(2023.11.13. revised)

# Comparison Evaluation of SMD type Aluminum Electrolytic Capacitors

# 面実装型電解コンデンサ試験結果報告Vol.2

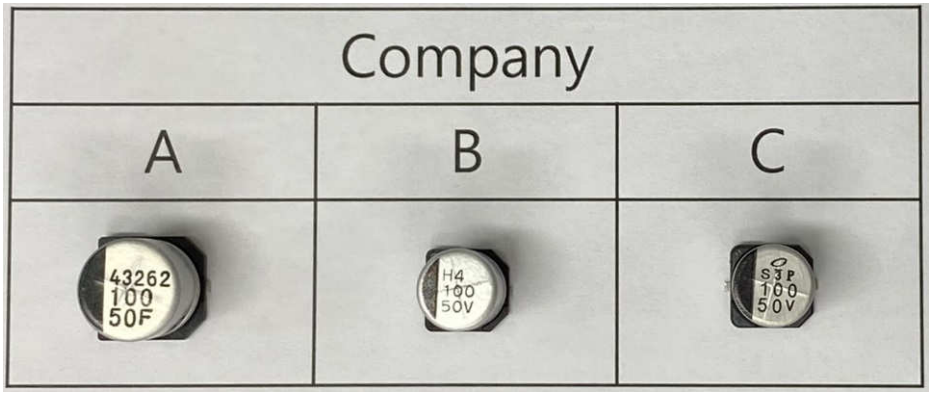
KETI

J Chip Consulting

# Table of Contents



# Specimens




| Sample | Capacitance (μF) (±10%) | Rated voltage ($V_{DC}$) | Capacitance tolerance (%) | Shelf life (Hr) | Operation Temp. (°C) | Dimensions (mm) |
|---|---|---|---|---|---|---|
| A | 100 | 50 | ± 20 | 1000 Hr at 105°C | -55 ~ +105 | Φ10×10 |
| B | 100 | 50 | ± 20 | 1000 Hr at 105°C | -55 ~ +105 | Φ8×10 |
| C | 100 | 50 | ± 20 | 1000 Hr at 105°C | -55 ~ +105 | Φ8×10 |

· A社：SAMWHA (韓国) (RC1H107M10010)
· B社：SU'SCON (台湾) (CH050M101F10PKKKV00R)
· C社：NICHICON (日本) (UWT1H101MNL1GS)

# II. Environmental test ～

# A社

# High temperature test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 98.9019 | 98.3452 | -0.562881 | 0.050808 | 0.048203 | -5.127145 | 0.685290 | 0.649850 | -5.171533 |
| 2 | 99.4635 | 99.0922 | -0.373303 | 0.050847 | 0.047271 | -7.032863 | 0.681300 | 0.628010 | -7.821811 |
| 3 | 100.551 | 99.7579 | -0.788754 | 0.050319 | 0.048764 | -3.090284 | 0.664650 | 0.646810 | -2.684119 |
| 4 | 98.5208 | 97.8814 | -0.649000 | 0.052205 | 0.050474 | -3.315774 | 0.696490 | 0.681120 | -2.206780 |
| 5 | 99.9911 | 99.4052 | -0.585952 | 0.049807 | 0.047151 | -5.332584 | 0.656770 | 0.627790 | -4.412504 |
| 6 | 100.507 | 99.9324 | -0.571701 | 0.048566 | 0.046253 | -4.762591 | 0.639990 | 0.611910 | -4.387569 |
| 7 | 99.1683 | 98.5295 | -0.644157 | 0.046947 | 0.045104 | -3.925703 | 0.627160 | 0.606460 | -3.300593 |
| 8 | 101.068 | 100.335 | -0.725254 | 0.044829 | 0.042978 | -4.129024 | 0.589040 | 0.565260 | -4.037077 |
| 9 | 97.9175 | 97.3167 | -0.613578 | 0.050123 | 0.047949 | -4.337330 | 0.680590 | 0.653180 | -4.027388 |
| 10 | 100.078 | 99.4922 | -0.585343 | 0.051886 | 0.049763 | -4.091662 | 0.682330 | 0.658520 | -3.489514 |
| Min | 97.9175 | 97.3167 | -0.613578 | 0.044829 | 0.042978 | -4.129024 | 0.589040 | 0.565260 | -4.037077 |
| Max | 101.068 | 100.335 | -0.725254 | 0.052205 | 0.050474 | -3.315774 | 0.696490 | 0.681120 | -2.206780 |
| Avg | 99.6167 | 99.0088 | -0.610279 | 0.049634 | 0.047391 | -4.518503 | 0.660361 | 0.632891 | -4.159846 |

# A社

# Low temperature test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 99.2494 | 98.9928 | -0.258541 | 0.050529 | 0.052879 | 4.650795 | 0.675840 | 0.707240 | 4.646070 |
| 2 | 99.6261 | 99.6972 | 0.071367 | 0.053288 | 0.054081 | 1.488140 | 0.700070 | 0.716010 | 2.276915 |
| 3 | 100.802 | 100.701 | -0.100196 | 0.048923 | 0.050625 | 3.478936 | 0.641810 | 0.665390 | 3.673985 |
| 4 | 97.0514 | 96.9893 | -0.063987 | 0.051525 | 0.053233 | 3.314896 | 0.704820 | 0.723980 | 2.718425 |
| 5 | 97.6265 | 97.6036 | -0.023457 | 0.052206 | 0.053511 | 2.499713 | 0.704510 | 0.726490 | 3.119899 |
| 6 | 99.8175 | 99.7504 | -0.067223 | 0.056198 | 0.057846 | 2.932489 | 0.741180 | 0.765210 | 3.242127 |
| 7 | 100.205 | 100.413 | 0.207574 | 0.057202 | 0.057227 | 0.043705 | 0.753120 | 0.754210 | 0.144731 |
| 8 | 99.1915 | 98.9246 | -0.269075 | 0.050374 | 0.052947 | 5.107794 | 0.674160 | 0.706240 | 4.758514 |
| 9 | 100.502 | 100.471 | -0.030845 | 0.045696 | 0.046654 | 2.096464 | 0.601170 | 0.614170 | 2.162450 |
| 10 | 99.5474 | 99.4842 | -0.063487 | 0.051462 | 0.053104 | 3.190704 | 0.683170 | 0.704120 | 3.066587 |
| Min | 97.0514 | 96.9893 | -0.063987 | 0.045696 | 0.046654 | 2.096464 | 0.601170 | 0.614170 | 2.162450 |
| Max | 100.802 | 100.701 | -0.100196 | 0.057202 | 0.057846 | 1.125835 | 0.753120 | 0.765210 | 1.605322 |
| Avg | 99.3619 | 99.3027 | -0.059550 | 0.05174 | 0.053211 | 2.841885 | 0.687985 | 0.708306 | 2.953698 |

# A社

# Thermal shock test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 97.5531 | 97.2053 | -0.356524 | 0.046851 | 0.048313 | 3.120531 | 0.632760 | 0.657640 | 3.931981 |
| 2 | 99.1395 | 99.0242 | -0.116301 | 0.047251 | 0.048199 | 2.006307 | 0.630630 | 0.643180 | 1.990073 |
| 3 | 99.2261 | 99.0915 | -0.135650 | 0.049398 | 0.050885 | 3.010243 | 0.657610 | 0.678880 | 3.234440 |
| 4 | 100.580 | 100.556 | -0.023862 | 0.051643 | 0.052297 | 1.266387 | 0.679940 | 0.686730 | 0.998618 |
| 5 | 100.109 | 100.026 | -0.082910 | 0.049240 | 0.049954 | 1.450041 | 0.650020 | 0.660920 | 1.676871 |
| 6 | 98.5103 | 98.6037 | 0.094812 | 0.058929 | 0.059821 | 1.513686 | 0.794170 | 0.799450 | 0.664845 |
| 7 | 100.673 | 100.569 | -0.103305 | 0.041346 | 0.042495 | 2.778987 | 0.566320 | 0.559790 | -1.153058 |
| 8 | 99.6298 | 99.5918 | -0.038141 | 0.053165 | 0.054451 | 2.418885 | 0.705350 | 0.722060 | 2.369037 |
| 9 | 98.7614 | 98.7628 | 0.001418 | 0.058346 | 0.058894 | 0.939225 | 0.779440 | 0.788360 | 1.144411 |
| 10 | 98.8416 | 98.9105 | 0.069707 | 0.053764 | 0.054321 | 1.036009 | 0.719160 | 0.721720 | 0.355971 |
| Min | 97.5531 | 97.2053 | -0.356524 | 0.041346 | 0.042495 | 2.778987 | 0.566320 | 0.559790 | -1.153058 |
| Max | 100.673 | 100.569 | -0.103305 | 0.058929 | 0.059821 | 1.513686 | 0.794170 | 0.799450 | 0.664845 |
| Avg | 99.3024 | 99.2341 | -0.068780 | 0.050993 | 0.051963 | 1.901622 | 0.681540 | 0.691873 | 1.516125 |

# A社

# Vibration test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 100.082 | 99.9699 | -0.112008 | 0.047986 | 0.049072 | 2.263160 | 0.632360 | 0.650470 | 2.863875 |
| 2 | 100.071 | 99.9198 | -0.151093 | 0.048719 | 0.050053 | 2.738151 | 0.644480 | 0.662130 | 2.738642 |
| 3 | 99.9607 | 99.9391 | -0.021608 | 0.051558 | 0.052199 | 1.243260 | 0.680860 | 0.692020 | 1.639103 |
| 4 | 100.234 | 100.12 | -0.113734 | 0.049643 | 0.050635 | 1.998268 | 0.655210 | 0.667650 | 1.898628 |
| 5 | 100.365 | 100.135 | -0.229164 | 0.049849 | 0.051804 | 3.921844 | 0.655140 | 0.684490 | 4.479958 |
| 6 | 100.011 | 99.8752 | -0.135785 | 0.051278 | 0.052355 | 2.100316 | 0.678140 | 0.691870 | 2.024656 |
| 7 | 99.7564 | 99.7305 | -0.025963 | 0.050192 | 0.050903 | 1.416560 | 0.664070 | 0.678230 | 2.132305 |
| 8 | 99.4196 | 99.2309 | -0.189802 | 0.048175 | 0.049948 | 3.680332 | 0.641670 | 0.664710 | 3.590631 |
| 9 | 99.5585 | 99.4073 | -0.151871 | 0.052647 | 0.054112 | 2.782685 | 0.698140 | 0.719320 | 3.033775 |
| 10 | 99.5338 | 99.3467 | -0.187976 | 0.047946 | 0.049555 | 3.355859 | 0.637580 | 0.658670 | 3.307820 |
| Min | 99.4196 | 99.2309 | -0.189802 | 0.047946 | 0.049072 | 2.348475 | 0.632360 | 0.650470 | 2.863875 |
| Max | 100.365 | 100.135 | -0.229164 | 0.052647 | 0.054112 | 2.782685 | 0.698140 | 0.719320 | 3.033775 |
| Avg | 99.8992 | 99.7674 | -0.131893 | 0.049799 | 0.051064 | 2.538791 | 0.658765 | 0.676956 | 2.761379 |

# A社

# High humidity test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 98.1053 | 97.9839 | -0.123745 | 0.052221 | 0.052768 | 1.047471 | 0.702510 | 0.714910 | 1.765099 |
| 2 | 100.424 | 99.8819 | -0.539811 | 0.048987 | 0.051813 | 5.768877 | 0.648860 | 0.684990 | 5.568227 |
| 3 | 99.4979 | 99.4083 | -0.090052 | 0.051119 | 0.051651 | 1.040709 | 0.678640 | 0.687940 | 1.370388 |
| 4 | 99.3859 | 99.1763 | -0.210895 | 0.052799 | 0.054224 | 2.698915 | 0.703170 | 0.721080 | 2.547037 |
| 5 | 99.2654 | 99.1503 | -0.115952 | 0.054374 | 0.054996 | 1.143929 | 0.723600 | 0.735530 | 1.648701 |
| 6 | 99.6528 | 99.3849 | -0.268833 | 0.051218 | 0.052726 | 2.944277 | 0.681030 | 0.700690 | 2.886804 |
| 7 | 99.5556 | 99.4224 | -0.133795 | 0.050548 | 0.051167 | 1.224579 | 0.670980 | 0.682030 | 1.646845 |
| 8 | 99.7863 | 99.6047 | -0.181989 | 0.056018 | 0.057272 | 2.238566 | 0.741430 | 0.759040 | 2.375140 |
| 9 | 99.6229 | 99.4951 | -0.128284 | 0.051047 | 0.051648 | 1.177346 | 0.677170 | 0.687260 | 1.490025 |
| 10 | 100.525 | 100.336 | -0.188013 | 0.048233 | 0.049317 | 2.247424 | 0.635290 | 0.649490 | 2.235200 |
| Min | 98.1053 | 97.9839 | -0.123745 | 0.048233 | 0.049317 | 2.247424 | 0.635290 | 0.649490 | 2.235200 |
| Max | 100.525 | 100.336 | -0.188013 | 0.056018 | 0.057272 | 2.238566 | 0.741430 | 0.759040 | 2.375140 |
| Avg | 99.5821 | 99.3844 | -0.198560 | 0.051656 | 0.052758 | 2.132940 | 0.686268 | 0.702296 | 2.335531 |

# A社

# High temperature test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 90.4254 | 90.7023 | 0.306219 | 0.225466 | 0.205411 | -8.894911 | 0.378170 | 0.344940 | -8.787053 |
| 2 | 90.7108 | 92.7730 | 2.273379 | 0.231813 | 0.196716 | -15.140221 | 0.385160 | 0.330920 | -14.082459 |
| 3 | 92.0519 | 91.9241 | -0.138835 | 0.223405 | 0.208741 | -6.563864 | 0.365410 | 0.345510 | -5.445937 |
| 4 | 89.7927 | 89.3494 | -0.493693 | 0.227895 | 0.216202 | -5.130872 | 0.386520 | 0.368470 | -4.669875 |
| 5 | 91.6985 | 91.5802 | -0.129010 | 0.226752 | 0.211136 | -6.886819 | 0.375850 | 0.350330 | -6.789943 |
| 6 | 92.5755 | 92.8122 | 0.255683 | 0.219850 | 0.200794 | -8.667728 | 0.359170 | 0.331920 | -7.586937 |
| 7 | 91.8635 | 91.8212 | -0.046047 | 0.209473 | 0.195368 | -6.733565 | 0.346070 | 0.325550 | -5.929436 |
| 8 | 93.9825 | 94.1613 | 0.190248 | 0.209891 | 0.190771 | -9.109490 | 0.338670 | 0.312770 | -7.647563 |
| 9 | 89.5191 | 89.6513 | 0.147678 | 0.227267 | 0.208716 | -8.162646 | 0.382410 | 0.353710 | -7.505034 |
| 10 | 91.7142 | 91.8104 | 0.104891 | 0.223496 | 0.209111 | -6.436357 | 0.375890 | 0.352720 | -6.164037 |
| Min | 89.5191 | 89.3494 | -0.189568 | 0.209473 | 0.190771 | -8.928120 | 0.338670 | 0.312770 | -7.647563 |
| Max | 93.9825 | 94.1613 | 0.190248 | 0.231813 | 0.216202 | -6.734307 | 0.386520 | 0.368470 | -4.669875 |
| Avg | 91.4334 | 91.6585 | 0.246223 | 0.222531 | 0.204297 | -8.194012 | 0.369332 | 0.341684 | -7.485948 |

# A社

# Low temperature test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 90.8862 | 90.1501 | -0.809914 | 0.223329 | 0.239126 | 7.073421 | 0.370070 | 0.397770 | 7.485070 |
| 2 | 90.5402 | 90.1436 | -0.438037 | 0.238071 | 0.252026 | 5.861697 | 0.397270 | 0.421030 | 5.980819 |
| 3 | 92.3007 | 91.7185 | -0.630764 | 0.225721 | 0.239338 | 6.032669 | 0.366740 | 0.391520 | 6.756830 |
| 4 | 88.5676 | 88.1827 | -0.434583 | 0.224295 | 0.237884 | 6.058539 | 0.382790 | 0.407510 | 6.457849 |
| 5 | 89.2138 | 88.4103 | -0.900645 | 0.224743 | 0.245103 | 9.059237 | 0.382750 | 0.415060 | 8.441541 |
| 6 | 89.9903 | 89.0531 | -1.041446 | 0.243781 | 0.265448 | 8.887895 | 0.409080 | 0.443320 | 8.370001 |
| 7 | 89.5619 | 89.3663 | -0.218396 | 0.249371 | 0.266876 | 7.019661 | 0.417050 | 0.440640 | 5.656396 |
| 8 | 90.7801 | 90.0199 | -0.837408 | 0.223855 | 0.240515 | 7.442318 | 0.370760 | 0.402860 | 8.657892 |
| 9 | 93.2873 | 92.8084 | -0.513360 | 0.211325 | 0.222095 | 5.096415 | 0.345730 | 0.361730 | 4.627889 |
| 10 | 91.0113 | 90.5434 | -0.514112 | 0.226403 | 0.237979 | 5.113006 | 0.375420 | 0.396610 | 5.644345 |
| Min | 88.5676 | 88.1827 | -0.434583 | 0.211325 | 0.222095 | 5.096415 | 0.345730 | 0.361730 | 4.627889 |
| Max | 93.2873 | 92.8084 | -0.513360 | 0.249371 | 0.266876 | 7.019661 | 0.417050 | 0.443320 | 6.299005 |
| Avg | 90.6139 | 90.0396 | -0.633799 | 0.229089 | 0.244639 | 6.787569 | 0.381766 | 0.407805 | 6.820670 |

# A社

# Thermal shock test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 91.1158 | 89.5002 | -1.773128 | 0.200705 | 0.222127 | 10.673376 | 0.343350 | 0.375380 | 9.328673 |
| 2 | 91.5666 | 91.0306 | -0.585366 | 0.218753 | 0.225881 | 3.258470 | 0.361980 | 0.376010 | 3.875905 |
| 3 | 91.3011 | 90.5187 | -0.856945 | 0.219811 | 0.229767 | 4.529346 | 0.365710 | 0.382550 | 4.604741 |
| 4 | 91.6541 | 91.2805 | -0.407620 | 0.232711 | 0.241036 | 3.577399 | 0.382220 | 0.398510 | 4.261943 |
| 5 | 92.1251 | 91.5621 | -0.611126 | 0.224155 | 0.231873 | 3.443153 | 0.369090 | 0.381440 | 3.346067 |
| 6 | 87.6826 | 87.1415 | -0.617112 | 0.250818 | 0.273125 | 8.893700 | 0.426110 | 0.464520 | 9.014104 |
| 7 | 94.1301 | 94.0021 | -0.135982 | 0.203455 | 0.203628 | 0.085031 | 0.331110 | 0.330240 | -0.262753 |
| 8 | 90.7015 | 90.0113 | -0.760958 | 0.233500 | 0.249093 | 6.677944 | 0.387610 | 0.415490 | 7.192797 |
| 9 | 88.0222 | 87.1804 | -0.956350 | 0.259198 | 0.277603 | 7.100749 | 0.439870 | 0.469410 | 6.715621 |
| 10 | 89.8622 | 89.5651 | -0.330617 | 0.234962 | 0.243871 | 3.791677 | 0.393320 | 0.409990 | 4.238279 |
| Min | 87.6826 | 87.1415 | -0.617112 | 0.200705 | 0.203628 | 1.456366 | 0.331110 | 0.330240 | -0.262753 |
| Max | 94.1301 | 94.0021 | -0.135982 | 0.259198 | 0.277603 | 7.100749 | 0.439870 | 0.469410 | 6.715621 |
| Avg | 90.8161 | 90.1793 | -0.701285 | 0.227807 | 0.2398 | 5.264812 | 0.380037 | 0.400354 | 5.346058 |

# A社

# Vibration test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 92.1316 | 91.4498 | -0.740028 | 0.223845 | 0.234511 | 4.764904 | 0.368720 | 0.385910 | 4.662074 |
| 2 | 92.1129 | 91.6891 | -0.460088 | 0.221976 | 0.228507 | 2.942210 | 0.364430 | 0.377450 | 3.572703 |
| 3 | 91.0775 | 90.6196 | -0.502759 | 0.233434 | 0.241202 | 3.327707 | 0.387550 | 0.398730 | 2.884789 |
| 4 | 91.9831 | 91.6981 | -0.309840 | 0.228812 | 0.232601 | 1.655945 | 0.374720 | 0.383650 | 2.383113 |
| 5 | 92.0626 | 91.1023 | -1.043095 | 0.222674 | 0.237211 | 6.528378 | 0.367670 | 0.391420 | 6.459597 |
| 6 | 91.8212 | 91.4804 | -0.371156 | 0.223431 | 0.228861 | 2.430280 | 0.368030 | 0.378620 | 2.877483 |
| 7 | 91.3087 | 90.7235 | -0.640903 | 0.229568 | 0.238638 | 3.950899 | 0.381030 | 0.394120 | 3.435425 |
| 8 | 91.5208 | 91.0222 | -0.544794 | 0.223671 | 0.232118 | 3.776529 | 0.368140 | 0.385270 | 4.653121 |
| 9 | 90.5261 | 89.8224 | -0.777345 | 0.233428 | 0.244796 | 4.870024 | 0.389750 | 0.408030 | 4.690186 |
| 10 | 91.7909 | 91.2873 | -0.548638 | 0.219878 | 0.227011 | 3.244072 | 0.362770 | 0.378010 | 4.201009 |
| Min | 90.5261 | 89.8224 | -0.777345 | 0.219878 | 0.227011 | 3.244072 | 0.362770 | 0.377450 | 4.046641 |
| Max | 92.1316 | 91.6981 | -0.470523 | 0.233434 | 0.244796 | 4.867329 | 0.389750 | 0.408030 | 4.690186 |
| Avg | 91.6335 | 91.0895 | -0.593745 | 0.226072 | 0.234546 | 3.748324 | 0.373281 | 0.388121 | 3.975557 |

# A社

# High humidity test ①

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 89.3357 | 88.7898 | -0.611066 | 0.232665 | 0.239125 | 2.776524 | 0.393930 | 0.403770 | 2.497906 |
| 2 | 91.9013 | 91.0016 | -0.978985 | 0.225316 | 0.236085 | 4.779510 | 0.366940 | 0.392140 | 6.867608 |
| 3 | 91.0514 | 90.5911 | -0.505539 | 0.230211 | 0.236017 | 2.522034 | 0.382110 | 0.390960 | 2.316087 |
| 4 | 90.2049 | 89.8147 | -0.432571 | 0.237118 | 0.241499 | 1.847603 | 0.395150 | 0.405440 | 2.604074 |
| 5 | 90.0296 | 89.5808 | -0.498503 | 0.235124 | 0.240315 | 2.207771 | 0.394010 | 0.402280 | 2.098931 |
| 6 | 90.8007 | 90.3059 | -0.544930 | 0.234914 | 0.240713 | 2.468563 | 0.389360 | 0.401950 | 3.233511 |
| 7 | 91.5176 | 90.9862 | -0.580653 | 0.222855 | 0.229810 | 3.120863 | 0.370010 | 0.380460 | 2.824248 |
| 8 | 89.5822 | 89.1111 | -0.525886 | 0.248315 | 0.253383 | 2.040956 | 0.414840 | 0.425850 | 2.654035 |
| 9 | 91.0689 | 90.6612 | -0.447683 | 0.228761 | 0.233912 | 2.251695 | 0.379980 | 0.388150 | 2.150113 |
| 10 | 92.5675 | 92.1773 | -0.421530 | 0.223571 | 0.228543 | 2.223902 | 0.365330 | 0.375440 | 2.767361 |
| Min | 89.3357 | 88.7898 | -0.611066 | 0.222855 | 0.228543 | 2.552332 | 0.365330 | 0.375440 | 2.767361 |
| Max | 92.5675 | 92.1773 | -0.421530 | 0.248315 | 0.253383 | 2.040956 | 0.414840 | 0.425850 | 2.654035 |
| Avg | 90.8060 | 90.3020 | -0.555041 | 0.231885 | 0.23794 | 2.611294 | 0.385166 | 0.396644 | 2.980014 |

# A社

# High humidity test ②

| No. | Leakage current (nA) | | | | | |
|---|---|---|---|---|---|---|
| | Before Test | After 200 hr | After 400 hr | After 600 hr | After 800 hr | After 1000 hr |
| 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| 4 | 2 | 2 | 2 | 2 | 2 | 2 |
| 5 | 2 | 2 | 1 | 2 | 2 | 2 |
| 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 7 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 2 | 2 | 2 | 2 | 2 | 2 |
| 9 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 | 2 | 2 | 2 | 2 | 2 | 2 |

# A社

# Stored in room temperature

| No. | Leakage current (nA) | | | | | |
|---|---|---|---|---|---|---|
| | Before Test | After 200 hr | After 400 hr | After 600 hr | After 800 hr | After 1000 hr |
| 1 | 2 | 2 | 1 | 3 | 2 | 2 |
| 2 | 2 | 2 | 1 | 3 | 2 | 2 |
| 3 | 2 | 2 | 1 | 3 | 2 | 2 |
| 4 | 2 | 2 | 1 | 3 | 2 | 2 |
| 5 | 2 | 2 | 1 | 2 | 2 | 2 |
| 6 | 2 | 2 | 1 | 3 | 2 | 2 |
| 7 | 2 | 2 | 1 | 2 | 2 | 2 |
| 8 | 2 | 2 | 1 | 2 | 2 | 2 |
| 9 | 2 | 2 | 1 | 2 | 2 | 2 |
| 10 | 2 | 2 | 1 | 2 | 2 | 2 |

# A社

# Withstanding voltage

＊＊印加電圧: 500Vdc

| | Original sample | | After the high temperature test sample | | |
|---|---|---|---|---|---|
| No. | Leakage current (uA) | Withstanding voltage (PASS/FAIL) | No. | Leakage current (uA) | Withstanding voltage (PASS/FAIL) |
| 1 | 1 | PASS | 11 | 1 | PASS |
| 2 | 1 | PASS | 12 | 1 | PASS |
| 3 | 1 | PASS | 13 | 1 | PASS |
| 4 | 1 | PASS | 14 | 1 | PASS |
| 5 | 1 | PASS | 15 | 1 | PASS |
| 6 | 1 | PASS | | | |
| 7 | 1 | PASS | | | |
| 8 | 1 | PASS | | | |
| 9 | 1 | PASS | | | |
| 10 | 1 | PASS | | | |

# A社

# Insulation resistance

＊＊印加電圧: 500Vdc

| | Original sample | After the high temperature test sample | |
|---|---|---|---|
| No. | Insulation resistance(MΩ) | No. | Insulation resistance(MΩ) |
| 1 | Over 100 | 11 | Over 100 |
| 2 | Over 100 | 12 | Over 100 |
| 3 | Over 100 | 13 | Over 100 |
| 4 | Over 100 | 14 | Over 100 |
| 5 | Over 100 | 15 | Over 100 |
| 6 | Over 100 | | |
| 7 | Over 100 | | |
| 8 | Over 100 | | |
| 9 | Over 100 | | |
| 10 | Over 100 | | |

# B社

# High temperature test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 93.6066 | 93.0811 | -0.561392 | 0.053834 | 0.051953 | -3.494074 | 0.763880 | 0.740350 | -3.080327 |
| 2 | 93.9321 | 93.3966 | -0.570093 | 0.050967 | 0.048208 | -5.413307 | 0.716170 | 0.682360 | -4.720946 |
| 3 | 93.1449 | 92.5313 | -0.658759 | 0.055081 | 0.053904 | -2.136853 | 0.784420 | 0.771900 | -1.596084 |
| 4 | 95.2706 | 94.9551 | -0.331162 | 0.047529 | 0.043923 | -7.586947 | 0.657730 | 0.611650 | -7.005914 |
| 5 | 94.1454 | 93.5375 | -0.645703 | 0.050584 | 0.047636 | -5.827930 | 0.712110 | 0.675330 | -5.164932 |
| 6 | 94.6083 | 94.3632 | -0.259068 | 0.046448 | 0.042862 | -7.720462 | 0.648130 | 0.599850 | -7.449123 |
| 7 | 95.2526 | 94.9422 | -0.325870 | 0.047294 | 0.043733 | -7.529496 | 0.658740 | 0.610480 | -7.326107 |
| 8 | 93.9368 | 93.3888 | -0.583371 | 0.052814 | 0.050037 | -5.258076 | 0.741120 | 0.707660 | -4.514788 |
| 9 | 95.3501 | 94.8593 | -0.514735 | 0.048227 | 0.045432 | -5.795509 | 0.670770 | 0.636830 | -5.059857 |
| 10 | 94.2225 | 93.8113 | -0.436414 | 0.046616 | 0.043531 | -6.617899 | 0.652960 | 0.613190 | -6.090725 |
| Min | 93.1449 | 92.5313 | -0.658759 | 0.046448 | 0.042862 | -7.720462 | 0.648130 | 0.599850 | -7.449123 |
| Max | 95.3501 | 94.9551 | -0.414263 | 0.055081 | 0.053904 | -2.136853 | 0.784420 | 0.771900 | -1.596084 |
| Avg | 94.3470 | 93.8866 | -0.487933 | 0.049939 | 0.047122 | -5.641838 | 0.700603 | 0.664960 | -5.087475 |

# B社

# Low temperature test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 95.2542 | 95.2829 | 0.030130 | 0.047311 | 0.047323 | 0.025364 | 0.659250 | 0.658650 | -0.091013 |
| 2 | 93.1987 | 93.2526 | 0.057833 | 0.054155 | 0.054131 | -0.044317 | 0.766420 | 0.765640 | -0.101772 |
| 3 | 93.5129 | 93.5278 | 0.015934 | 0.055394 | 0.055518 | 0.223851 | 0.785360 | 0.785970 | 0.077671 |
| 4 | 94.6173 | 94.5626 | -0.057812 | 0.048553 | 0.048686 | 0.273927 | 0.677720 | 0.679620 | 0.280352 |
| 5 | 94.8423 | 94.6819 | -0.169123 | 0.049331 | 0.050544 | 2.458900 | 0.690530 | 0.706300 | 2.283753 |
| 6 | 94.8023 | 94.7808 | -0.022679 | 0.046864 | 0.047303 | 0.936753 | 0.652520 | 0.660060 | 1.155520 |
| 7 | 95.0806 | 95.0506 | -0.031552 | 0.046321 | 0.046844 | 1.129078 | 0.646490 | 0.652220 | 0.886325 |
| 8 | 94.1439 | 94.1685 | 0.026130 | 0.054292 | 0.054355 | 0.116039 | 0.760520 | 0.762620 | 0.276127 |
| 9 | 94.1603 | 93.9756 | -0.196155 | 0.049928 | 0.051125 | 2.397452 | 0.702640 | 0.719950 | 2.463566 |
| 10 | 94.2833 | 94.2595 | -0.025243 | 0.048458 | 0.047975 | -0.996739 | 0.664550 | 0.672780 | 1.238432 |
| Min | 93.1987 | 93.2526 | 0.057833 | 0.046321 | 0.046844 | 1.129078 | 0.646490 | 0.652220 | 0.886325 |
| Max | 95.2542 | 95.2829 | 0.030130 | 0.055394 | 0.055518 | 0.223851 | 0.785360 | 0.785970 | 0.077671 |
| Avg | 94.3896 | 94.3543 | -0.037398 | 0.050061 | 0.05038 | 0.638625 | 0.700600 | 0.706381 | 0.825150 |

# B社

# Thermal shock test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 94.3954 | 93.7925 | -0.638696 | 0.048645 | 0.050094 | 2.978723 | 0.688500 | 0.707820 | 2.806100 |
| 2 | 94.4953 | 93.8991 | -0.630931 | 0.047151 | 0.048208 | 2.241734 | 0.657680 | 0.678130 | 3.109415 |
| 3 | 95.4177 | 95.0714 | -0.362931 | 0.046937 | 0.046811 | -0.268445 | 0.652530 | 0.652460 | -0.010727 |
| 4 | 95.0848 | 94.7719 | -0.329075 | 0.046748 | 0.046414 | -0.714469 | 0.648640 | 0.647370 | -0.195794 |
| 5 | 94.6813 | 94.1923 | -0.516469 | 0.045888 | 0.046284 | 0.862971 | 0.643740 | 0.651330 | 1.179047 |
| 6 | 93.3620 | 93.2622 | -0.106896 | 0.052569 | 0.051126 | -2.744964 | 0.742850 | 0.723840 | -2.559063 |
| 7 | 95.0366 | 94.2552 | -0.822210 | 0.046903 | 0.048321 | 3.023261 | 0.655420 | 0.680130 | 3.770102 |
| 8 | 94.4831 | 94.2813 | -0.213583 | 0.046508 | 0.045773 | -1.580373 | 0.647410 | 0.641880 | -0.854173 |
| 9 | 94.0102 | 93.7881 | -0.236251 | 0.053049 | 0.052436 | -1.155535 | 0.747720 | 0.740560 | -0.957578 |
| 10 | 95.1511 | 94.6408 | -0.536305 | 0.045099 | 0.046197 | 2.434644 | 0.622240 | 0.645050 | 3.665788 |
| Min | 93.362 | 93.2622 | -0.106896 | 0.045099 | 0.045773 | 1.494490 | 0.622240 | 0.641880 | 3.156338 |
| Max | 95.4177 | 95.0714 | -0.362931 | 0.053049 | 0.052436 | -1.155535 | 0.747720 | 0.740560 | -0.957578 |
| Avg | 94.6118 | 94.1955 | -0.439977 | 0.04795 | 0.048166 | 0.451932 | 0.670673 | 0.676857 | 0.922059 |

# B社

# Vibration test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 95.8121 | 95.8271 | 0.015656 | 0.048303 | 0.048565 | 0.542409 | 0.668230 | 0.671870 | 0.544723 |
| 2 | 95.3945 | 95.3845 | -0.010483 | 0.050112 | 0.050543 | 0.860073 | 0.692840 | 0.700060 | 1.042088 |
| 3 | 95.3703 | 95.3473 | -0.024117 | 0.046074 | 0.046603 | 1.148153 | 0.641940 | 0.648310 | 0.992305 |
| 4 | 93.8434 | 93.8307 | -0.013533 | 0.054221 | 0.054399 | 0.328286 | 0.761330 | 0.764080 | 0.361210 |
| 5 | 95.3712 | 95.3442 | -0.028310 | 0.047049 | 0.047448 | 0.848052 | 0.654650 | 0.659550 | 0.748492 |
| 6 | 95.3404 | 95.3461 | 0.005979 | 0.048757 | 0.049009 | 0.516849 | 0.674620 | 0.678680 | 0.601820 |
| 7 | 95.8201 | 95.8287 | 0.008975 | 0.046673 | 0.046922 | 0.533499 | 0.646070 | 0.649120 | 0.472085 |
| 8 | 95.4489 | 95.4855 | 0.038345 | 0.047435 | 0.047465 | 0.063244 | 0.655740 | 0.655870 | 0.019825 |
| 9 | 94.2589 | 94.3041 | 0.047953 | 0.050222 | 0.050403 | 0.360400 | 0.706060 | 0.708740 | 0.379571 |
| 10 | 96.1055 | 96.1002 | -0.005515 | 0.048013 | 0.048405 | 0.816446 | 0.659210 | 0.663770 | 0.691737 |
| Min | 93.8434 | 93.8307 | -0.013533 | 0.046074 | 0.046603 | 1.148153 | 0.641940 | 0.648310 | 0.992305 |
| Max | 96.1055 | 96.1002 | -0.005515 | 0.054221 | 0.054399 | 0.328286 | 0.761330 | 0.764080 | 0.361210 |
| Avg | 95.2765 | 95.2798 | 0.003474 | 0.048686 | 0.048976 | 0.596271 | 0.676069 | 0.680005 | 0.582189 |

# B社

# High humidity test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 93.4482 | 93.5205 | 0.077369 | 0.053154 | 0.052435 | -1.352673 | 0.752750 | 0.743110 | -1.280638 |
| 2 | 95.0061 | 94.9765 | -0.031156 | 0.045801 | 0.045839 | 0.082968 | 0.636730 | 0.638020 | 0.202598 |
| 3 | 93.3847 | 93.2645 | -0.128715 | 0.053539 | 0.053787 | 0.463214 | 0.760830 | 0.763480 | 0.348304 |
| 4 | 94.9887 | 94.9445 | -0.046532 | 0.046517 | 0.046613 | 0.206376 | 0.646670 | 0.648590 | 0.296906 |
| 5 | 95.2943 | 95.2209 | -0.077025 | 0.047331 | 0.047812 | 1.016247 | 0.659540 | 0.665240 | 0.864239 |
| 6 | 95.7227 | 95.6881 | -0.036146 | 0.047032 | 0.047108 | 0.161592 | 0.648850 | 0.650140 | 0.198813 |
| 7 | 93.1561 | 93.0566 | -0.106810 | 0.057221 | 0.057229 | 0.013981 | 0.816950 | 0.814010 | -0.359875 |
| 8 | 94.9141 | 94.8607 | -0.056261 | 0.047085 | 0.047312 | 0.482107 | 0.654420 | 0.659340 | 0.751811 |
| 9 | 94.6794 | 94.6503 | -0.030735 | 0.050653 | 0.050711 | 0.114505 | 0.710620 | 0.709840 | -0.109763 |
| 10 | 94.1108 | 94.0088 | -0.108383 | 0.047779 | 0.048502 | 1.513217 | 0.669610 | 0.682250 | 1.887666 |
| Min | 93.1561 | 93.0566 | -0.106810 | 0.045801 | 0.045839 | 0.082968 | 0.636730 | 0.638020 | 0.202598 |
| Max | 95.7227 | 95.6881 | -0.036146 | 0.057221 | 0.057229 | 0.013981 | 0.816950 | 0.814010 | -0.359875 |
| Avg | 94.4705 | 94.4191 | -0.054377 | 0.049611 | 0.049735 | 0.249137 | 0.695697 | 0.697402 | 0.245078 |

# B社

# High temperature test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 83.4631 | 83.9767 | 0.615362 | 0.293613 | 0.271454 | -7.547009 | 0.512610 | 0.478120 | -6.728312 |
| 2 | 84.8931 | 85.4105 | 0.609472 | 0.278915 | 0.257921 | -7.527024 | 0.488500 | 0.451580 | -7.557830 |
| 3 | 82.4817 | 82.7013 | 0.266241 | 0.304818 | 0.282945 | -7.175757 | 0.535530 | 0.502960 | -6.081825 |
| 4 | 86.1801 | 86.8165 | 0.738454 | 0.276935 | 0.258444 | -6.677018 | 0.477180 | 0.444810 | -6.783604 |
| 5 | 84.6468 | 85.2701 | 0.736354 | 0.285426 | 0.262616 | -7.991563 | 0.494940 | 0.456830 | -7.699923 |
| 6 | 85.8001 | 86.6241 | 0.960372 | 0.272864 | 0.252055 | -7.626143 | 0.472770 | 0.436640 | -7.642194 |
| 7 | 85.7916 | 86.7041 | 1.063624 | 0.282519 | 0.260063 | -7.948492 | 0.483250 | 0.446380 | -7.629591 |
| 8 | 84.5914 | 85.1251 | 0.630915 | 0.281909 | 0.260253 | -7.681912 | 0.493840 | 0.457090 | -7.441682 |
| 9 | 86.0501 | 86.8437 | 0.922253 | 0.280516 | 0.253251 | -9.719588 | 0.478710 | 0.433170 | -9.513066 |
| 10 | 85.5315 | 86.1657 | 0.741481 | 0.271410 | 0.250212 | -7.810324 | 0.473250 | 0.436220 | -7.824617 |
| Min | 82.4817 | 82.7013 | 0.266241 | 0.27141 | 0.250212 | -7.810324 | 0.472770 | 0.433170 | -8.376166 |
| Max | 86.1801 | 86.8437 | 0.770015 | 0.304818 | 0.282945 | -7.175757 | 0.535530 | 0.502960 | -6.081825 |
| Avg | 84.9430 | 85.5638 | 0.730879 | 0.282893 | 0.260921 | -7.766590 | 0.491058 | 0.454380 | -7.469179 |

# B社

# Low temperature test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 85.7876 | 85.8636 | 0.088591 | 0.282614 | 0.282133 | -0.170197 | 0.483830 | 0.482530 | -0.268689 |
| 2 | 83.6442 | 83.6972 | 0.063364 | 0.287633 | 0.287290 | -0.119249 | 0.509540 | 0.507040 | -0.490639 |
| 3 | 82.9622 | 83.1202 | 0.190448 | 0.303007 | 0.301177 | -0.603946 | 0.530380 | 0.527560 | -0.531694 |
| 4 | 85.5364 | 85.5429 | 0.007599 | 0.276718 | 0.275745 | -0.351622 | 0.479920 | 0.478230 | -0.352142 |
| 5 | 85.4841 | 85.1962 | -0.336788 | 0.281975 | 0.285183 | 1.137690 | 0.482750 | 0.492510 | 2.021750 |
| 6 | 85.8441 | 85.5299 | -0.366012 | 0.276491 | 0.281894 | 1.954132 | 0.477750 | 0.486360 | 1.802198 |
| 7 | 86.0136 | 85.9061 | -0.124980 | 0.276181 | 0.278354 | 0.786803 | 0.473110 | 0.478060 | 1.046268 |
| 8 | 84.4819 | 84.1564 | -0.385290 | 0.286199 | 0.292317 | 2.137673 | 0.500290 | 0.509760 | 1.892902 |
| 9 | 84.8707 | 84.5249 | -0.407443 | 0.278936 | 0.282707 | 1.351923 | 0.483350 | 0.492510 | 1.895107 |
| 10 | 85.3525 | 84.8926 | -0.538824 | 0.275603 | 0.283464 | 2.852291 | 0.480750 | 0.492410 | 2.425377 |
| Min | 82.9622 | 83.1202 | 0.190448 | 0.275603 | 0.275745 | 0.051523 | 0.473110 | 0.478060 | 1.046268 |
| Max | 86.0136 | 85.9061 | -0.124980 | 0.303007 | 0.301177 | -0.603946 | 0.530380 | 0.527560 | -0.531694 |
| Avg | 84.9977 | 84.8430 | -0.182040 | 0.282536 | 0.285026 | 0.881552 | 0.490167 | 0.494697 | 0.924175 |

# B社

# Thermal shock test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 85.3678 | 85.1502 | -0.254897 | 0.272826 | 0.267045 | -2.118933 | 0.466970 | 0.464750 | -0.475405 |
| 2 | 85.6916 | 85.3931 | -0.348342 | 0.272712 | 0.266512 | -2.273461 | 0.474440 | 0.465080 | -1.972852 |
| 3 | 85.9925 | 86.2661 | 0.318167 | 0.281818 | 0.270252 | -4.104067 | 0.480550 | 0.464030 | -3.437728 |
| 4 | 86.2067 | 86.2813 | 0.086536 | 0.273798 | 0.265939 | -2.870364 | 0.472540 | 0.459020 | -2.861133 |
| 5 | 85.6812 | 85.7651 | 0.097921 | 0.275314 | 0.264403 | -3.963111 | 0.472690 | 0.457350 | -3.245256 |
| 6 | 84.3032 | 84.4227 | 0.141750 | 0.278936 | 0.272611 | -2.267545 | 0.491770 | 0.479450 | -2.505236 |
| 7 | 85.9737 | 85.8041 | -0.197270 | 0.272914 | 0.261832 | -4.060620 | 0.468250 | 0.453310 | -3.190603 |
| 8 | 86.0619 | 85.7732 | -0.335456 | 0.268305 | 0.266256 | -0.763683 | 0.467950 | 0.462420 | -1.181750 |
| 9 | 84.3666 | 84.5719 | 0.243343 | 0.284571 | 0.275751 | -3.099402 | 0.494930 | 0.481530 | -2.707454 |
| 10 | 87.3301 | 86.4161 | -1.046604 | 0.254251 | 0.259801 | 2.182882 | 0.444130 | 0.449310 | 1.166325 |
| Min | 84.3032 | 84.4227 | 0.141750 | 0.254251 | 0.259801 | 2.182882 | 0.444130 | 0.449310 | 1.166325 |
| Max | 87.3301 | 86.4161 | -1.046604 | 0.284571 | 0.275751 | -3.099402 | 0.494930 | 0.481530 | -2.707454 |
| Avg | 85.6975 | 85.5844 | -0.132034 | 0.273545 | 0.26704 | -2.377785 | 0.473422 | 0.463625 | -2.069401 |

# B社

# Vibration test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 86.1007 | 86.0216 | -0.091869 | 0.284912 | 0.286774 | 0.653535 | 0.485690 | 0.489220 | 0.726801 |
| 2 | 85.7181 | 85.4201 | -0.347651 | 0.284907 | 0.290261 | 1.879210 | 0.491390 | 0.499630 | 1.676876 |
| 3 | 86.3364 | 86.1719 | -0.190534 | 0.273881 | 0.277093 | 1.172772 | 0.467870 | 0.473150 | 1.128519 |
| 4 | 84.1331 | 84.0361 | -0.115294 | 0.287622 | 0.289385 | 0.612957 | 0.504570 | 0.507120 | 0.505381 |
| 5 | 86.0581 | 85.9602 | -0.113760 | 0.278703 | 0.280719 | 0.723351 | 0.476510 | 0.480590 | 0.856225 |
| 6 | 85.9872 | 85.8513 | -0.158047 | 0.279873 | 0.282198 | 0.830734 | 0.482290 | 0.485830 | 0.733998 |
| 7 | 86.4816 | 86.4276 | -0.062441 | 0.279504 | 0.280975 | 0.526289 | 0.475470 | 0.478050 | 0.542621 |
| 8 | 86.3415 | 86.2329 | -0.125780 | 0.277846 | 0.279377 | 0.551025 | 0.478050 | 0.479650 | 0.334693 |
| 9 | 84.8516 | 84.8497 | -0.002239 | 0.282701 | 0.283662 | 0.339935 | 0.489230 | 0.491120 | 0.386321 |
| 10 | 86.8024 | 86.6601 | -0.163936 | 0.277912 | 0.280375 | 0.886252 | 0.475230 | 0.480350 | 1.077373 |
| Min | 84.1331 | 84.0361 | -0.115294 | 0.273881 | 0.277093 | 1.172772 | 0.467870 | 0.473150 | 1.128519 |
| Max | 86.8024 | 86.6601 | -0.163936 | 0.287622 | 0.290261 | 0.917524 | 0.504570 | 0.507120 | 0.505381 |
| Avg | 85.8811 | 85.7632 | -0.137306 | 0.280786 | 0.283082 | 0.817633 | 0.482630 | 0.486471 | 0.795848 |

# B社

# High humidity test ①

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 83.6891 | 83.9472 | 0.308403 | 0.290354 | 0.286022 | -1.491972 | 0.509110 | 0.499610 | -1.866001 |
| 2 | 86.3628 | 86.2079 | -0.179360 | 0.270605 | 0.272719 | 0.781212 | 0.466610 | 0.469330 | 0.582928 |
| 3 | 83.2249 | 83.2445 | 0.023551 | 0.294184 | 0.293048 | -0.386153 | 0.514510 | 0.515190 | 0.132165 |
| 4 | 86.2637 | 86.0716 | -0.222689 | 0.271155 | 0.273171 | 0.743486 | 0.468730 | 0.471020 | 0.488554 |
| 5 | 85.9517 | 85.8239 | -0.148688 | 0.278801 | 0.280635 | 0.657817 | 0.476630 | 0.481190 | 0.956717 |
| 6 | 86.7701 | 86.6403 | -0.149591 | 0.271603 | 0.273329 | 0.635486 | 0.465910 | 0.468230 | 0.497950 |
| 7 | 82.1112 | 82.2104 | 0.120812 | 0.309881 | 0.307301 | -0.832578 | 0.545530 | 0.541430 | -0.751563 |
| 8 | 86.0257 | 85.7501 | -0.320369 | 0.272592 | 0.276245 | 1.340098 | 0.471110 | 0.477040 | 1.258729 |
| 9 | 85.1621 | 85.1402 | -0.025716 | 0.283309 | 0.283614 | 0.107656 | 0.488320 | 0.488110 | -0.043005 |
| 10 | 85.4011 | 84.7662 | -0.743433 | 0.274024 | 0.283491 | 3.454807 | 0.478130 | 0.493250 | 3.162320 |
| Min | 82.1112 | 82.2104 | 0.120812 | 0.270605 | 0.272719 | 0.781212 | 0.465910 | 0.468230 | 0.497950 |
| Max | 86.7701 | 86.6403 | -0.149591 | 0.309881 | 0.307301 | -0.832578 | 0.545530 | 0.541430 | -0.751563 |
| Avg | 85.0962 | 84.9802 | -0.136328 | 0.281651 | 0.282958 | 0.463943 | 0.488459 | 0.490440 | 0.405561 |

# B社

# High humidity test ②

| No. | Leakage current (nA) | | | | | |
|---|---|---|---|---|---|---|
| | Before Test | After 200 hr | After 400 hr | After 600 hr | After 800 hr | After 1000 hr |
| 1 | 2 | 2 | 2 | 3 | 2 | 2 |
| 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| 4 | 2 | 2 | 2 | 2 | 2 | 2 |
| 5 | 2 | 2 | 2 | 2 | 2 | 2 |
| 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 7 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 2 | 2 | 2 | 2 | 2 | 2 |
| 9 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 | 2 | 2 | 2 | 2 | 2 | 2 |

# B社

# Stored in room temperature

| No. | Leakage current (nA) | | | | | |
|---|---|---|---|---|---|---|
| | Before Test | After 200 hr | After 400 hr | After 600 hr | After 800 hr | After 1000 hr |
| 1 | 2 | 2 | 1 | 2 | 2 | 2 |
| 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 3 | 2 | 2 | 1 | 2 | 2 | 2 |
| 4 | 2 | 2 | 1 | 2 | 2 | 2 |
| 5 | 2 | 2 | 1 | 2 | 2 | 2 |
| 6 | 2 | 2 | 1 | 2 | 2 | 2 |
| 7 | 2 | 2 | 1 | 2 | 2 | 2 |
| 8 | 2 | 2 | 1 | 2 | 2 | 2 |
| 9 | 2 | 2 | 1 | 2 | 2 | 2 |
| 10 | 2 | 2 | 1 | 2 | 2 | 2 |

# B社

# Withstanding voltage

＊＊印加電圧: 500Vdc

| | Original sample | | After the high temperature test sample | | |
|---|---|---|---|---|---|
| No. | Leakage current (uA) | Withstanding voltage (PASS/FAIL) | No. | Leakage current (uA) | Withstanding voltage (PASS/FAIL) |
| 1 | 1 | PASS | 11 | 1 | PASS |
| 2 | 1 | PASS | 12 | 1 | PASS |
| 3 | 1 | PASS | 13 | 1 | PASS |
| 4 | 1 | PASS | 14 | 1 | PASS |
| 5 | 1 | PASS | 15 | 1 | PASS |
| 6 | 1 | PASS | | | |
| 7 | 1 | PASS | | | |
| 8 | 1 | PASS | | | |
| 9 | 1 | PASS | | | |
| 10 | 1 | PASS | | | |

# B社

# Insulation resistance

＊＊印加電圧: 500Vdc

| | Original sample | After the high temperature test sample | |
|---|---|---|---|
| No. | Insulation resistance(MΩ) | No. | Insulation resistance(MΩ) |
| 1 | Over 100 | 11 | Over 100 |
| 2 | Over 100 | 12 | Over 100 |
| 3 | Over 100 | 13 | Over 100 |
| 4 | Over 100 | 14 | Over 100 |
| 5 | Over 100 | 15 | Over 100 |
| 6 | Over 100 | | |
| 7 | Over 100 | | |
| 8 | Over 100 | | |
| 9 | Over 100 | | |
| 10 | Over 100 | | |

# C社

# High temperature test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 94.7209 | 93.2358 | -1.567869 | 0.060298 | 0.060388 | 0.149259 | 0.849660 | 0.860270 | 1.248735 |
| 2 | 94.6974 | 93.4428 | -1.324852 | 0.063657 | 0.060466 | -5.012803 | 0.884990 | 0.851120 | -3.827162 |
| 3 | 94.9466 | 93.9283 | -1.072498 | 0.062581 | 0.058567 | -6.414087 | 0.874150 | 0.829960 | -5.055196 |
| 4 | 95.0235 | 93.9461 | -1.133825 | 0.063143 | 0.060594 | -4.036869 | 0.874450 | 0.849520 | -2.850935 |
| 5 | 93.1939 | 92.0192 | -1.260490 | 0.064955 | 0.060098 | -7.477484 | 0.924010 | 0.865510 | -6.331100 |
| 6 | 95.0882 | 93.9738 | -1.171965 | 0.064004 | 0.060901 | -4.848134 | 0.886050 | 0.854120 | -3.603634 |
| 7 | 95.2122 | 93.8984 | -1.379865 | 0.062204 | 0.060098 | -3.385634 | 0.868450 | 0.849660 | -2.163625 |
| 8 | 94.4002 | 93.2384 | -1.230718 | 0.064455 | 0.061522 | -4.550462 | 0.897860 | 0.868960 | -3.218765 |
| 9 | 94.7589 | 93.5655 | -1.259407 | 0.061994 | 0.057228 | -7.687841 | 0.869130 | 0.814880 | -6.241874 |
| 10 | 93.0862 | 92.0029 | -1.163760 | 0.075709 | 0.073505 | -2.911147 | 1.069110 | 1.051190 | -1.676161 |
| Min | 93.0862 | 92.0029 | -1.163760 | 0.060298 | 0.057228 | -5.091379 | 0.849660 | 0.814880 | -4.093402 |
| Max | 95.2122 | 93.9738 | -1.300674 | 0.075709 | 0.073505 | -2.911147 | 1.069110 | 1.051190 | -1.676161 |
| Avg | 94.5128 | 93.32512 | -1.256634 | 0.0643 | 0.061337 | -4.608554 | 0.899786 | 0.869519 | -3.363800 |

# C社

# Low temperature test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 93.2082 | 93.1884 | -0.021243 | 0.065449 | 0.065347 | -0.155847 | 0.924500 | 0.928450 | 0.427258 |
| 2 | 94.2425 | 94.0545 | -0.199485 | 0.064331 | 0.066366 | 3.163327 | 0.905580 | 0.928290 | 2.507785 |
| 3 | 94.7718 | 94.5621 | -0.221268 | 0.061166 | 0.062328 | 1.899748 | 0.846610 | 0.873130 | 3.132493 |
| 4 | 95.0341 | 94.8963 | -0.145001 | 0.063529 | 0.064986 | 2.293441 | 0.885320 | 0.901020 | 1.773370 |
| 5 | 94.5276 | 94.2552 | -0.288170 | 0.059824 | 0.062052 | 3.724258 | 0.824930 | 0.871140 | 5.601687 |
| 6 | 94.2115 | 93.9119 | -0.318008 | 0.060467 | 0.063152 | 4.440439 | 0.854560 | 0.886520 | 3.739936 |
| 7 | 93.2411 | 93.1001 | -0.151221 | 0.065278 | 0.066112 | 1.277613 | 0.921150 | 0.941380 | 2.196168 |
| 8 | 94.2969 | 94.1789 | -0.125137 | 0.060997 | 0.062606 | 2.637835 | 0.852110 | 0.876970 | 2.917464 |
| 9 | 92.2146 | 91.8335 | -0.413275 | 0.058329 | 0.061156 | 4.846646 | 0.839860 | 0.881030 | 4.902007 |
| 10 | 94.2450 | 94.1011 | -0.152687 | 0.061621 | 0.062782 | 1.884098 | 0.859740 | 0.879120 | 2.254170 |
| Min | 92.2146 | 91.8335 | -0.413275 | 0.058329 | 0.061156 | 4.846646 | 0.824930 | 0.871140 | 5.601687 |
| Max | 95.0341 | 94.8963 | -0.145001 | 0.065449 | 0.066366 | 1.401091 | 0.924500 | 0.941380 | 1.825852 |
| Avg | 93.9993 | 93.8082 | -0.203331 | 0.062099 | 0.063689 | 2.559779 | 0.871436 | 0.896705 | 2.899697 |

# C社

# Thermal shock test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 92.8789 | 92.4431 | -0.469213 | 0.063650 | 0.059704 | -6.199529 | 0.863130 | 0.860840 | -0.265313 |
| 2 | 93.9935 | 93.7346 | -0.275445 | 0.064072 | 0.061688 | -3.720814 | 0.897970 | 0.863150 | -3.877635 |
| 3 | 92.0825 | 91.8108 | -0.295061 | 0.061194 | 0.058701 | -4.073929 | 0.879790 | 0.848470 | -3.559940 |
| 4 | 94.5446 | 94.0515 | -0.521553 | 0.064436 | 0.063211 | -1.901111 | 0.897290 | 0.884670 | -1.406457 |
| 5 | 93.4778 | 93.1138 | -0.389397 | 0.081258 | 0.079226 | -2.500677 | 1.149970 | 1.133210 | -1.457429 |
| 6 | 94.8327 | 94.3425 | -0.516910 | 0.063272 | 0.061333 | -3.064547 | 0.883390 | 0.855820 | -3.120932 |
| 7 | 94.6812 | 94.1815 | -0.527771 | 0.063031 | 0.060645 | -3.785439 | 0.876230 | 0.853950 | -2.542711 |
| 8 | 95.3121 | 94.7012 | -0.640947 | 0.063408 | 0.062728 | -1.072420 | 0.881020 | 0.869910 | -1.261038 |
| 9 | 93.5803 | 93.1438 | -0.466444 | 0.064242 | 0.061888 | -3.664269 | 0.903890 | 0.881260 | -2.503623 |
| 10 | 94.2537 | 93.7331 | -0.552339 | 0.063968 | 0.062282 | -2.635693 | 0.897650 | 0.873680 | -2.670306 |
| Min | 92.0825 | 91.8108 | -0.295061 | 0.061194 | 0.058701 | -4.073929 | 0.863130 | 0.848470 | -1.698470 |
| Max | 95.3121 | 94.7012 | -0.640947 | 0.081258 | 0.079226 | -2.500677 | 1.149970 | 1.133210 | -1.457429 |
| Avg | 93.9637 | 93.5256 | -0.466286 | 0.065253 | 0.063141 | -3.237394 | 0.913033 | 0.892496 | -2.249316 |

# C社

# Vibration test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 94.5555 | 94.3744 | -0.191528 | 0.065170 | 0.065774 | 0.926807 | 0.915380 | 0.925040 | 1.055299 |
| 2 | 94.3573 | 94.2906 | -0.070689 | 0.064882 | 0.065478 | 0.918591 | 0.904290 | 0.915170 | 1.203154 |
| 3 | 94.9221 | 94.8003 | -0.128316 | 0.061028 | 0.061594 | 0.927443 | 0.852930 | 0.862840 | 1.161877 |
| 4 | 93.3810 | 93.3473 | -0.036089 | 0.073629 | 0.074149 | 0.706243 | 1.037560 | 1.044350 | 0.654420 |
| 5 | 94.9506 | 94.9297 | -0.022011 | 0.062136 | 0.064947 | 4.523947 | 0.908730 | 0.906960 | -0.194777 |
| 6 | 94.3384 | 94.2883 | -0.053107 | 0.067084 | 0.067087 | 0.004472 | 0.935660 | 0.935730 | 0.007481 |
| 7 | 94.5076 | 94.3919 | -0.122424 | 0.063635 | 0.064964 | 2.088473 | 0.894550 | 0.912970 | 2.059136 |
| 8 | 94.5438 | 94.4154 | -0.135810 | 0.066723 | 0.067042 | 0.478096 | 0.928570 | 0.933640 | 0.546001 |
| 9 | 95.0315 | 94.8174 | -0.225294 | 0.063012 | 0.064177 | 1.848854 | 0.878640 | 0.896240 | 2.003096 |
| 10 | 94.5461 | 94.4603 | -0.090749 | 0.065482 | 0.065957 | 0.725390 | 0.911460 | 0.919010 | 0.828341 |
| Min | 93.381 | 93.3473 | -0.036089 | 0.061028 | 0.061594 | 0.927443 | 0.852930 | 0.862840 | 1.161877 |
| Max | 95.0315 | 94.9297 | -0.107122 | 0.073629 | 0.074149 | 0.706243 | 1.037560 | 1.044350 | 0.654420 |
| Avg | 94.5134 | 94.4116 | -0.107741 | 0.065278 | 0.066117 | 1.284964 | 0.916777 | 0.925195 | 0.918217 |

# C社

# High humidity test

＊120 Hzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 94.9411 | 94.7624 | -0.188222 | 0.063451 | 0.062602 | -1.338040 | 0.886860 | 0.877050 | -1.106150 |
| 2 | 94.5936 | 94.2604 | -0.352244 | 0.065773 | 0.066343 | 0.866617 | 0.915220 | 0.927770 | 1.371255 |
| 3 | 92.2638 | 91.9522 | -0.337727 | 0.060968 | 0.061982 | 1.663168 | 0.875270 | 0.891340 | 1.836005 |
| 4 | 94.4303 | 94.1239 | -0.324472 | 0.065484 | 0.066128 | 0.983446 | 0.910990 | 0.925780 | 1.623508 |
| 5 | 93.7636 | 93.5351 | -0.243698 | 0.065805 | 0.065659 | -0.221868 | 0.929770 | 0.930050 | 0.030115 |
| 6 | 91.8462 | 91.6166 | -0.249983 | 0.088052 | 0.090014 | 2.228229 | 1.257240 | 1.290150 | 2.617639 |
| 7 | 92.3388 | 92.1648 | -0.188436 | 0.060867 | 0.061564 | 1.145120 | 0.867450 | 0.882910 | 1.782235 |
| 8 | 91.9674 | 91.6853 | -0.306739 | 0.063507 | 0.064986 | 2.328877 | 0.915020 | 0.934670 | 2.147494 |
| 9 | 94.8412 | 94.5941 | -0.260541 | 0.064994 | 0.065471 | 0.733914 | 0.902730 | 0.915110 | 1.371396 |
| 10 | 94.6507 | 94.3393 | -0.328999 | 0.067325 | 0.067734 | 0.607501 | 0.940870 | 0.946190 | 0.565434 |
| Min | 91.8462 | 91.6166 | -0.249983 | 0.060867 | 0.061564 | 1.145120 | 0.867450 | 0.877050 | 1.106692 |
| Max | 94.9411 | 94.7624 | -0.188222 | 0.088052 | 0.090014 | 2.228229 | 1.257240 | 1.290150 | 2.617639 |
| Avg | 93.5637 | 93.3034 | -0.278164 | 0.066623 | 0.067248 | 0.939171 | 0.940142 | 0.952102 | 1.272148 |

# C社

# High temperature test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 82.3083 | 81.7511 | -0.676967 | 0.338739 | 0.326801 | -3.524247 | 0.575210 | 0.571910 | -0.573704 |
| 2 | 82.4759 | 82.6013 | 0.152044 | 0.341958 | 0.320667 | -6.226203 | 0.597510 | 0.564140 | -5.584844 |
| 3 | 82.2104 | 82.6131 | 0.489841 | 0.349772 | 0.325601 | -6.910502 | 0.597440 | 0.560340 | -6.209829 |
| 4 | 82.8476 | 82.7210 | -0.152811 | 0.341891 | 0.326913 | -4.380928 | 0.591770 | 0.571220 | -3.472633 |
| 5 | 79.7435 | 80.8616 | 1.402121 | 0.365522 | 0.320877 | -12.214039 | 0.638970 | 0.569670 | -10.845580 |
| 6 | 82.7531 | 82.7996 | 0.056191 | 0.341719 | 0.324229 | -5.118240 | 0.592260 | 0.566460 | -4.356195 |
| 7 | 82.5561 | 82.4481 | -0.130820 | 0.344411 | 0.327067 | -5.035844 | 0.584590 | 0.565160 | -3.323697 |
| 8 | 82.3610 | 82.1666 | -0.236034 | 0.342527 | 0.323913 | -5.434316 | 0.598010 | 0.572090 | -4.334376 |
| 9 | 82.1199 | 82.7761 | 0.799075 | 0.345326 | 0.310714 | -10.022993 | 0.591770 | 0.533270 | -9.885597 |
| 10 | 77.8011 | 77.4825 | -0.409506 | 0.393566 | 0.377044 | -4.198025 | 0.702710 | 0.681240 | -3.055314 |
| Min | 77.8011 | 77.4825 | -0.409506 | 0.338739 | 0.310714 | -8.273331 | 0.575210 | 0.533270 | -7.291250 |
| Max | 82.8476 | 82.7996 | -0.057938 | 0.393566 | 0.377044 | -4.198025 | 0.702710 | 0.681240 | -3.055314 |
| Avg | 81.7177 | 81.8221 | 0.127769 | 0.350543 | 0.328383 | -6.321762 | 0.607024 | 0.575550 | -5.184968 |

# C社

# Low temperature test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 80.6481 | 79.9088 | -0.916699 | 0.350777 | 0.362111 | 3.231113 | 0.624320 | 0.634210 | 1.584124 |
| 2 | 81.1661 | 80.8315 | -0.412241 | 0.355125 | 0.359954 | 1.359803 | 0.612460 | 0.629390 | 2.764262 |
| 3 | 83.8044 | 82.0251 | -2.123158 | 0.319551 | 0.347412 | 8.718796 | 0.558660 | 0.598120 | 7.063330 |
| 4 | 82.1827 | 82.0446 | -0.168040 | 0.351213 | 0.354471 | 0.927642 | 0.602760 | 0.614970 | 2.025682 |
| 5 | 84.8145 | 82.1981 | -3.084850 | 0.29748 | 0.337791 | 13.550827 | 0.527150 | 0.584540 | 10.886844 |
| 6 | 82.3354 | 81.7957 | -0.655490 | 0.333405 | 0.342214 | 2.642132 | 0.575250 | 0.601480 | 4.559757 |
| 7 | 80.5031 | 79.3412 | -1.443298 | 0.354908 | 0.372822 | 5.047505 | 0.627290 | 0.653140 | 4.120901 |
| 8 | 83.0529 | 81.8711 | -1.422949 | 0.327931 | 0.344577 | 5.076068 | 0.573450 | 0.599930 | 4.617665 |
| 9 | 81.3357 | 80.2077 | -1.386845 | 0.318057 | 0.335951 | 5.626036 | 0.560850 | 0.597060 | 6.456272 |
| 10 | 82.7413 | 81.8032 | -1.133775 | 0.330416 | 0.345438 | 4.546390 | 0.577580 | 0.602080 | 4.241837 |
| Min | 80.5031 | 79.3412 | -1.443298 | 0.29748 | 0.335951 | 12.932298 | 0.527150 | 0.584540 | 10.886844 |
| Max | 84.8145 | 82.1981 | -3.084850 | 0.355125 | 0.372822 | 4.983316 | 0.627290 | 0.653140 | 4.120901 |
| Avg | 82.2584 | 81.2027 | -1.283419 | 0.333886 | 0.350274 | 4.908198 | 0.583977 | 0.611492 | 4.711658 |

# C社

# Thermal shock test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 81.2601 | 80.9551 | -0.375338 | 0.329789 | 0.328049 | -0.527610 | 0.576380 | 0.575330 | -0.182171 |
| 2 | 81.9637 | 82.9501 | 1.203460 | 0.340432 | 0.318954 | -6.309043 | 0.596610 | 0.562330 | -5.745797 |
| 3 | 80.5297 | 81.0374 | 0.630451 | 0.333794 | 0.318911 | -4.458738 | 0.590410 | 0.562620 | -4.706899 |
| 4 | 82.0107 | 82.1767 | 0.202413 | 0.346357 | 0.333726 | -3.646815 | 0.604340 | 0.586220 | -2.998312 |
| 5 | 75.0552 | 75.1711 | 0.154420 | 0.436477 | 0.427665 | -2.018892 | 0.773550 | 0.756780 | -2.167927 |
| 6 | 82.2403 | 83.1017 | 1.047418 | 0.345691 | 0.325053 | -5.970072 | 0.594360 | 0.567440 | -4.529242 |
| 7 | 82.7249 | 82.5111 | -0.258447 | 0.335011 | 0.329616 | -1.610395 | 0.581930 | 0.568540 | -2.300964 |
| 8 | 82.5180 | 82.8615 | 0.416273 | 0.348908 | 0.335084 | -3.962076 | 0.596150 | 0.581890 | -2.392015 |
| 9 | 81.0556 | 80.9401 | -0.142495 | 0.348256 | 0.340552 | -2.212166 | 0.612340 | 0.594760 | -2.870954 |
| 10 | 81.5666 | 82.3072 | 0.907970 | 0.349095 | 0.328903 | -5.784099 | 0.604030 | 0.578720 | -4.190189 |
| Min | 75.0552 | 75.1711 | 0.154420 | 0.329789 | 0.318911 | -3.298473 | 0.576380 | 0.562330 | -2.437628 |
| Max | 82.7249 | 83.1017 | 0.455486 | 0.436477 | 0.427665 | -2.018892 | 0.773550 | 0.756780 | -2.167927 |
| Avg | 81.0925 | 81.4012 | 0.380701 | 0.351381 | 0.338651 | -3.622763 | 0.613010 | 0.593463 | -3.188692 |

# C社

# Vibration test

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 80.8818 | 80.5604 | -0.397370 | 0.365431 | 0.369592 | 1.138655 | 0.631480 | 0.637770 | 0.996073 |
| 2 | 81.8204 | 81.4711 | -0.426911 | 0.348524 | 0.352103 | 1.026902 | 0.608420 | 0.618130 | 1.595937 |
| 3 | 82.4857 | 82.1551 | -0.400797 | 0.343020 | 0.348275 | 1.531981 | 0.587530 | 0.596660 | 1.553963 |
| 4 | 77.6213 | 77.3811 | -0.309451 | 0.402845 | 0.406717 | 0.961164 | 0.714750 | 0.720990 | 0.873033 |
| 5 | 81.1547 | 81.1823 | 0.034009 | 0.368956 | 0.367712 | -0.337168 | 0.633760 | 0.631550 | -0.348712 |
| 6 | 80.6553 | 80.8004 | 0.179901 | 0.368431 | 0.363541 | -1.327250 | 0.642410 | 0.642220 | -0.029576 |
| 7 | 81.4465 | 80.9782 | -0.574979 | 0.355336 | 0.362703 | 2.073249 | 0.611330 | 0.627190 | 2.594343 |
| 8 | 81.1137 | 80.9113 | -0.249526 | 0.364424 | 0.366719 | 0.629761 | 0.634260 | 0.638610 | 0.685839 |
| 9 | 82.1325 | 81.5865 | -0.664779 | 0.351506 | 0.359324 | 2.224144 | 0.600740 | 0.617320 | 2.759929 |
| 10 | 81.6413 | 81.5113 | -0.159233 | 0.354875 | 0.356831 | 0.551180 | 0.618810 | 0.626680 | 1.271796 |
| Min | 77.6213 | 77.3811 | -0.309451 | 0.34302 | 0.348275 | 1.531981 | 0.587530 | 0.596660 | 1.553963 |
| Max | 82.4857 | 82.1551 | -0.400797 | 0.402845 | 0.406717 | 0.961164 | 0.714750 | 0.720990 | 0.873033 |
| Avg | 81.0953 | 80.8538 | -0.297859 | 0.362335 | 0.365352 | 0.832628 | 0.628349 | 0.635712 | 1.171801 |

# C社

# High humidity test ①

＊1 kHzで測定

| No. | Capacitance (uF) | | | Tan (δ) | | | ESR (ohm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) | Before Test | After test | Change rate (%) |
| 1 | 81.6684 | 81.7321 | 0.077998 | 0.359544 | 0.356406 | -0.872772 | 0.615540 | 0.606760 | -1.426390 |
| 2 | 81.6037 | 80.9392 | -0.814301 | 0.355737 | 0.362861 | 2.002603 | 0.619710 | 0.632850 | 2.120347 |
| 3 | 80.4121 | 79.8666 | -0.678380 | 0.339443 | 0.345802 | 1.873363 | 0.599440 | 0.613710 | 2.380555 |
| 4 | 81.5515 | 80.6203 | -1.141855 | 0.357732 | 0.368273 | 2.946619 | 0.624200 | 0.642710 | 2.965396 |
| 5 | 80.3333 | 80.1313 | -0.251452 | 0.365133 | 0.365768 | 0.173909 | 0.636530 | 0.636660 | 0.020423 |
| 6 | 72.2167 | 70.7181 | -2.075143 | 0.466821 | 0.485977 | 4.103500 | 0.852820 | 0.886510 | 3.950423 |
| 7 | 81.0034 | 80.0743 | -1.146989 | 0.331393 | 0.345715 | 4.321757 | 0.591180 | 0.611110 | 3.371224 |
| 8 | 79.4502 | 79.1513 | -0.376211 | 0.349706 | 0.352021 | 0.661985 | 0.620060 | 0.631930 | 1.914331 |
| 9 | 81.6722 | 80.9042 | -0.940344 | 0.359267 | 0.369388 | 2.817125 | 0.622160 | 0.637760 | 2.507394 |
| 10 | 80.0888 | 80.1134 | 0.030716 | 0.382912 | 0.379472 | -0.898379 | 0.660060 | 0.661770 | 0.259067 |
| Min | 72.2167 | 70.7181 | -2.075143 | 0.331393 | 0.345715 | 4.321757 | 0.591180 | 0.606760 | 2.635407 |
| Max | 81.6722 | 81.7321 | 0.073342 | 0.466821 | 0.485977 | 4.103500 | 0.852820 | 0.886510 | 3.950423 |
| Avg | 80.0000 | 79.4251 | -0.718687 | 0.366769 | 0.373168 | 1.744832 | 0.644170 | 0.656177 | 1.863949 |

# C社

# High humidity test ②

| No. | Leakage current (nA) | | | | | |
|---|---|---|---|---|---|---|
| | Before Test | After 200 hr | After 400 hr | After 600 hr | After 800 hr | After 1000 hr |
| 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| 4 | 2 | 2 | 2 | 2 | 2 | 2 |
| 5 | 2 | 2 | 2 | 2 | 2 | 2 |
| 6 | 2 | 2 | 1 | 2 | 2 | 2 |
| 7 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 2 | 2 | 1 | 2 | 2 | 2 |
| 9 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 | 2 | 2 | 1 | 2 | 2 | 2 |

# C社

# Stored in room temperature

| No. | Leakage current (nA) | | | | | |
|---|---|---|---|---|---|---|
| | Before Test | After 200 hr | After 400 hr | After 600 hr | After 800 hr | After 1000 hr |
| 1 | 2 | 2 | 1 | 2 | 2 | 2 |
| 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 3 | 2 | 2 | 1 | 2 | 2 | 2 |
| 4 | 2 | 2 | 1 | 2 | 2 | 2 |
| 5 | 2 | 2 | 1 | 2 | 2 | 2 |
| 6 | 2 | 2 | 1 | 2 | 2 | 2 |
| 7 | 2 | 2 | 1 | 2 | 2 | 2 |
| 8 | 2 | 2 | 1 | 2 | 2 | 2 |
| 9 | 2 | 2 | 1 | 2 | 2 | 2 |
| 10 | 2 | 2 | 1 | 2 | 2 | 2 |

# C社

# Withstanding voltage

＊＊印加電圧: 500Vdc

| | Original sample | | After the high temperature test sample | | |
|---|---|---|---|---|---|
| No. | Leakage current (uA) | Withstanding voltage (PASS/FAIL) | No. | Leakage current (uA) | Withstanding voltage (PASS/FAIL) |
| 1 | 1 | PASS | 11 | 1 | PASS |
| 2 | 1 | PASS | 12 | 1 | PASS |
| 3 | 1 | PASS | 13 | 1 | PASS |
| 4 | 1 | PASS | 14 | 1 | PASS |
| 5 | 1 | PASS | 15 | 1 | PASS |
| 6 | 1 | PASS | | | |
| 7 | 1 | PASS | | | |
| 8 | 1 | PASS | | | |
| 9 | 1 | PASS | | | |
| 10 | 1 | PASS | | | |

# C社

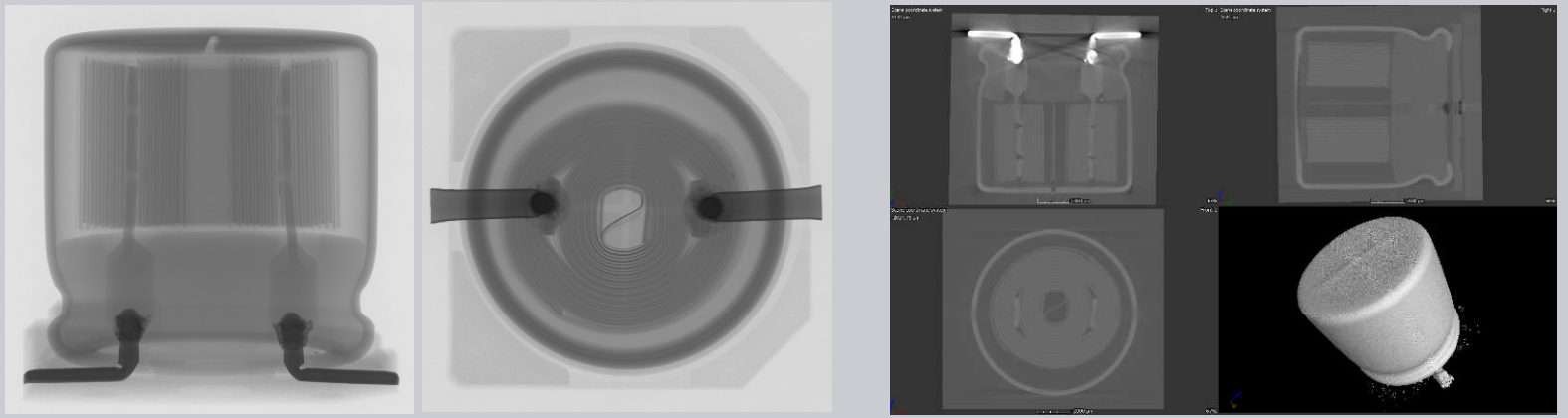
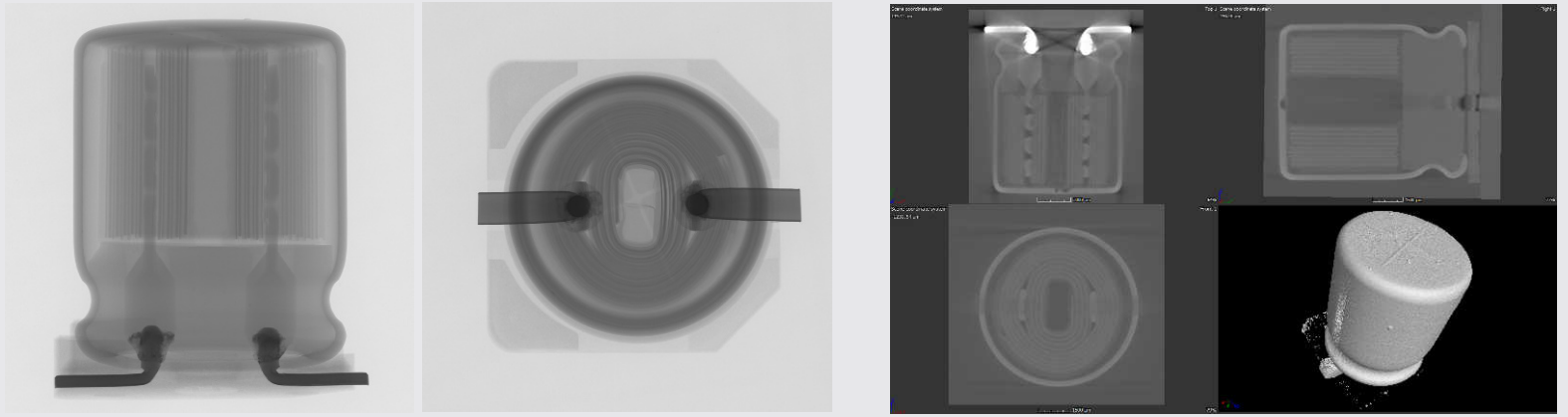
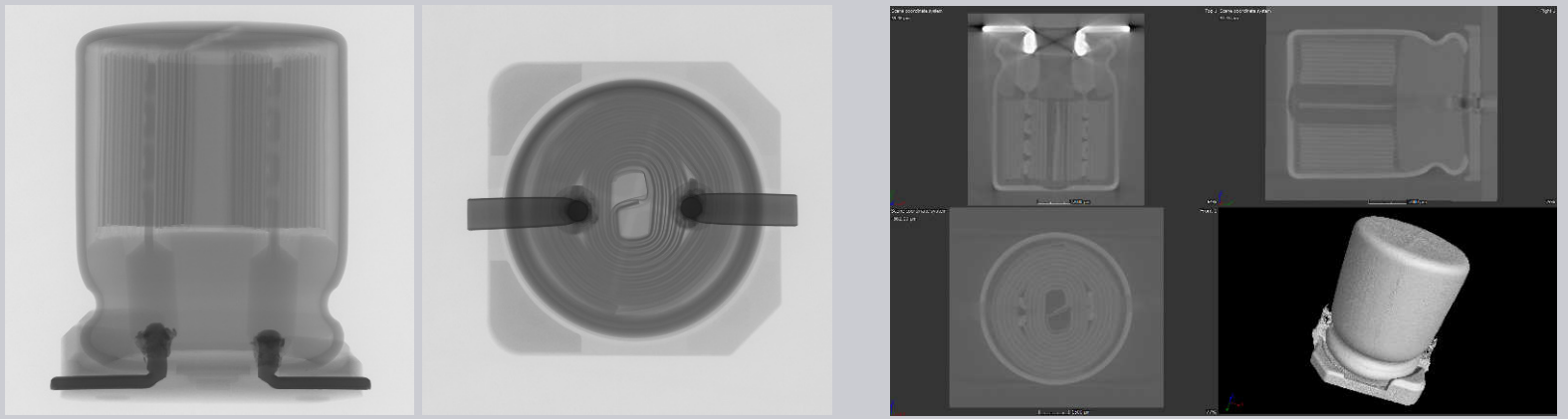
# Insulation resistance

＊＊印加電圧: 500Vdc

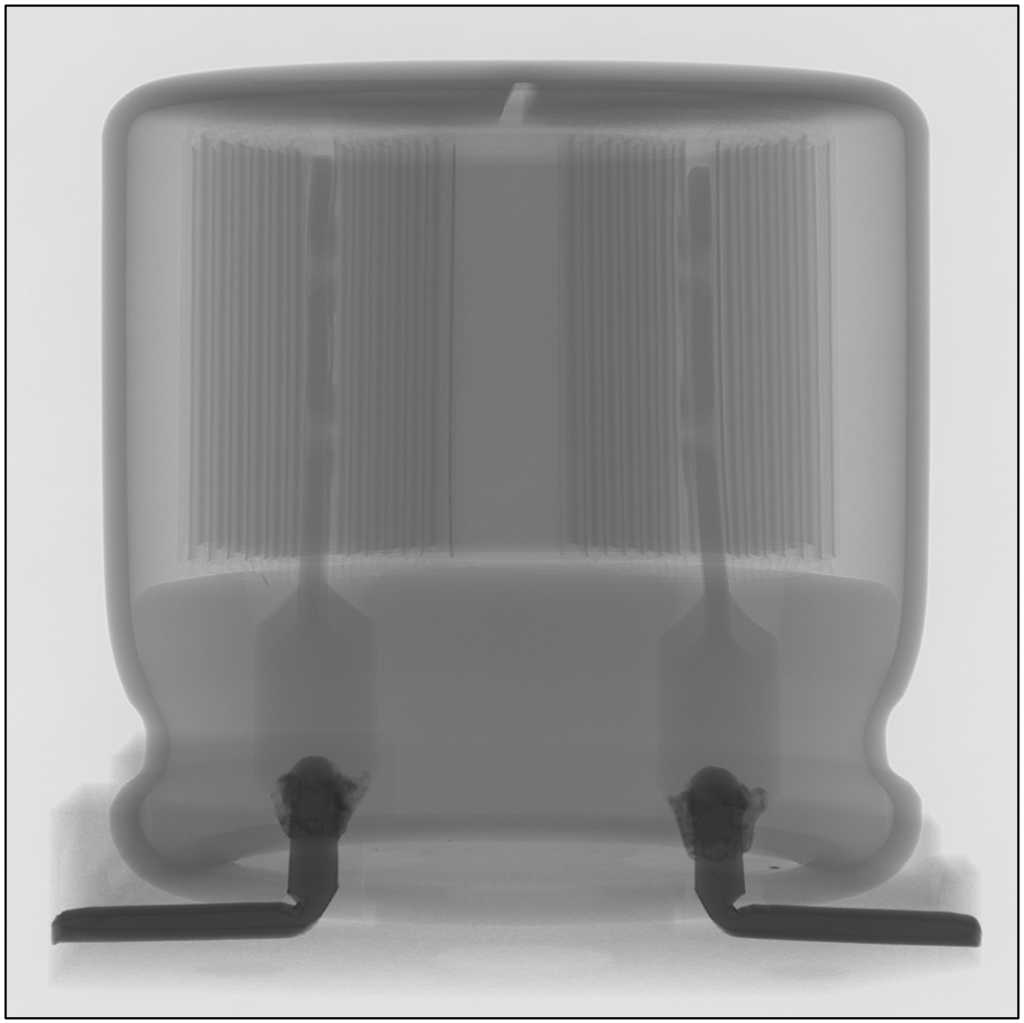
| | Original sample | After the high temperature test sample | |
|---|---|---|---|
| No. | Insulation resistance(MΩ) | No. | Insulation resistance(MΩ) |
| 1 | Over 100 | 11 | Over 100 |
| 2 | Over 100 | 12 | Over 100 |
| 3 | Over 100 | 13 | Over 100 |
| 4 | Over 100 | 14 | Over 100 |
| 5 | Over 100 | 15 | Over 100 |
| 6 | Over 100 | | |
| 7 | Over 100 | | |
| 8 | Over 100 | | |
| 9 | Over 100 | | |
| 10 | Over 100 | | |

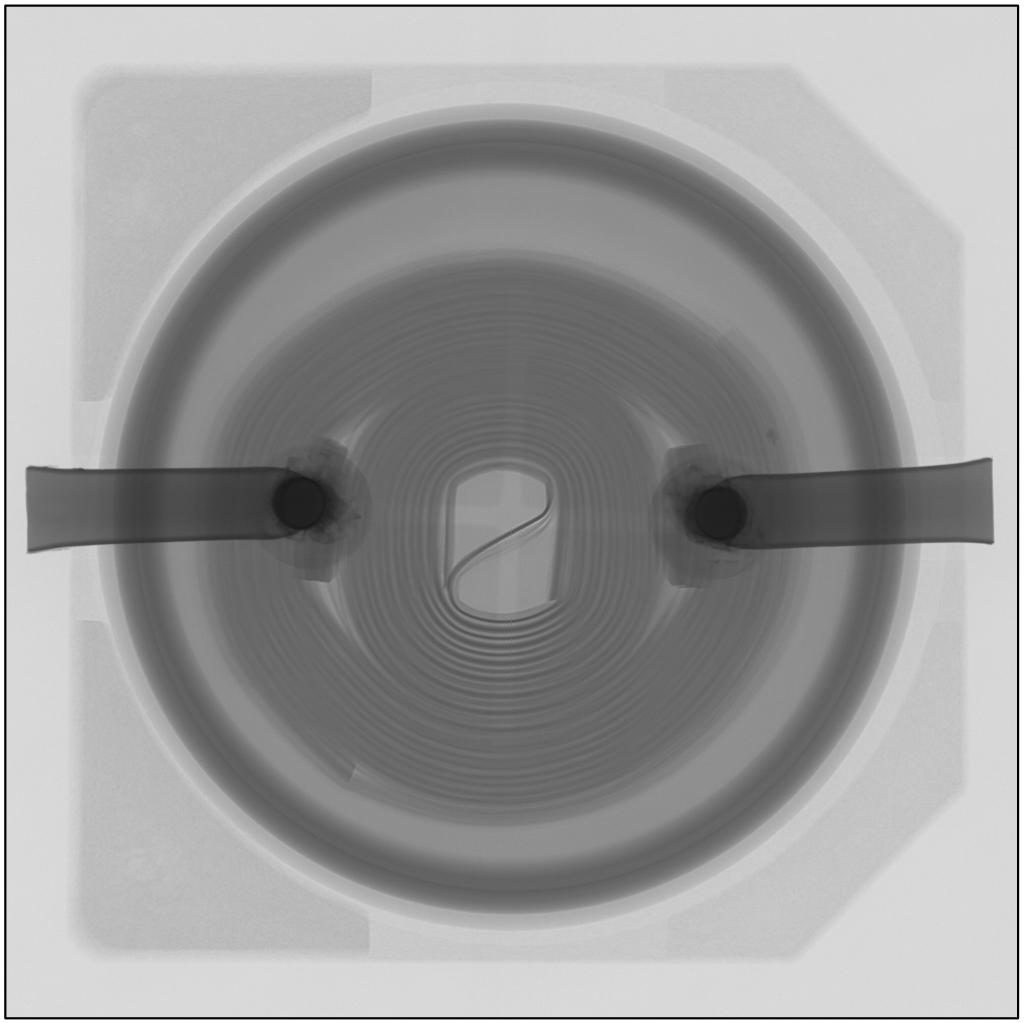
# III. X-ray analyses

# A/B/C社

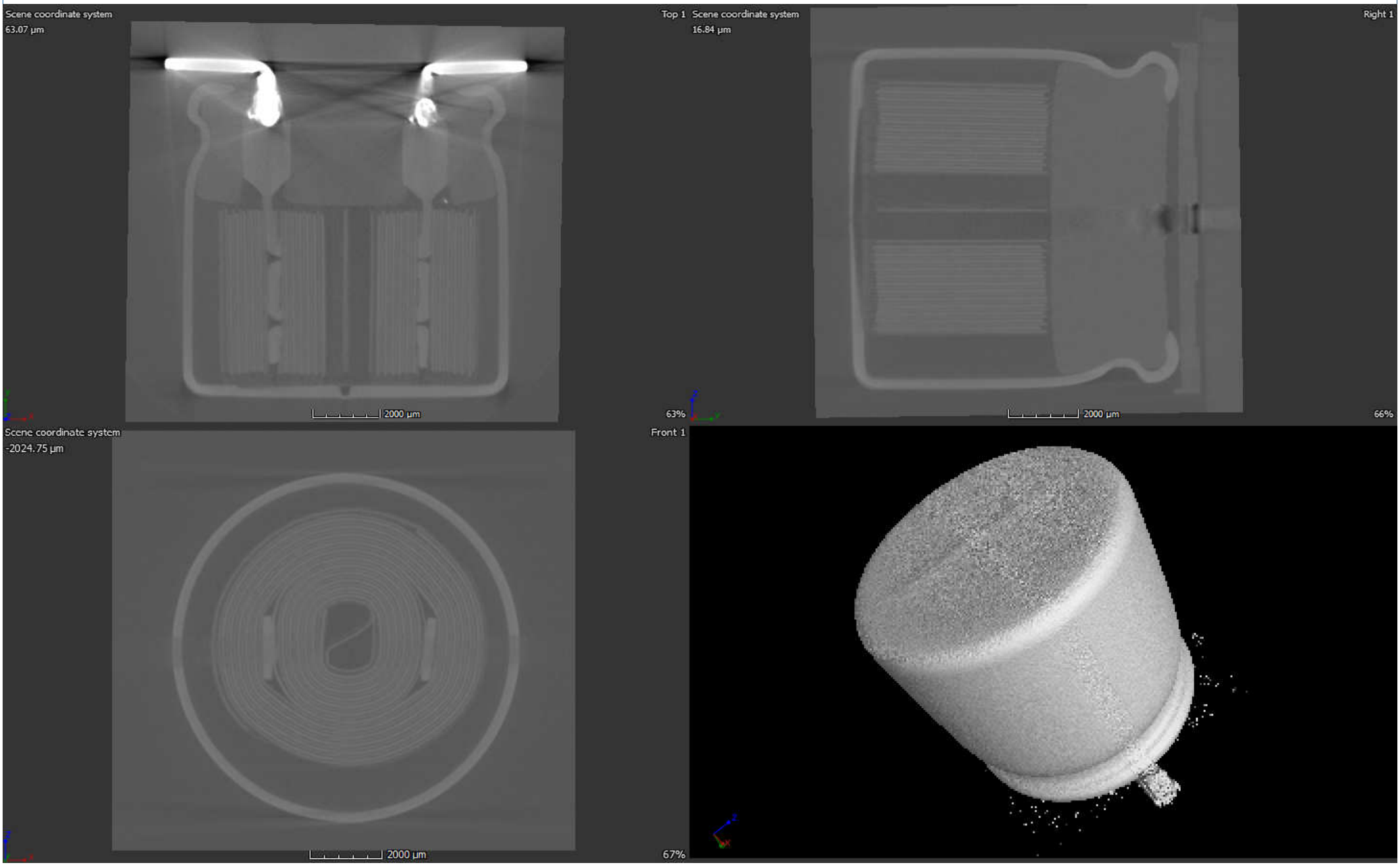
| Specimen | X-ray analyses |
|---|---|
| A |  |
| B |  |
| C |  |

A社

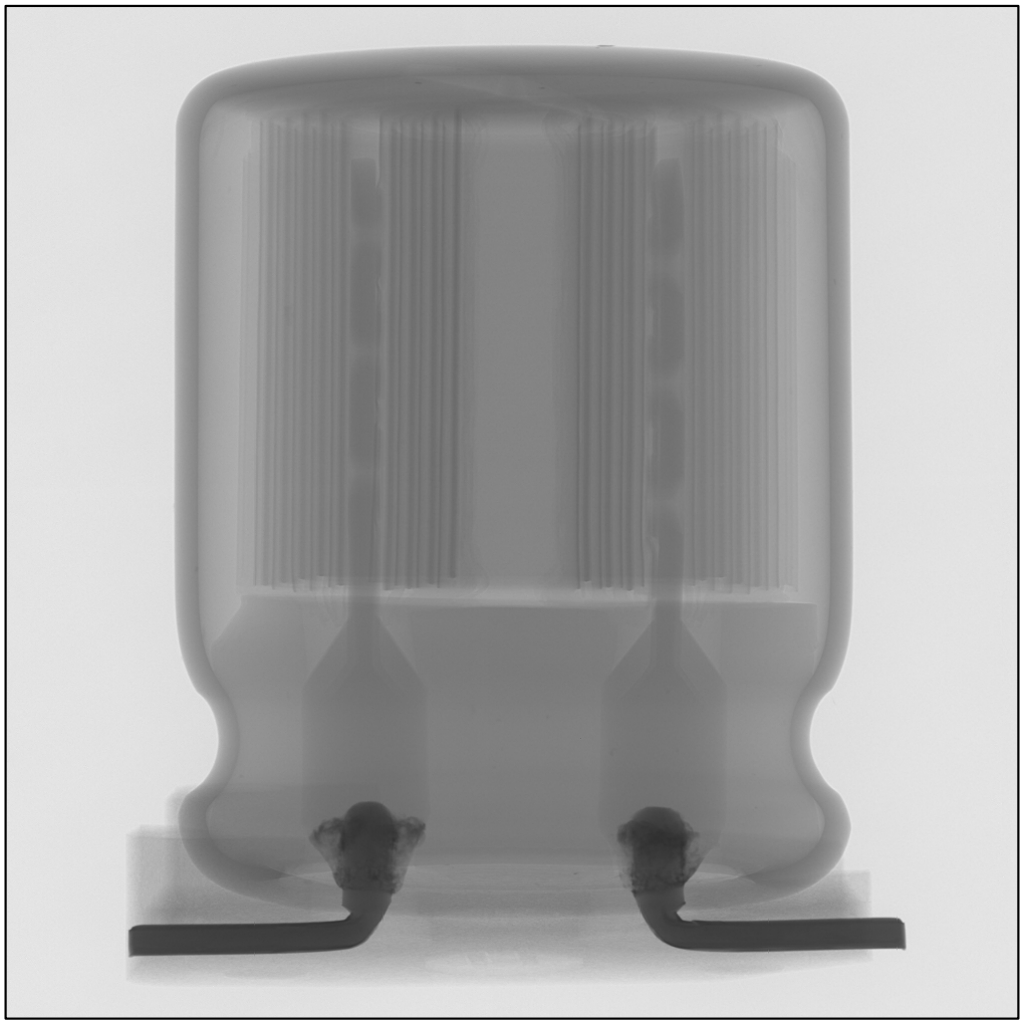


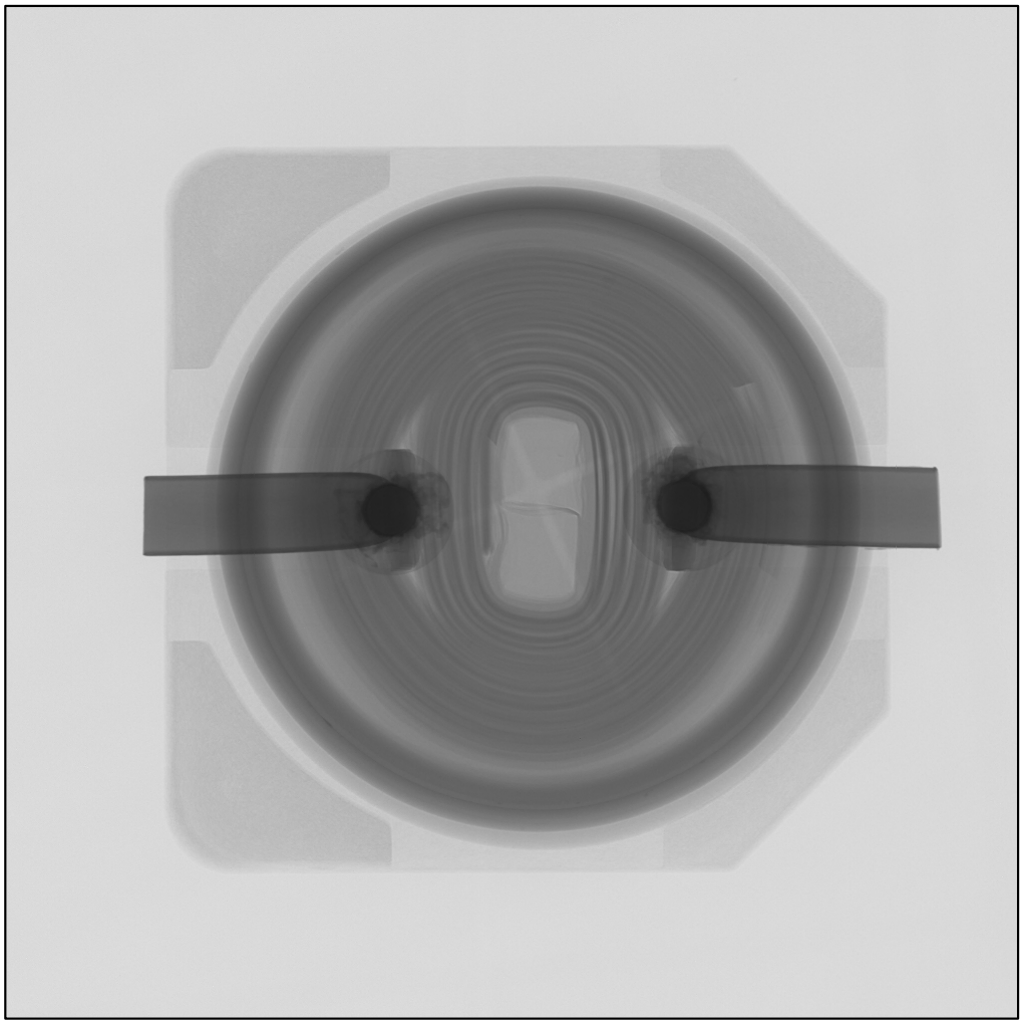


# A社

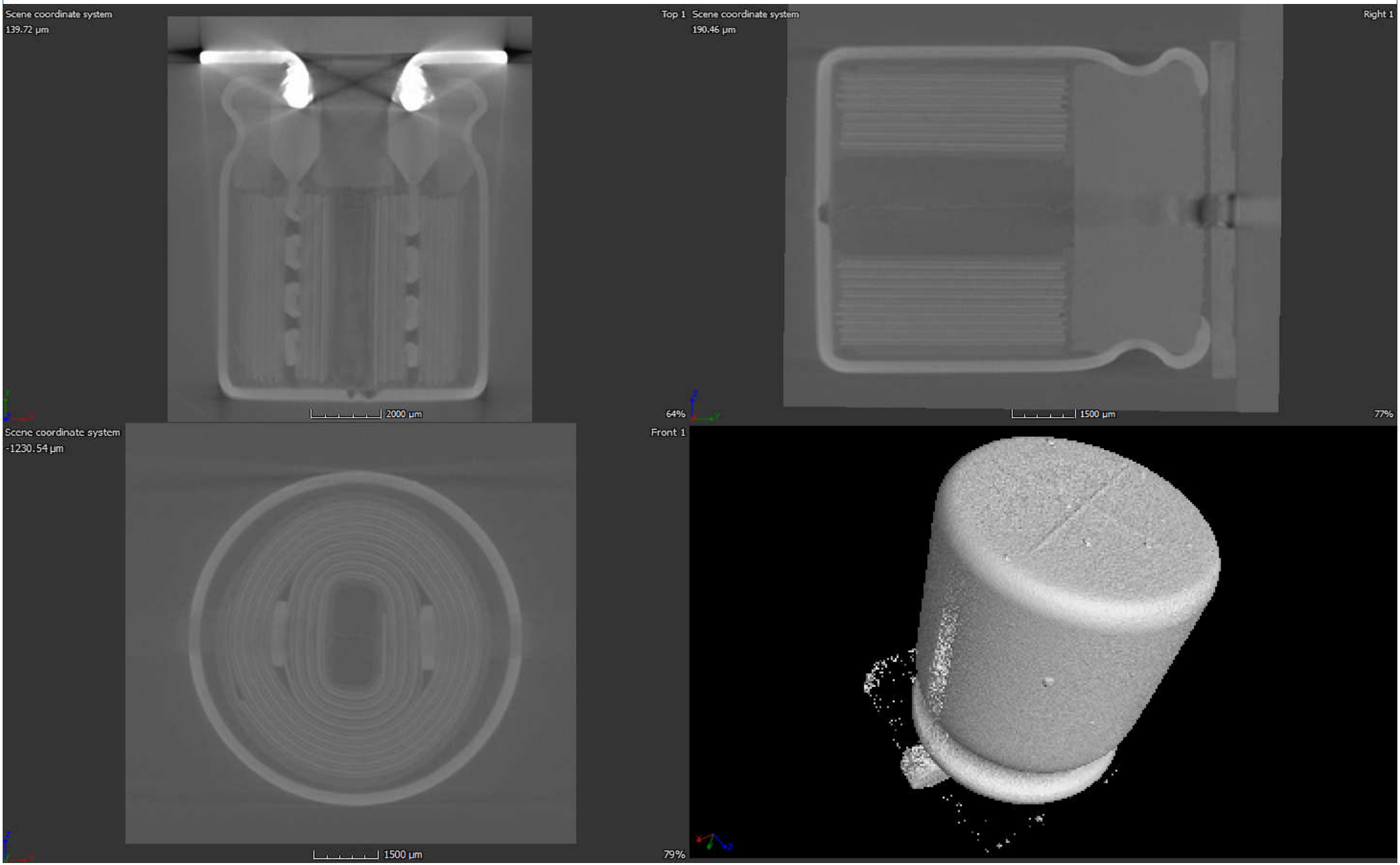

Scene coordinate system
63.07 µm
2000 µm
Top 1
Scene coordinate system
16.84 µm
Right 1
63%
2000 µm
66%
Scene coordinate system
-2024.75 µm
2000 µm
Front 1
67%

B社

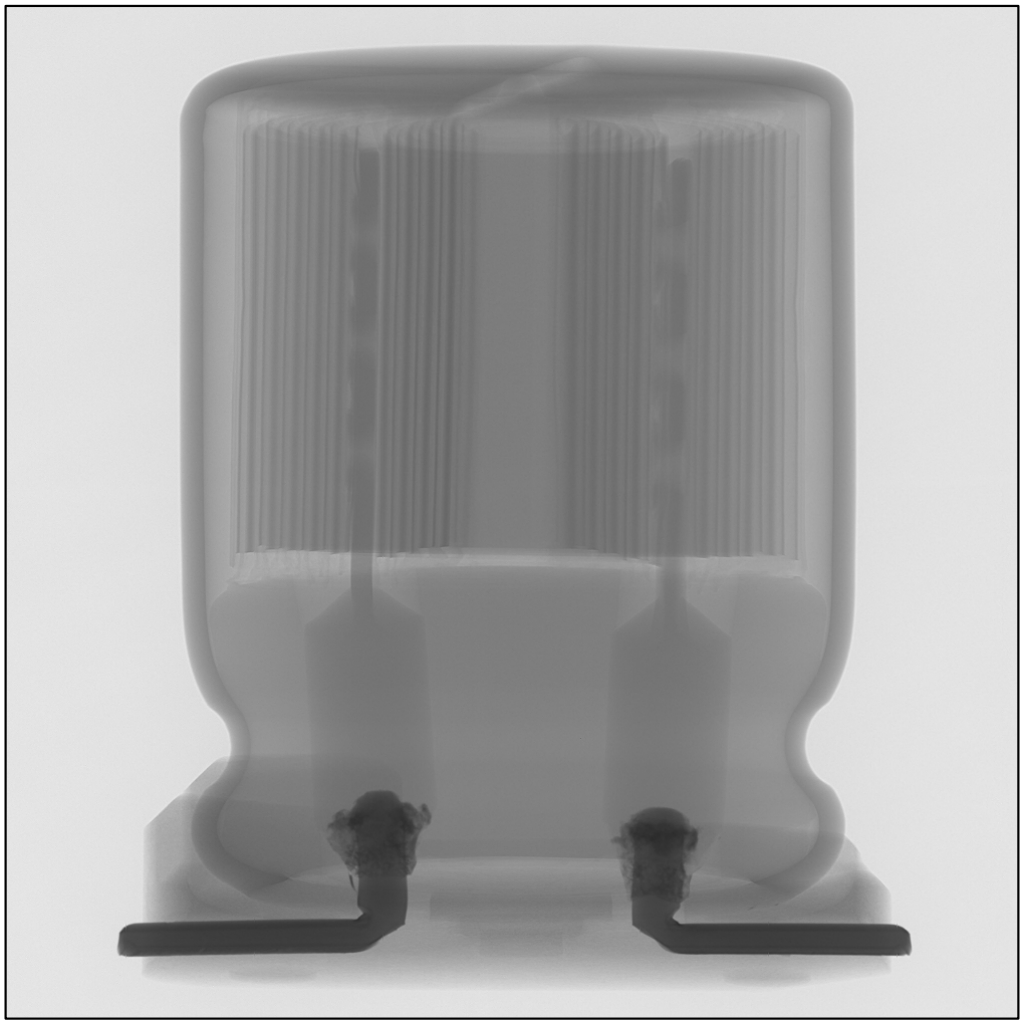


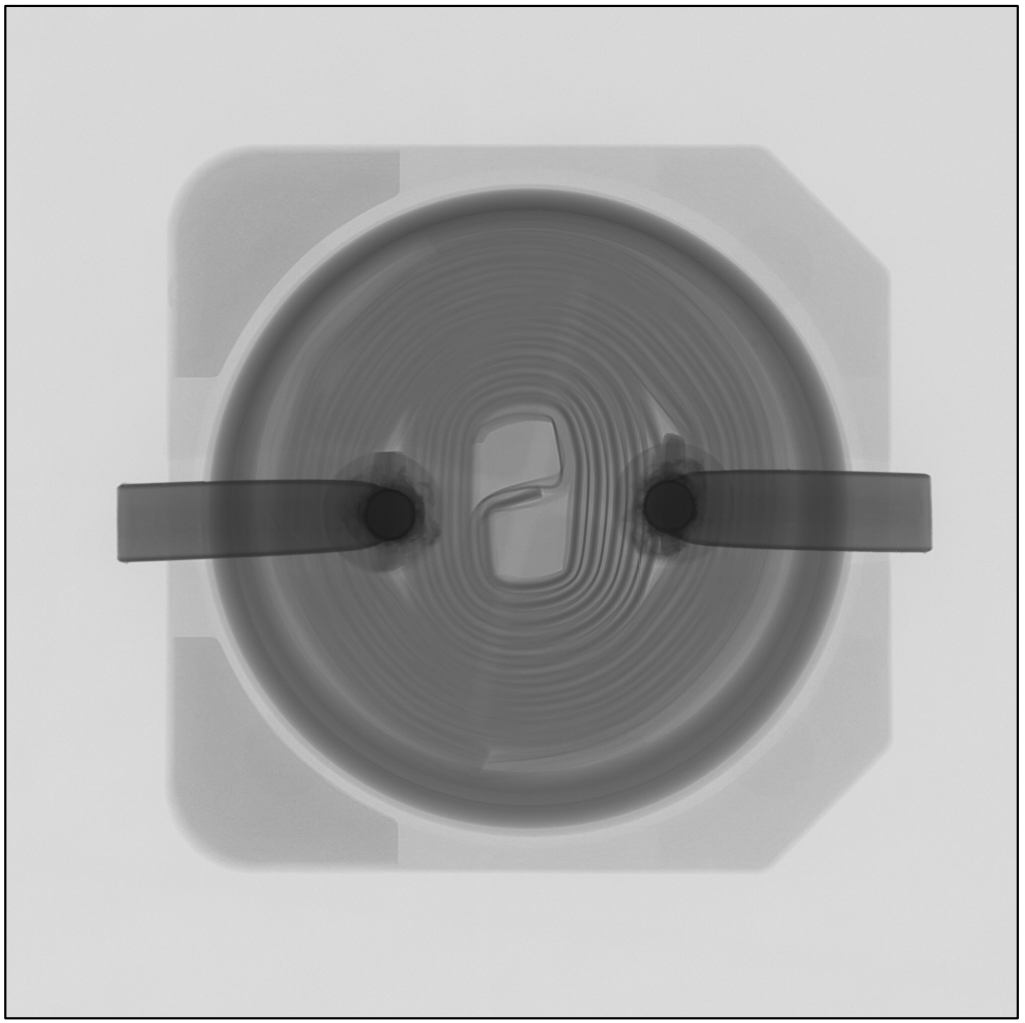


# B社

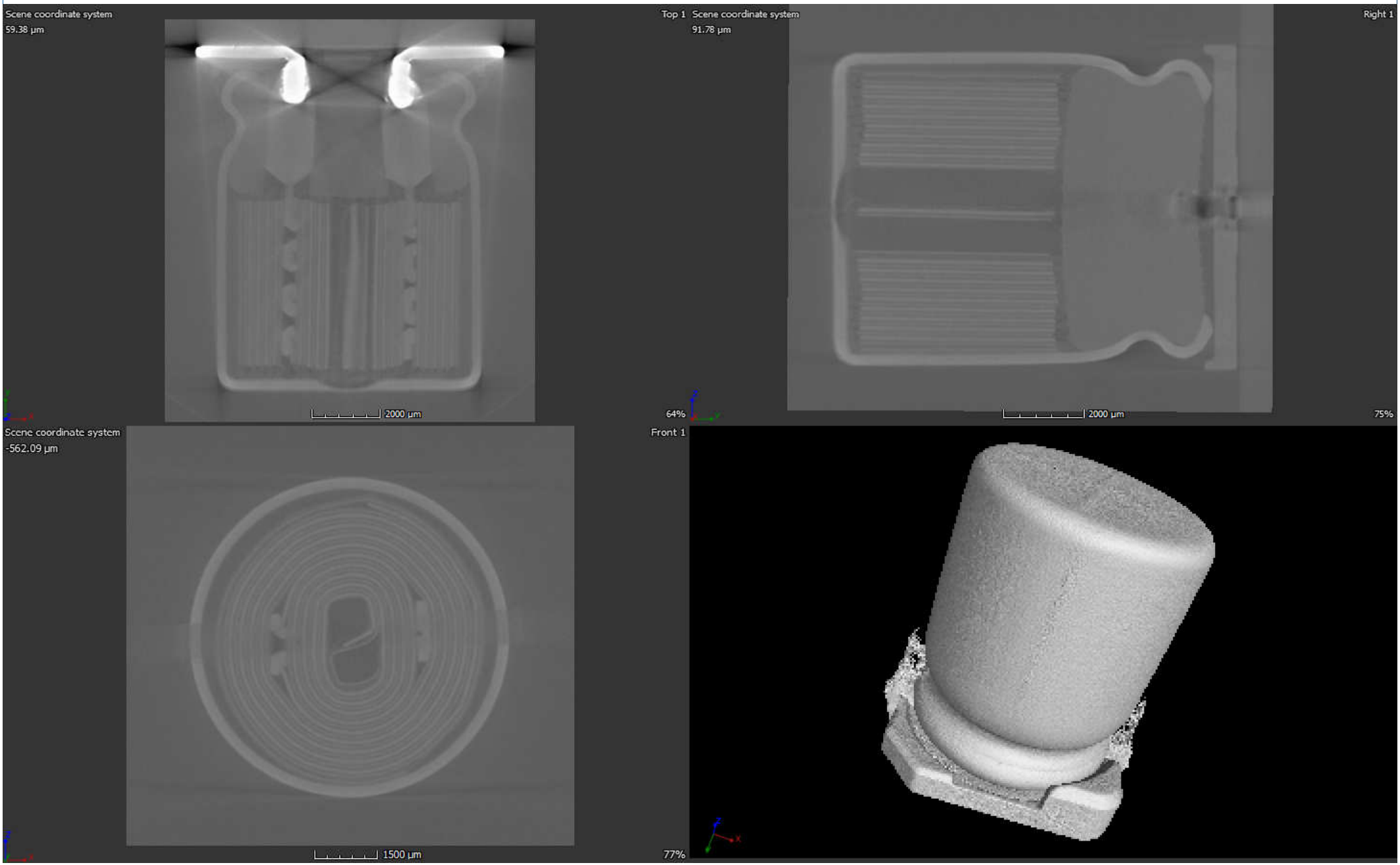

Scene coordinate system
139.72 µm
2000 µm
Top 1
Scene coordinate system
190.46 µm
Right 1
64%
1500 µm
77%
Scene coordinate system
-1230.54 µm
1500 µm
Front 1
79%

C社



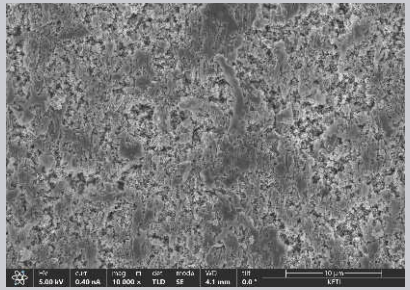
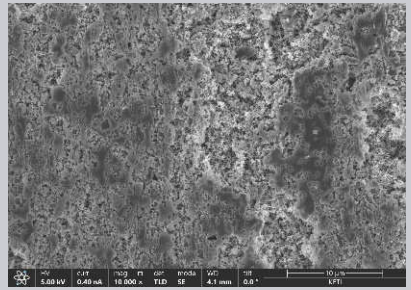
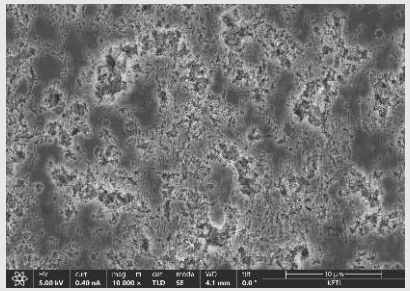
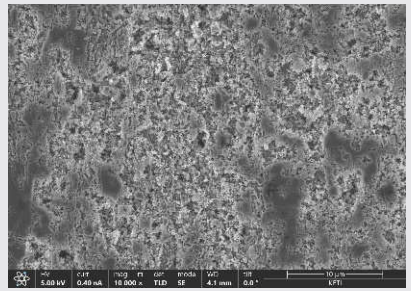
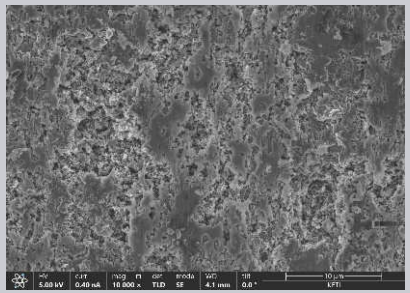
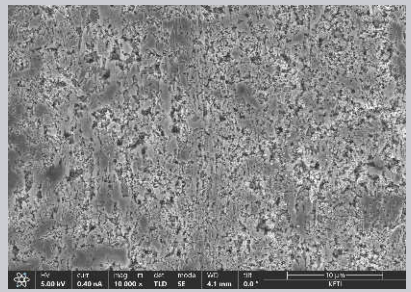


# C社


Scene coordinate system
59.38 µm
2000 µm
Top 1
Scene coordinate system
91.78 µm
Right 1
64%
2000 µm
75%
Scene coordinate system
-562.09 µm
1500 µm
Front 1
77%

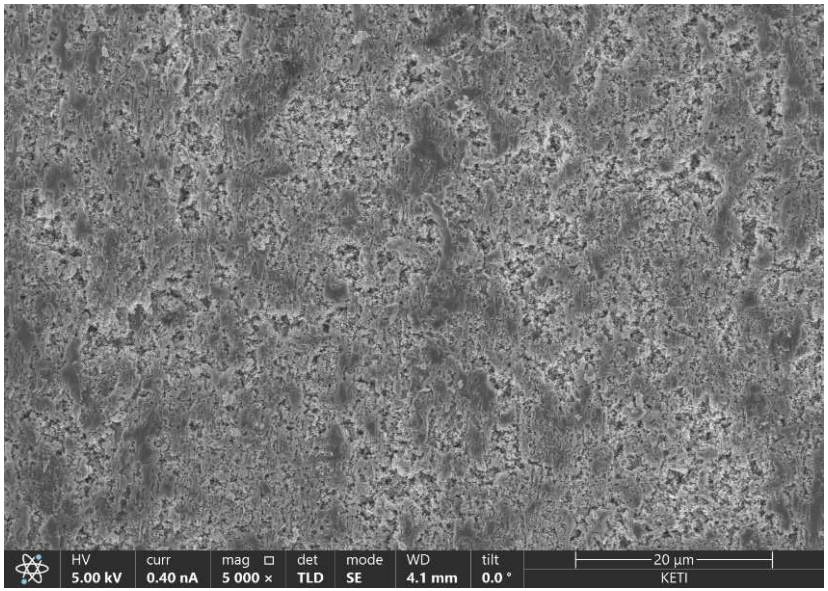
# IV. SEM analyses

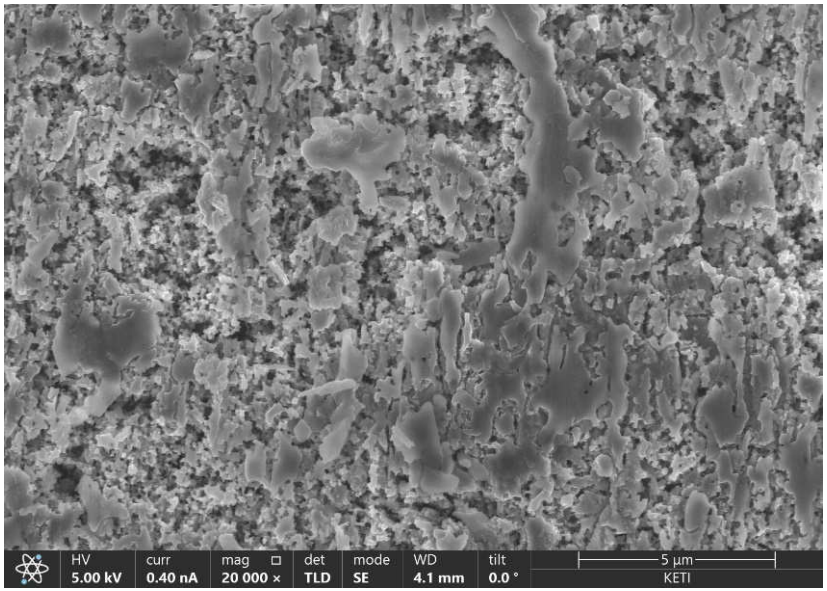
# A/B/C社

| Sample | | | SEM analyses | |
|---|---|---|---|---|
| A |  |  |  |  |
| B |  |  |  |  |
| C |  |  |  |  |

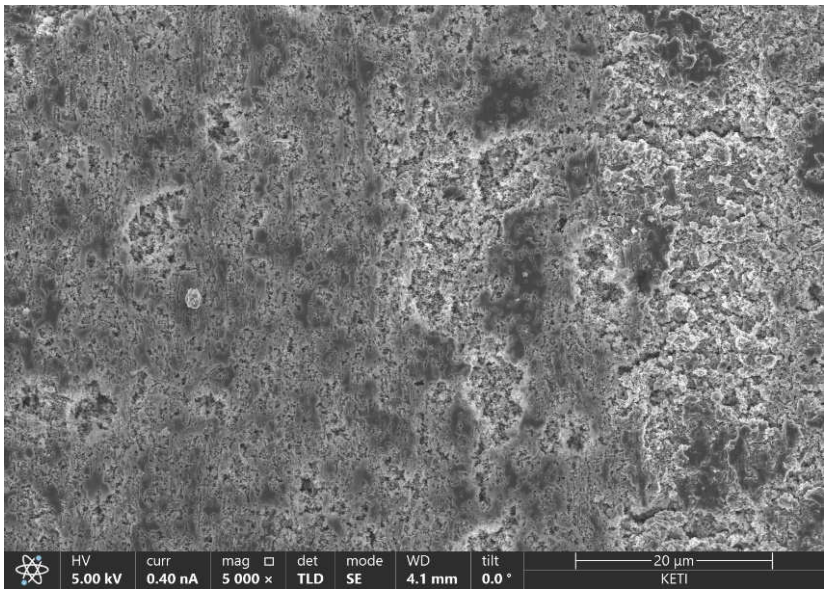
# A社

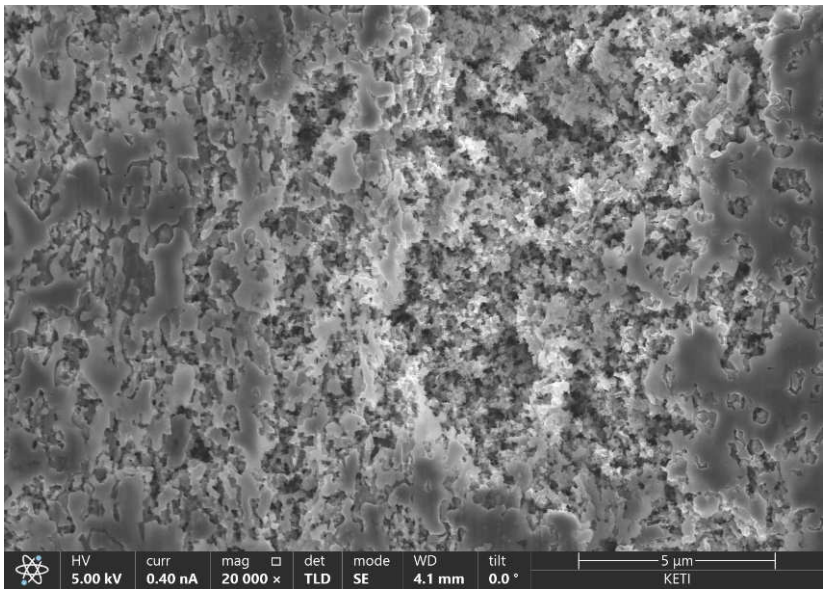
- **Front**



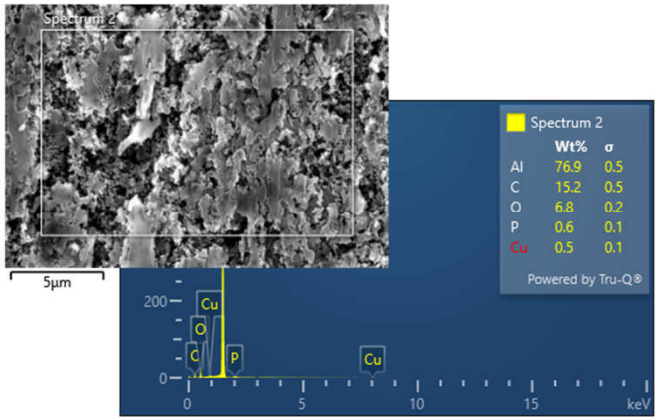

- **Back**

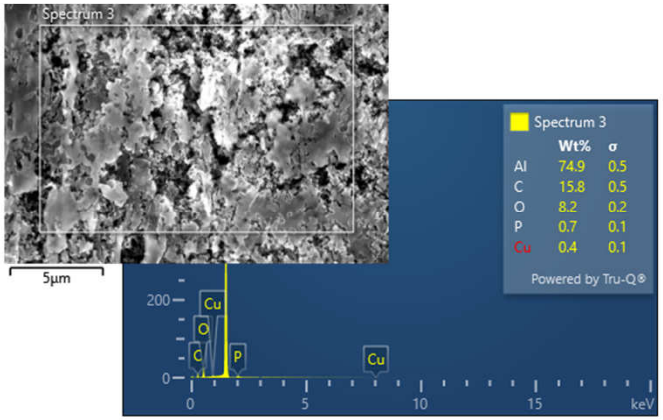


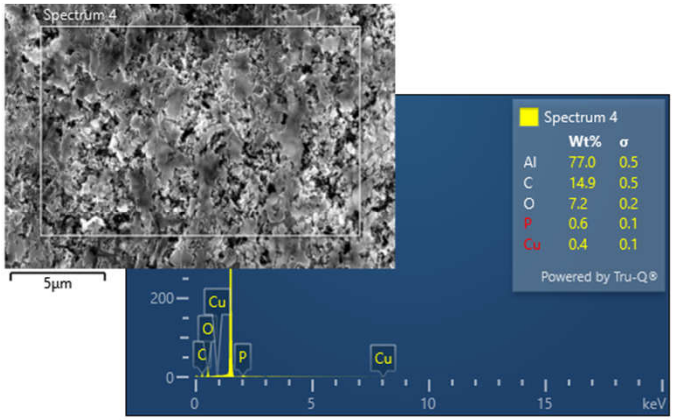



# A社

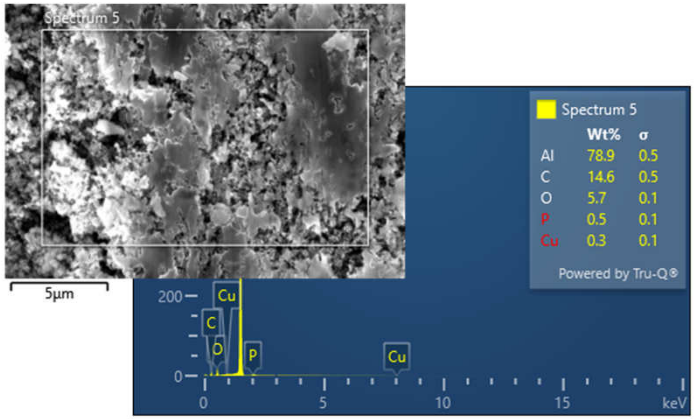
- **Front**

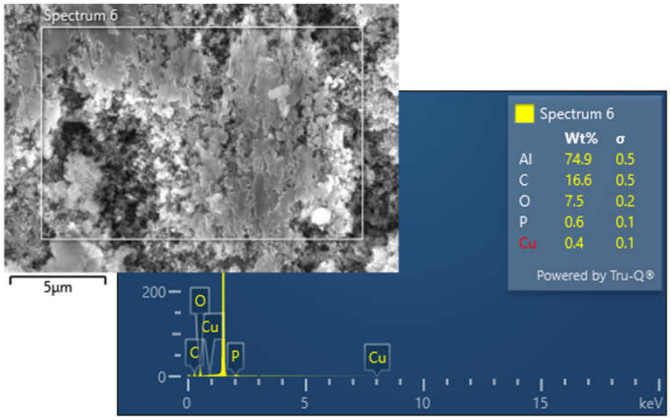


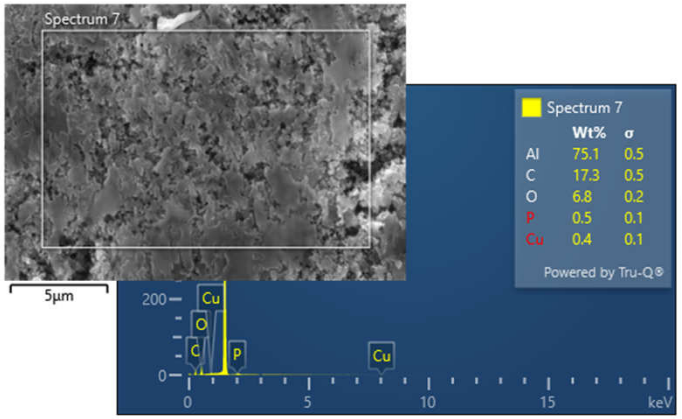




- **Back**

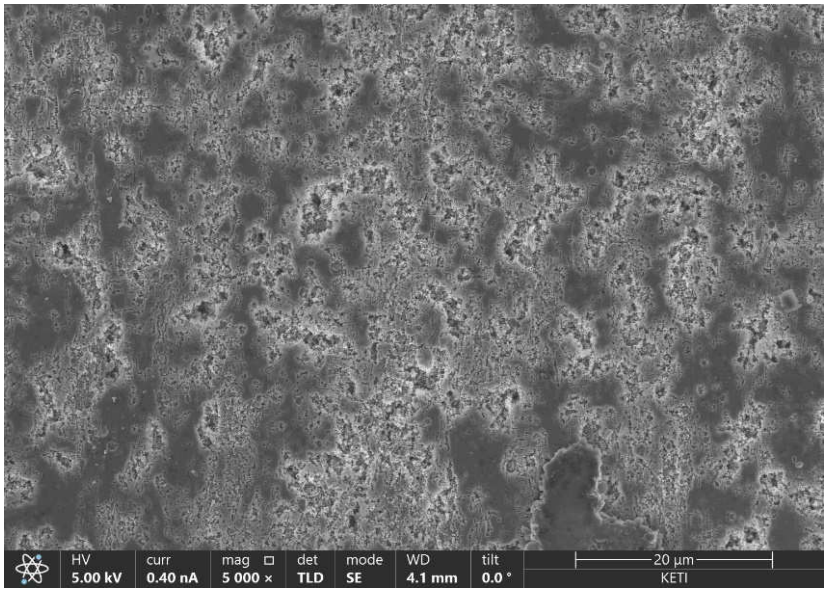


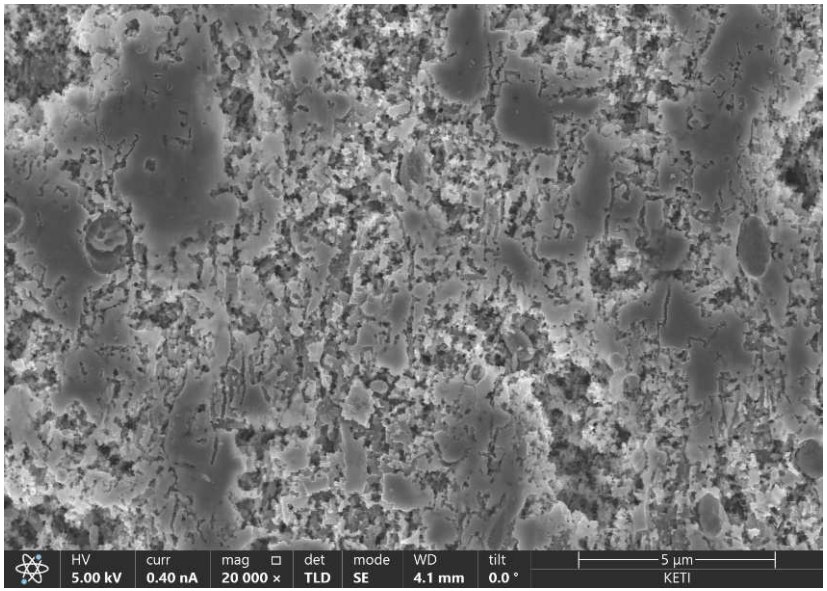



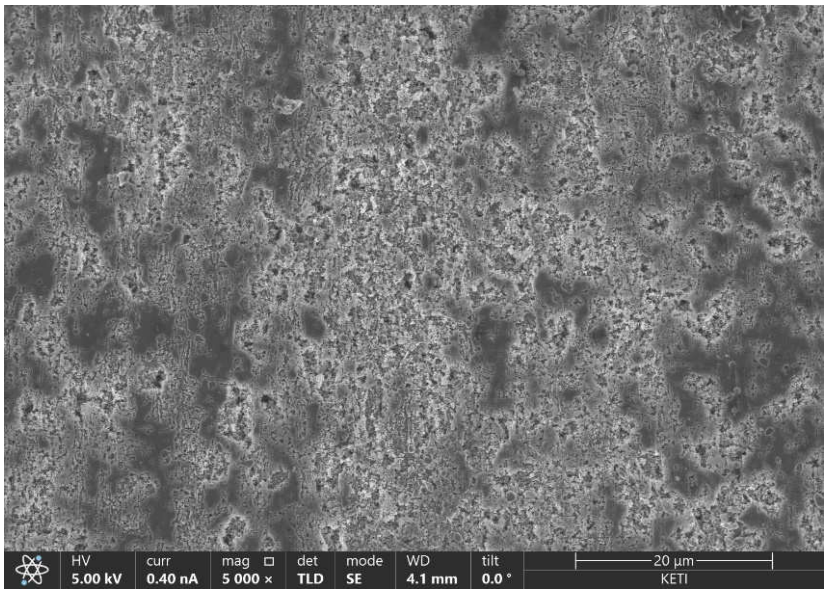
# B社

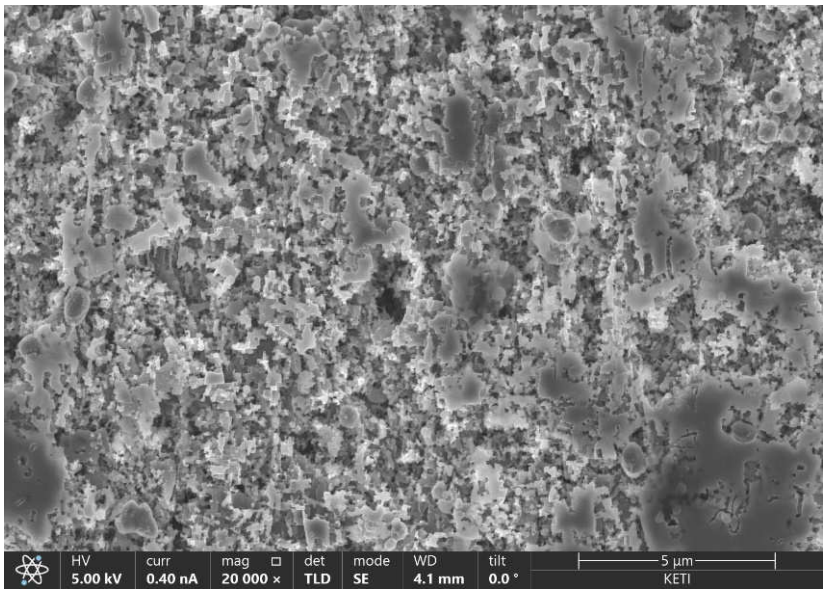
- **Front**



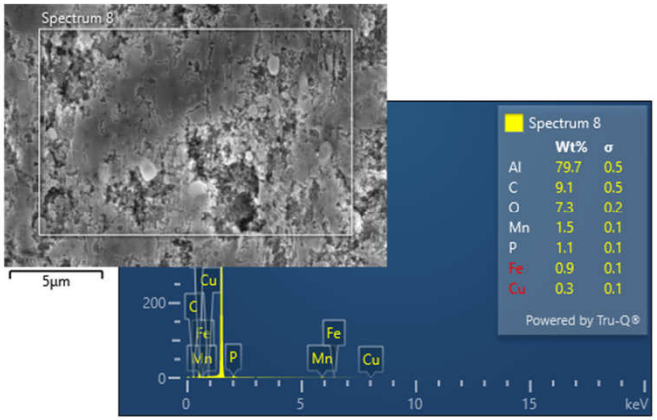

- **Back**

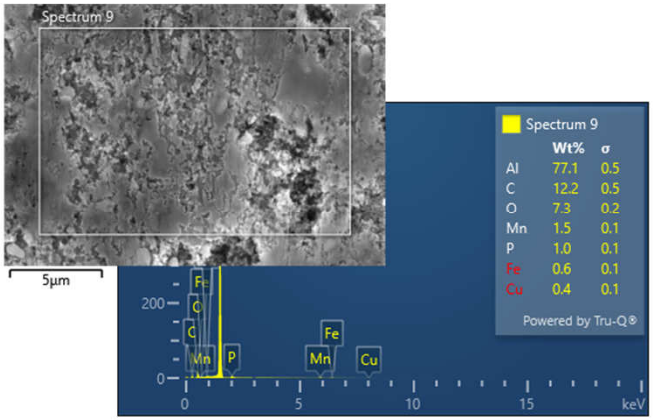


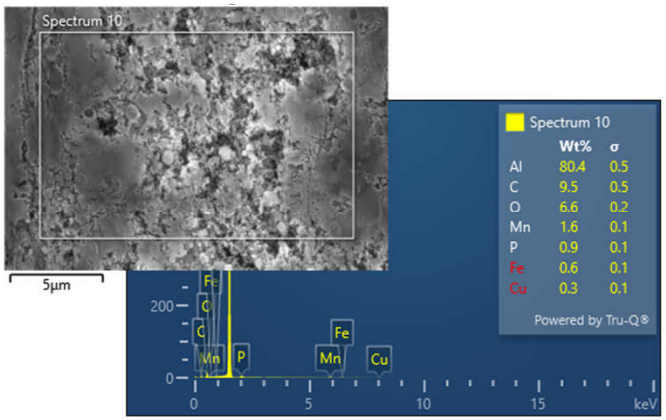



# B社

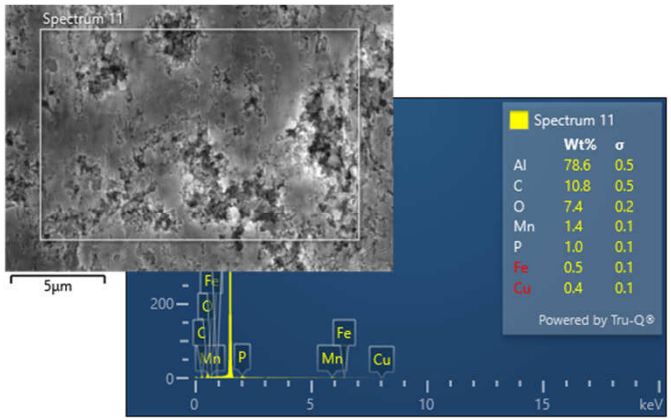
- **Front**

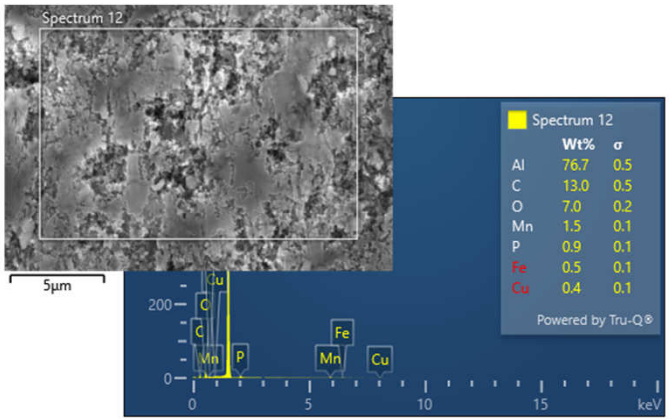


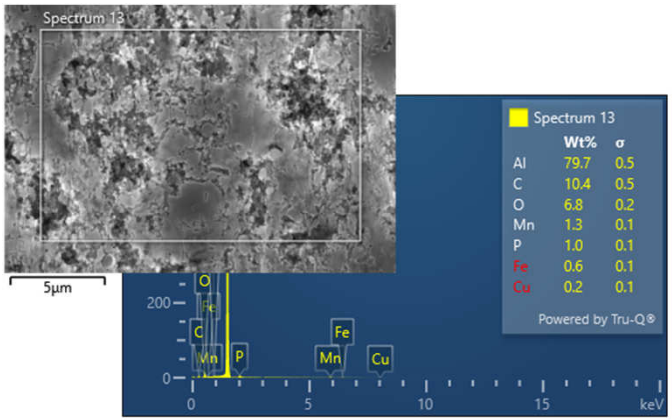




- **Back**

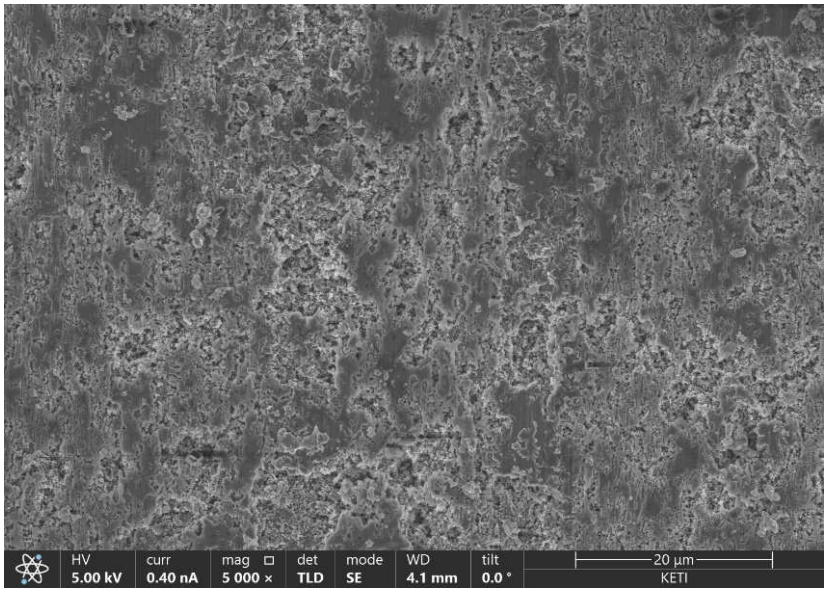


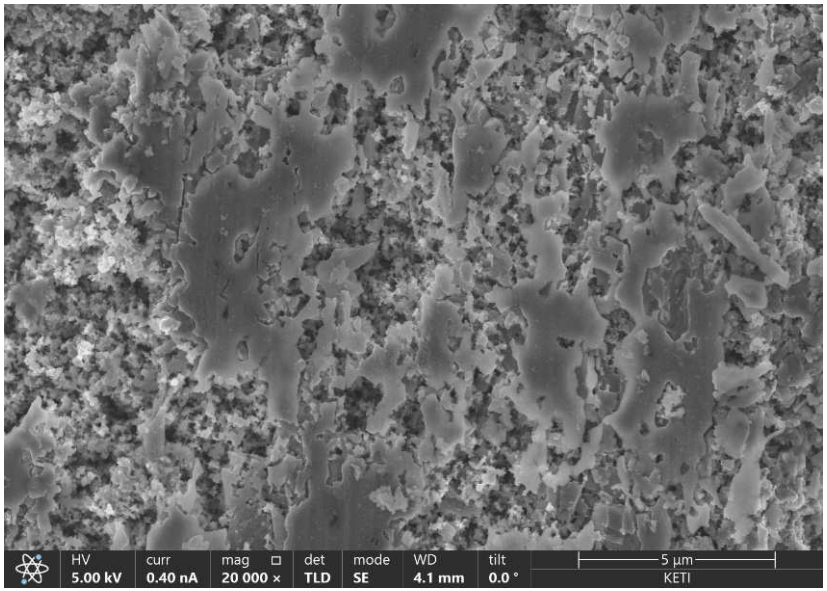



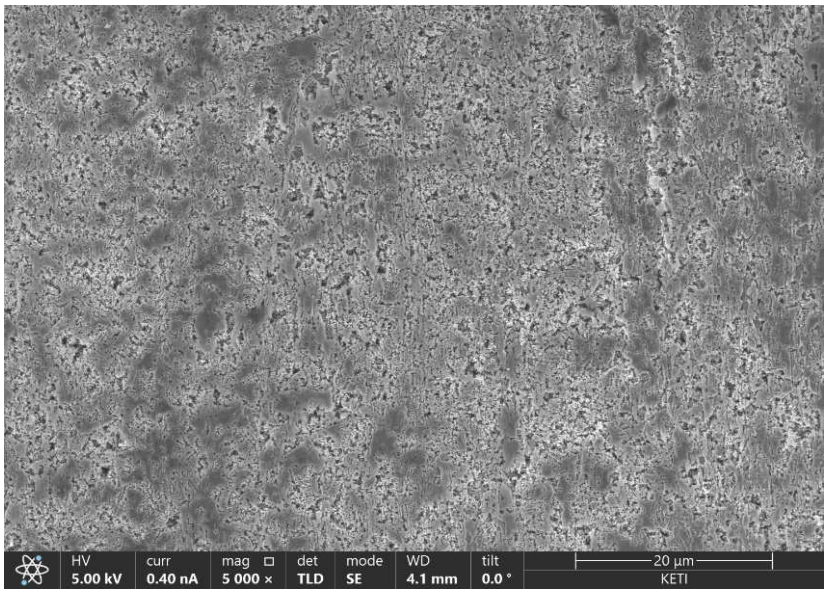
# C社

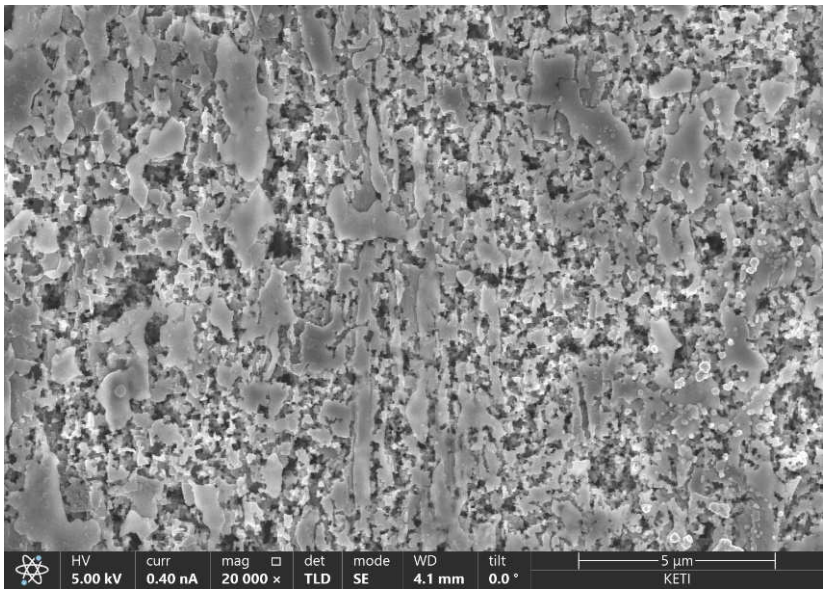
- **Front**



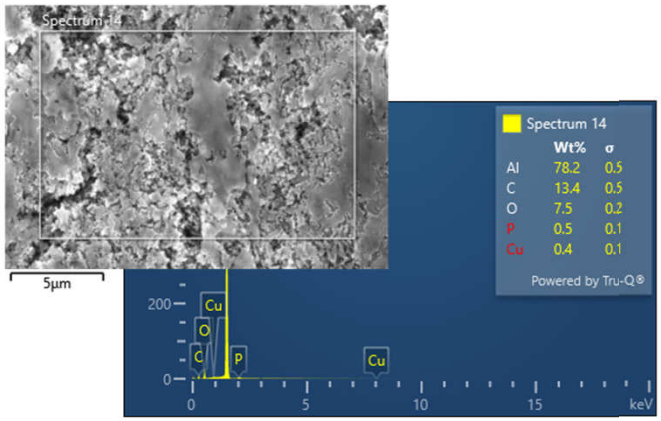

- **Back**

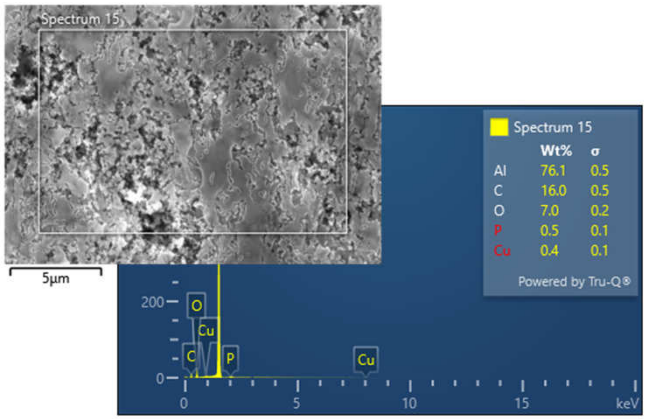


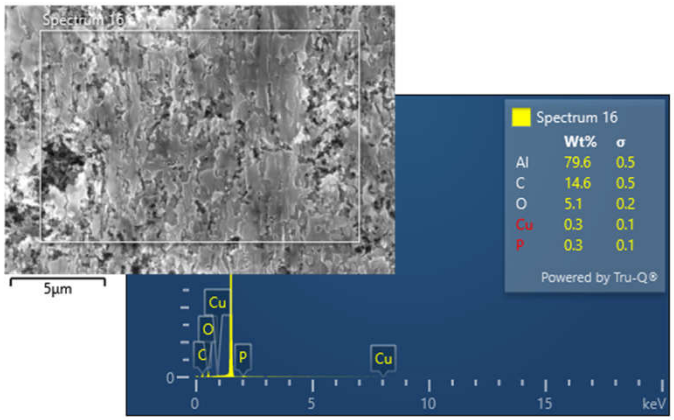



# C社

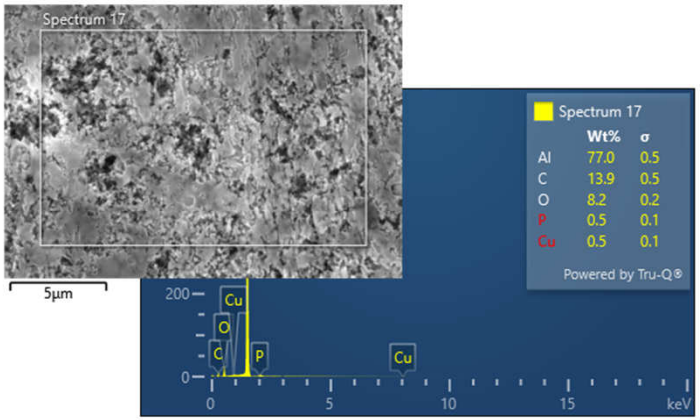
- **Front**

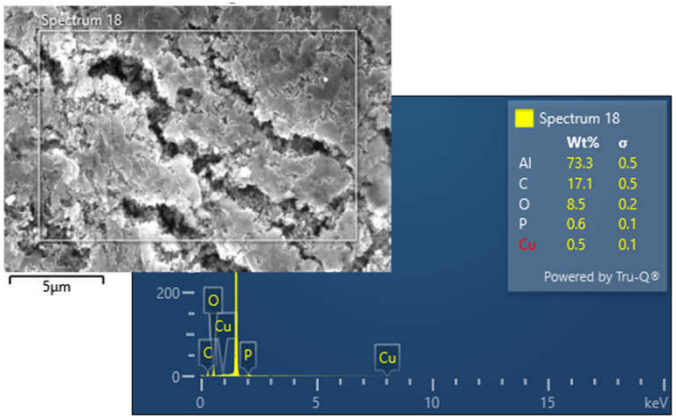


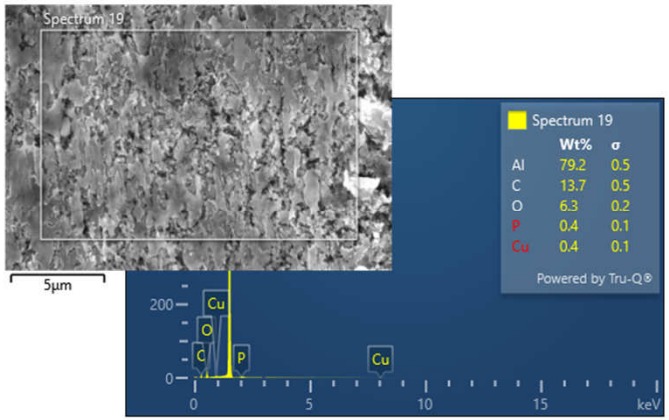




- **Back**



# V. Summary and conclusions

- 3社のSMD type capacitorにて数種の環境試験(高温, 低温, 熱衝撃, 振動, 耐湿性), 漏れ電流測定, 耐電圧試験, 絶縁抵抗試験, 内部構造分析(非破壊分析), 内部電極の成分分析(破壊分析)を行う。
- 3社のコンデンサーの内部構造には差がない。
- B社のコンデンサーが環境試験による特性変化が一番小さい。すなわち、外部環境のストレスに一番強いと言える。
- A社のコンデンサーは相対的に熱衝撃と振動環境に弱い。
- C社のコンデンサーは相対的に低温と濕氣環境に弱い。
- 高温試験によるCapacitance(@1 kHz)の変化はC社の製品が一番小さい。(C<A<B)
- 低温試験によるCapacitance(@1 kHz)の変化はB社の製品が一番大きい。(B<A<C)
- 熱衝撃試験によるCapacitance(@1 kHz)の変化はB社の製品が一番小さい。(B<C<A)
- 振動試験によるCapacitance(@1 kHz)の変化はB社の製品が一番小さい。(B<C<A)
- 高度湿度試験によるCapacitance(@1 kHz)の変化はB社の製品が一番小さい。(B<A<C)

# KETI試験結果の考察

J_Chip Consulting

## ■面実装型アルミ電解コンデンサ各種試験結果比較

**KETIにて実施しましたアルミ電解コンデンサ製品3社の各種試験結果を比較して纏めました。**
**特に大きな問題は散見されず性能/品質は安定していると推測できます。**

| 試験項目 | | A: Samwha | B: Su'scon | C: NICHICON |
|---|---|---|---|---|
| X線解析 | | 異常なし/異物なし | 異常なし/異物なし | 異常なし/異物なし |
| SEM観察/成分分析 | | 異常なし/異物なし | 異常なし/異物なし | 異常なし/異物なし |
| 高温保存試験 (105℃/16時間) | 容量変化最大値 | -0.79% | -0.66% | 1.57% |
| | 容量変化平均値 | -0.37% | -0.26% | 1.07% |
| 低温保存試験 (-40℃/2時間) | 容量変化最大値 | -0.26% | -0.20% | -0.41% |
| | 容量変化平均値 | -0.02% | -0.03% | -0.02% |
| サーマルショック試験 (-40℃～105℃変化/30分間隔5サイクル) | 容量変化最大値 | -0.35% | -0.82% | -0.64% |
| | 容量変化平均値 | -0.02% | -0.10% | -0.29% |
| 高湿度保存試験 (40℃/93%RH/500時間) | 容量変化最大値 | -0.97% | -0.74% | -0.35% |
| | 容量変化平均値 | -0.42% | 0.02% | -0.18% |
| 過電圧印加試験(500V) | | オープン | オープン | オープン |

KETI

J Chip Consulting