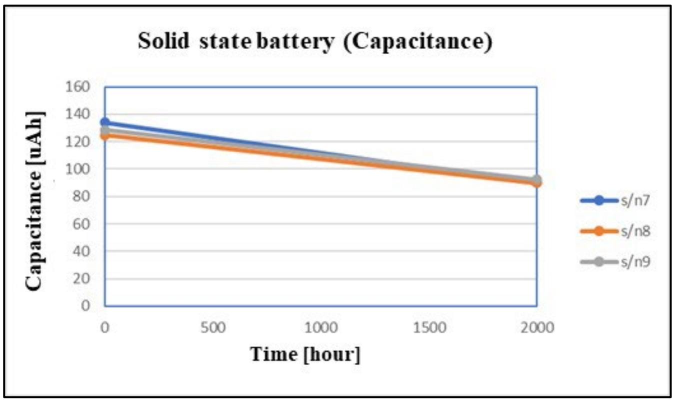


Fig. 37. The result of the electrical characteristic measurements after the ion migration test on solid-state battery

The results of the external visual examination after the thermal shock test are shown in Fig. 38.
During charging and discharging before the thermal shock test, discoloration (brown) was confirmed in the negative electrode of all samples. After 2000 hours, peeling occurred on the positive electrode. The browned area is indicated by the yellow arrow, the crack area is indicated by the red arrow and the peeling area is indicated by the blue arrow in the figure.

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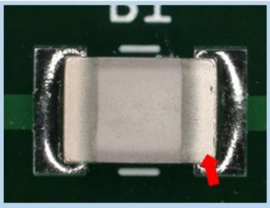
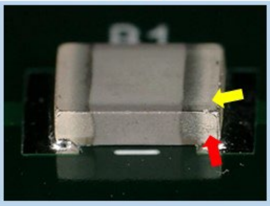
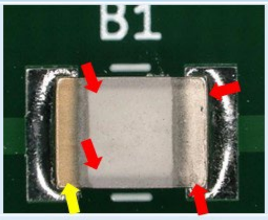
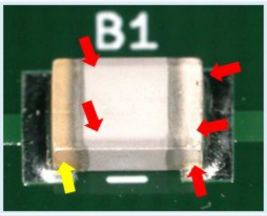
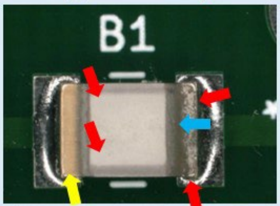
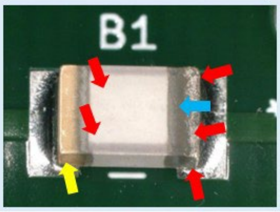
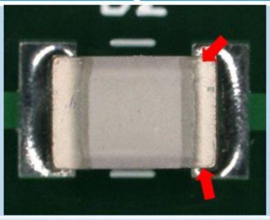
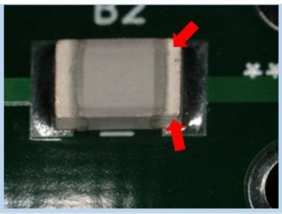
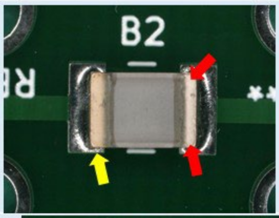
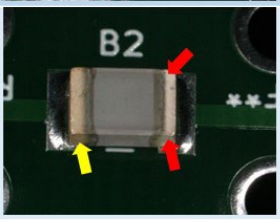
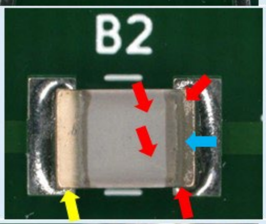
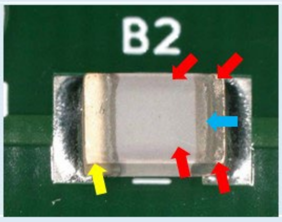
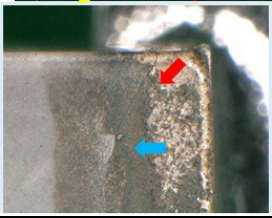
Pre		
500hours		
2000hours		
2000hours (Enlarged image)		

s/n:8	Top	Tilt 45°
Pre		
500hours		
2000hours		
2000hours (Enlarged image)		

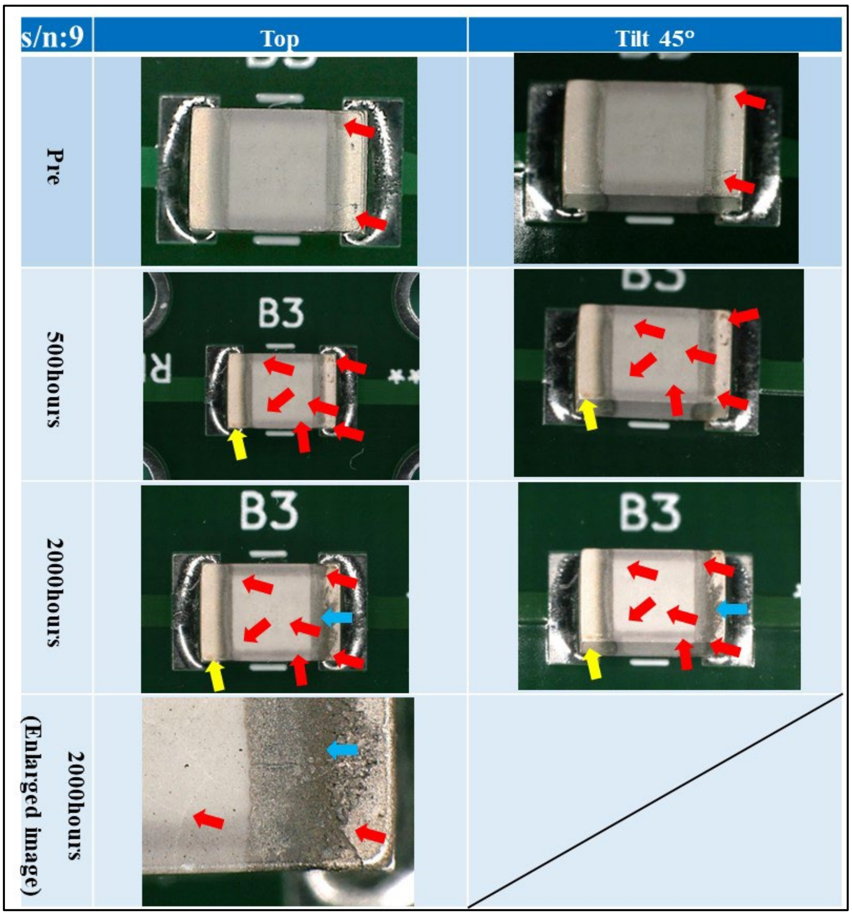


Fig. 38. The result of external visual examination after the ion migration test on solid-state battery

As a result of the TID tests, the mechanical stress tests, and the thermal environment tests on polymer tantalum capacitor, voltage-controlled crystal oscillator, and laminated metallized film chip capacitor, no abnormalities or failures were found under the test conditions implemented. We believe that they are suitable for use in space applications under the test conditions implemented.

On the other hand, for solid-state battery, discoloration occurred in the electrodes and cracks occurred in the electrodes and bodies due to charging and discharging before the application of stress, so we believe that they are unsuitable for use in spacecraft.

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 the TID tests, the mechanical stress tests, and the thermal environment tests on the four types of passive components mentioned above, it was found that the solid-state battery used in these tests are not suitable for use in space applications. In the future, we will conduct outgassing tests and whisker growth evaluations on the remaining three types of passive components and prepare evaluation guidelines for the use of passive COTS components in space applications.

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[2] N.Ikeda, K,Suzuki, *"Introduction of JAXA qualified Passive Components and Their Qualification Requirement in Comparison with ESCC Qualification Requirement", 2nd Space Passive Component Days,* 2016

[3] JAXA-QTS-2000 Common Parts/Materials, Space Use, General specification for.