Diffusion Limitée

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

EVALUATION OF COMMERCIAL GRADE TANTALUM CAPACITORS FOR SPACE APPLICATIONS

DR. LYA FONTAINE - 6TH SPACE PASSIVE COMPONENT DAYS (SPCD)

ESA/ESTEC, NOORDWIJK, THE NETHERLANDS

OCTOBER 15TH 2026

CONTENT

01 Introduction & context

02 Part selection & Test sequence overview

03 Screening results & Failure analysis

04 Life-Test results & Failure analysis

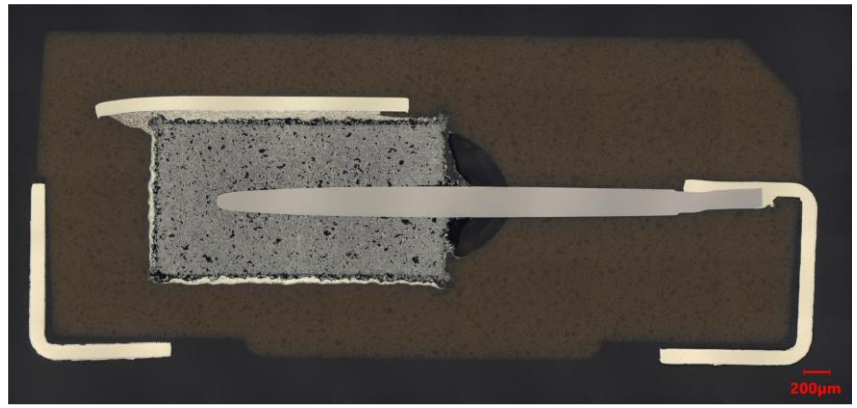
05 Conclusion

INTRODUCTION & CONTEXT

Growing use of COTS parts in space

✓ Cost
✓ Lead-times
✓ Performance

? Reliability for space



Solid Tantalum Capacitors

✓ High volumetric efficiency
✓ Very stable capacitance value
✓ Low ESR

? Commercial grade reliability uncertain

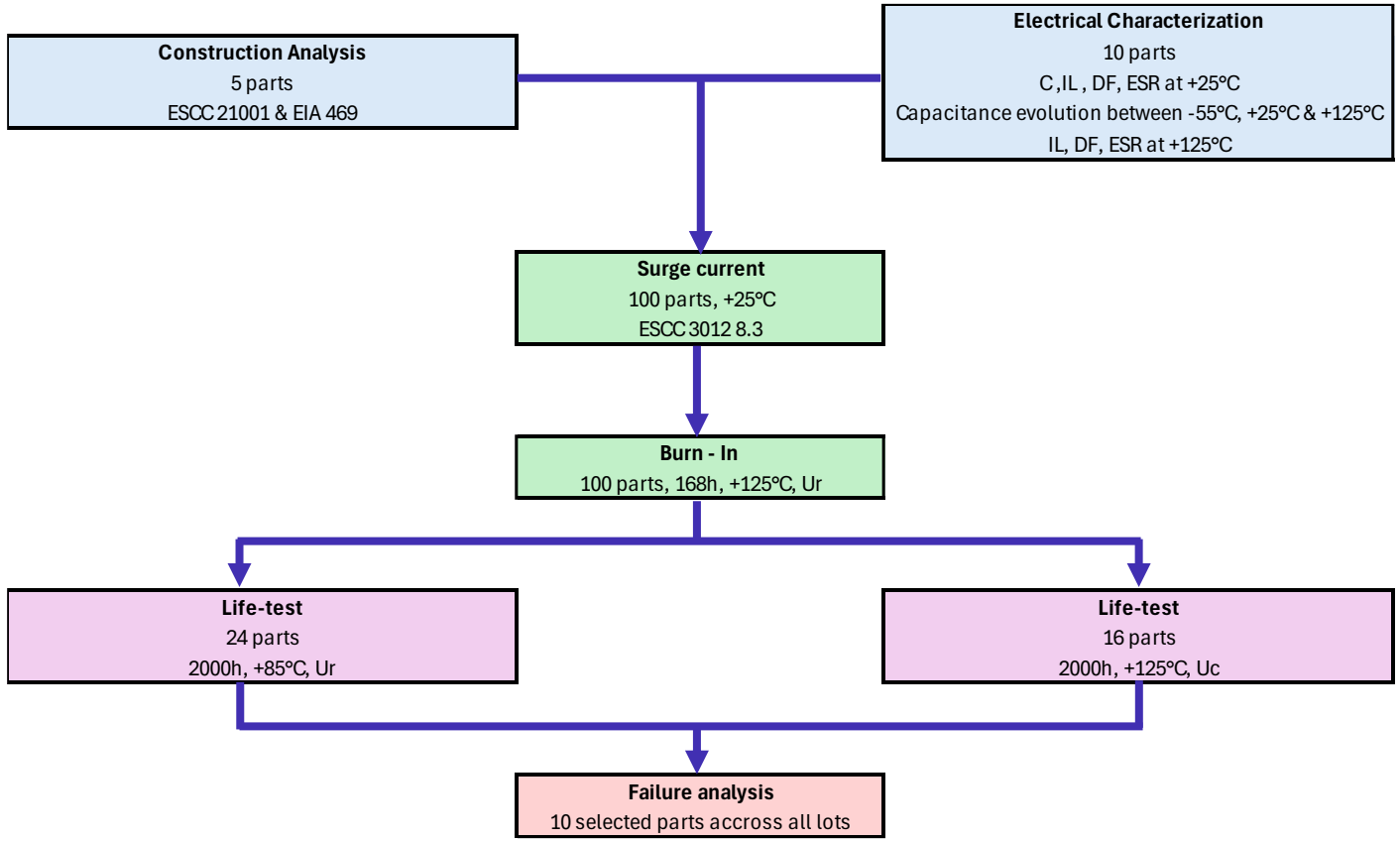


Can commercial-grade solid tantalum capacitors satisfy the stringent reliability standards required for space missions?

PART SELECTION & TEST SEQUENCE

- **15 references, commonly encountered in space projects**

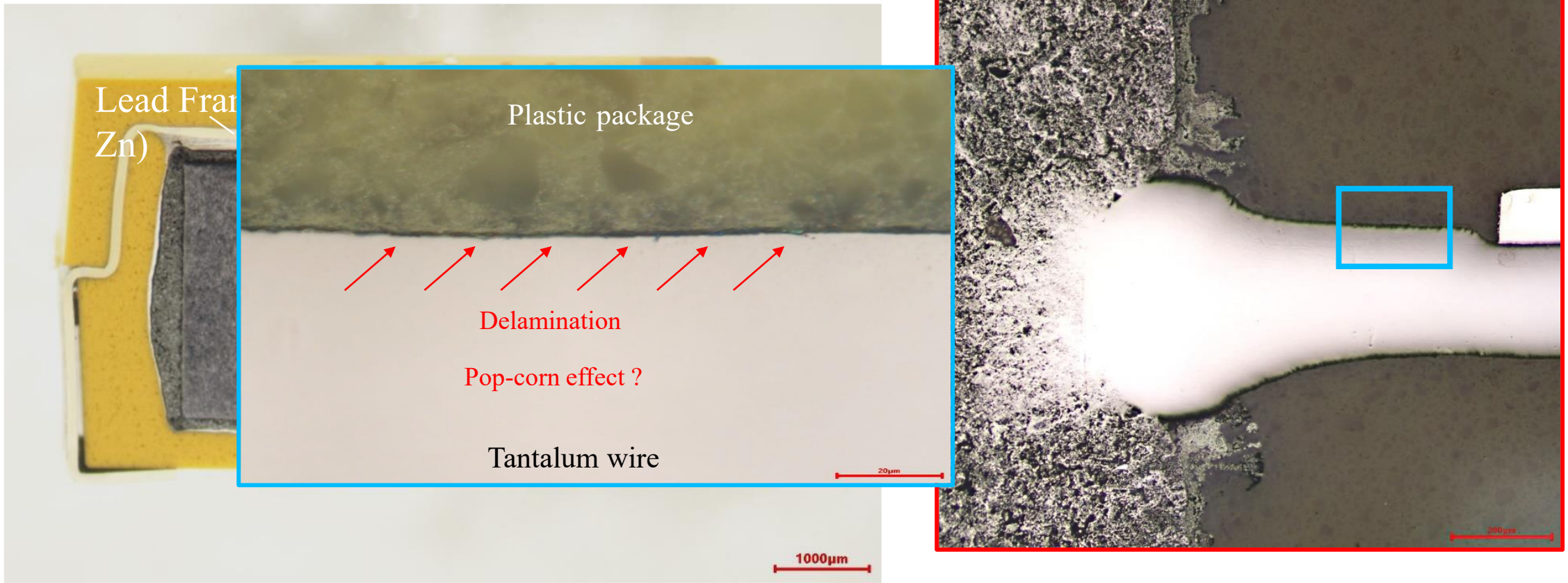
Lot	Capacitance (µF)	Voltage (V)	Package	Manufacturer	Part reference
1	1	50	C	KEMET	T491C105K050AT
2	1	50	C	Kyocera AVX	TAJC105K050RNJ
3	1	50	C	Vishay	293D105X9050C2TE3
4	4,7	50	D	KEMET	T491D475K050AT
5	4,7	50	D	Kyocera AVX	TAJD475K050RNJ
6	4,7	50	D	Vishay	293D475X9050D2TE3
7	10	50	D	KEMET	T491D106K050AT
8	10	50	D	Kyocera AVX	TAJD106K050RNJ
9	10	50	D	Vishay	293D106X9050D2TE3
10	47	35	X	KEMET	T495X476K035ATE300
11	47	35	E	Kyocera AVX	TPSE476K035R0200
12	47	20	E	Vishay	593D476X9020E2TE3
13	100	20	X	KEMET	T491X107K020AT
14	100	20	D	Kyocera AVX	TAJD107K020RNJ
15	100	20	E	Vishay	593D107X9020E2TE3



In accordance with : ECSS-Q-ST-60-13 and ESCC 3012 standards

PHASE 1 : CONSTRUCTION ANALYSIS & ELECTRICAL CHARACTERIZATION

Lot 10 internal visual inspection :



Lot 11 internal visual inspection : variation in MnO_2 layer thickness

PHASE 2 : SCREENING

- Surge current test according to ESCC 3012 8.3
- Burn-in : 168h, +125°C, DC rated voltage according to ESCC 3012 8.5

Excessive leakage
OOS capacitance values
OOS dissipation factor

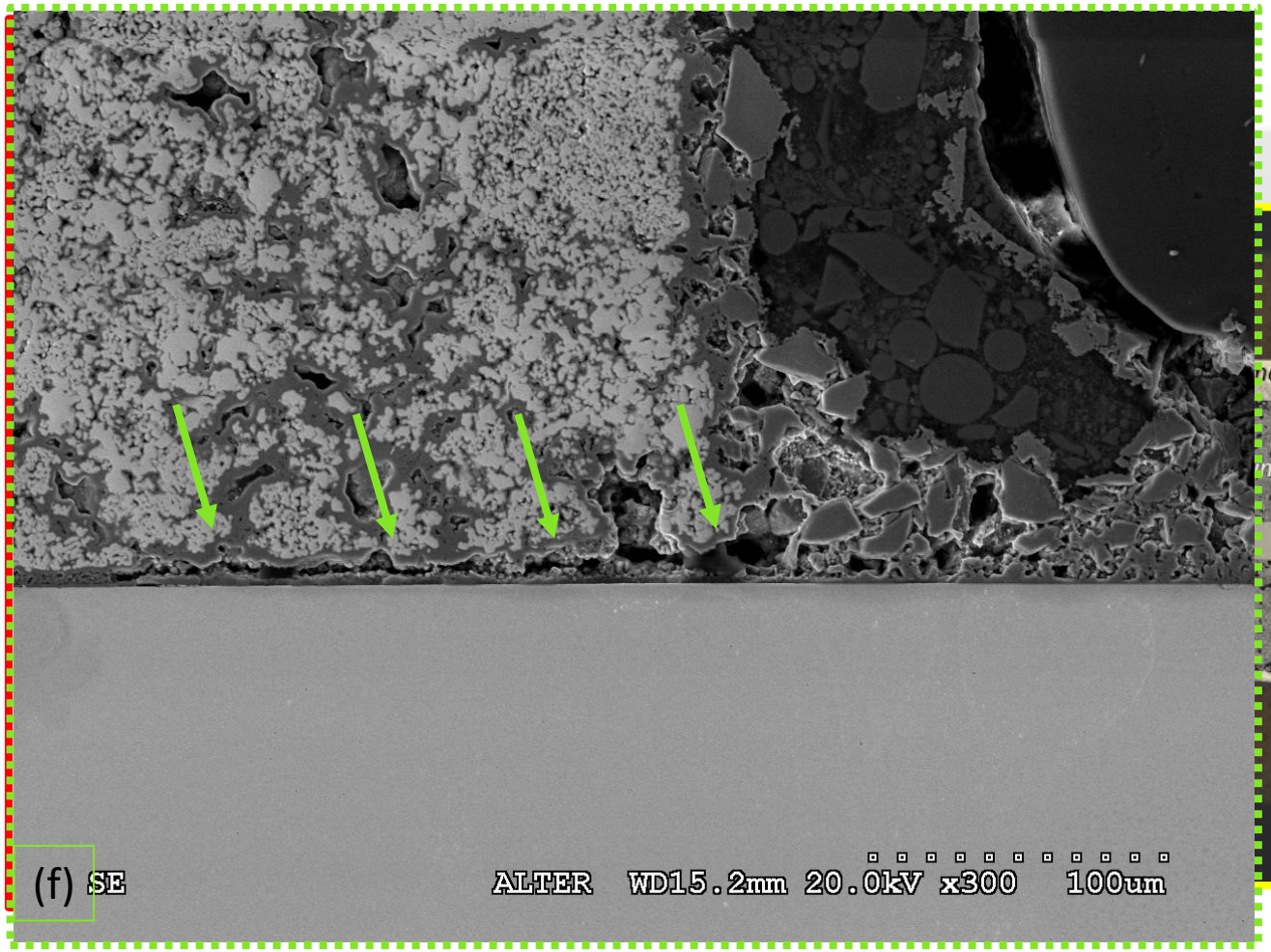
Catastrophic failures in surge current testing

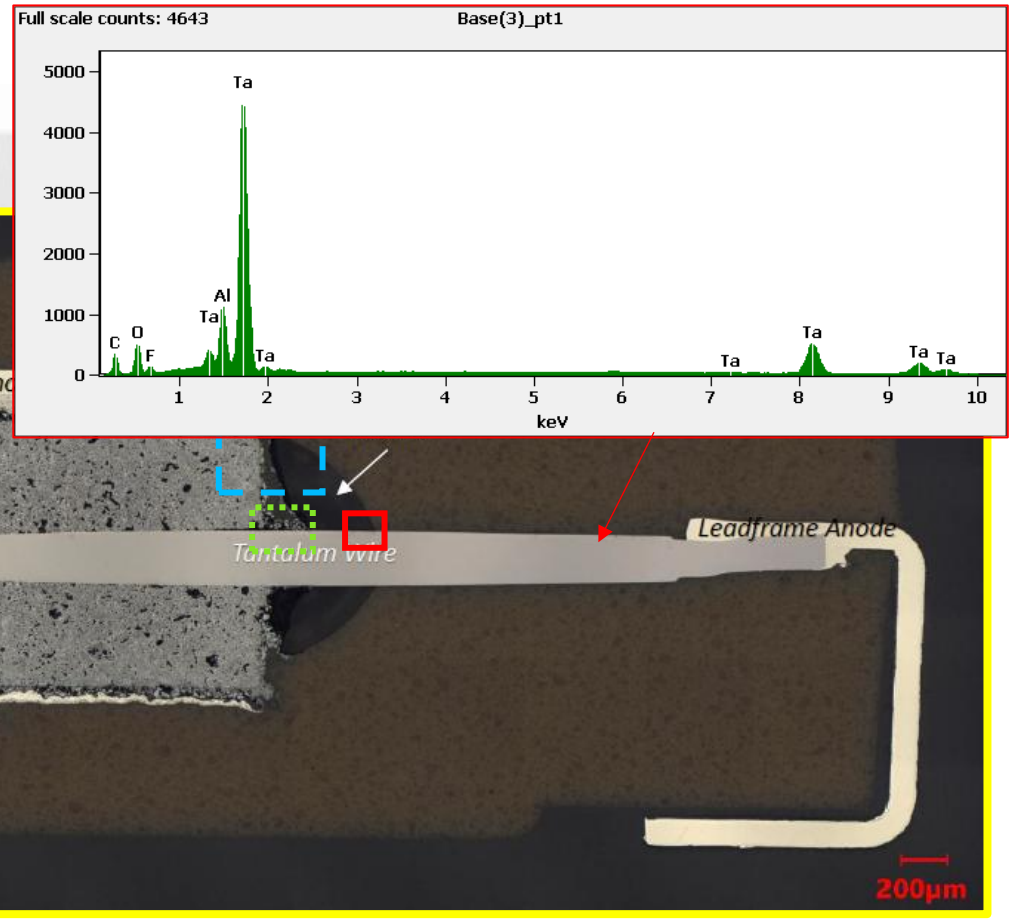
OOS = Out of specification

Lot	Capacitance (µF)	Voltage (V)	Surge test	Burn in
1	1	50	1 reject (electrical failure)	
2	1	50		
3	1	50		
4	4,7	50		1 reject (DCL OOS)
5	4,7	50		
6	4,7	50		1 reject (electrical failure)
7	10	50		5 rejects (DCL OOS)
8	10	50		
9	10	50		
10	47	35		
11	47	35		2 rejects (C OOS) ; 1 reject (DF OOS)
12	47	20		
13	100	20	1 reject (catastrophic)	
14	100	20		
15	100	20		

PHASE 4 (PART 1) : FAILURE ANALYSIS

- SN 1 (Lot 1, 1 µF, 50 V, KEMET): failed the surge-test





PHASE 2 : SCREENING

- Surge current test according to ESCC 3012 8.3
- Burn-in : 168h, +125°C, DC rated voltage according to ESCC 3012 8.5

Excessive leakage
OOS capacitance values
OOS dissipation factor

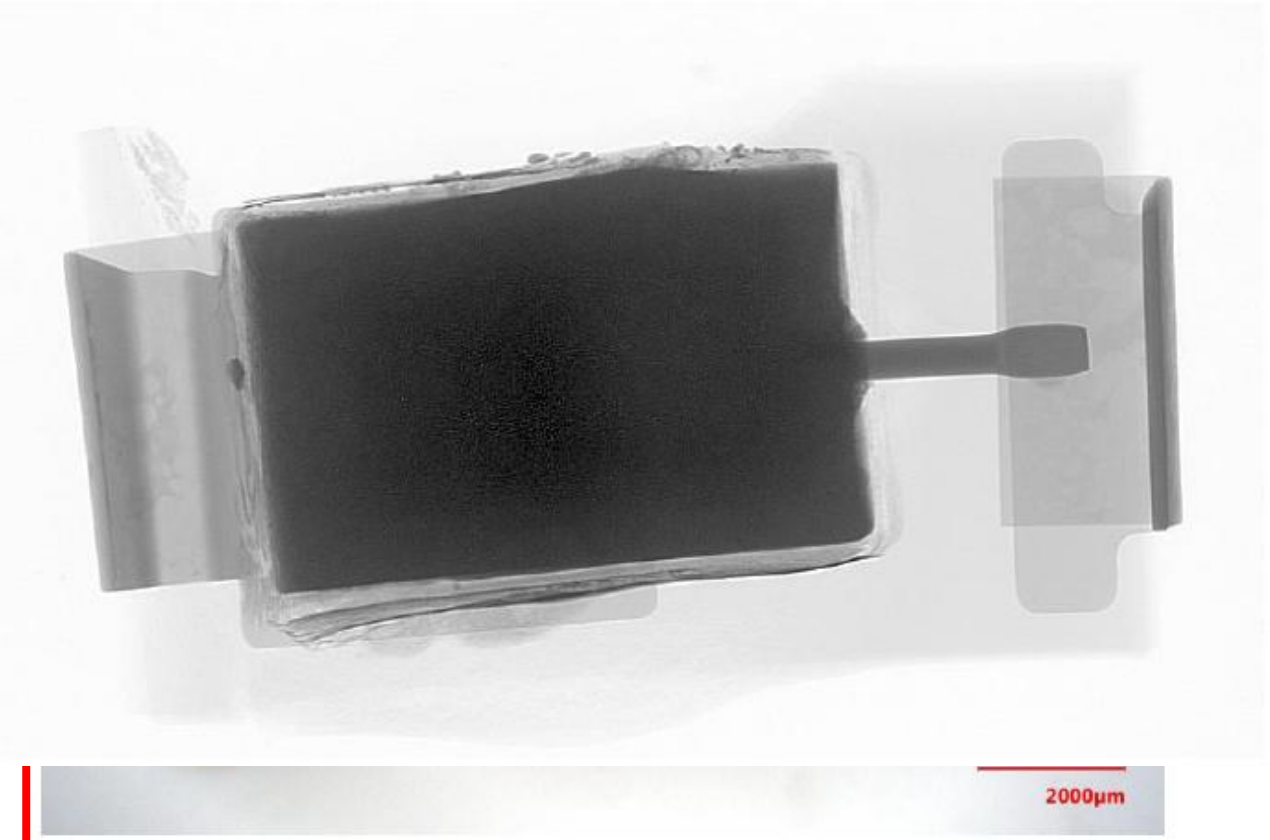
Catastrophic failures in surge current testing

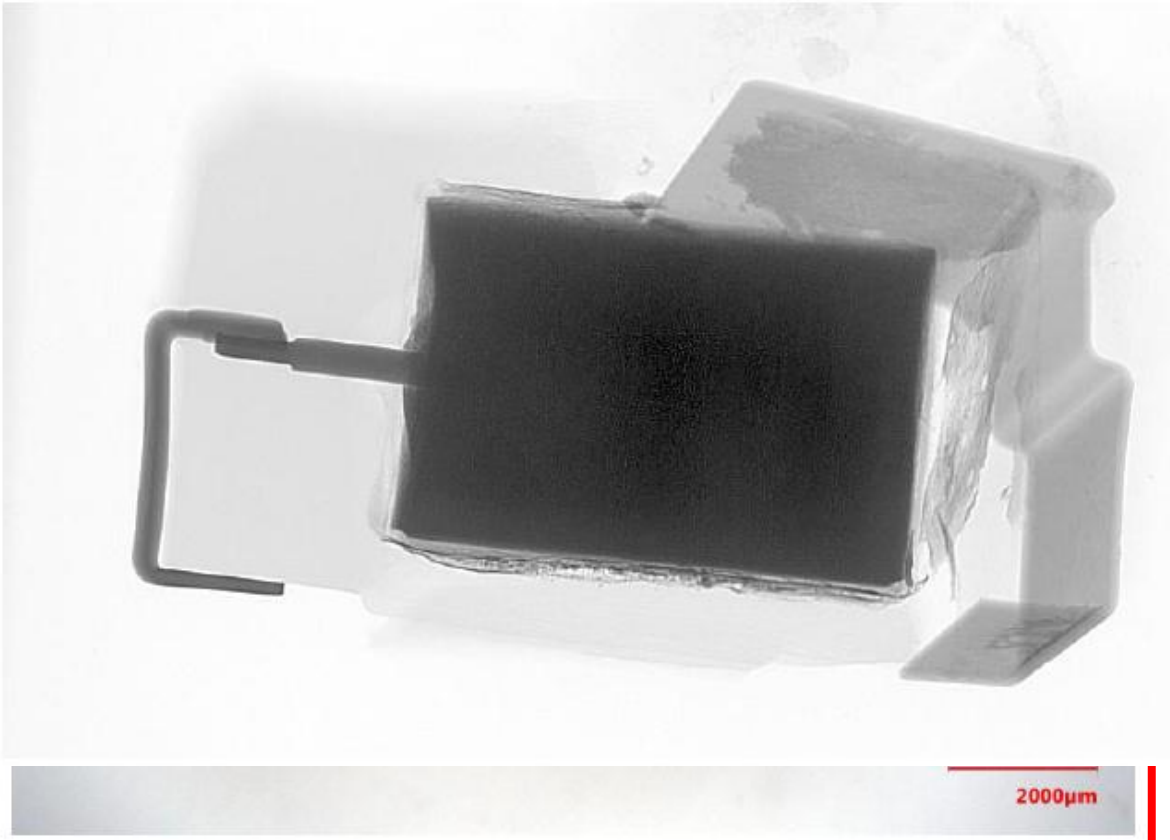
Lot	Capacitance (µF)	Voltage (V)	Surge test	Burn in
1	1	50	1 reject (electrical failure)	
2	1	50		
3	1	50		
4	4,7	50		1 reject (DCL OOS)
5	4,7	50		
6	4,7	50		1 reject (electrical failure)
7	10	50		5 rejects (DCL OOS)
8	10	50		
9	10	50		
10	47	35		
11	47	35		2 rejects (C OOS) ; 1 reject (DF OOS)
12	47	20		
13	100	20	1 reject (catastrophic)	
14	100	20		
15	100	20		

OOS = Out of specification

PHASE 4 (PART 1) : FAILURE ANALYSIS

- SN 33 (Lot 13, 100 µF, 20 V, KEMET): failed the surge current test (catastrophic failure)





PHASE 2 : SCREENING

- Surge current test according to ESCC 3012 8.3
- Burn-in : 168h, +125°C, DC rated voltage according to ESCC 3012 8.5

Excessive leakage
OOS capacitance values
OOS dissipation factor

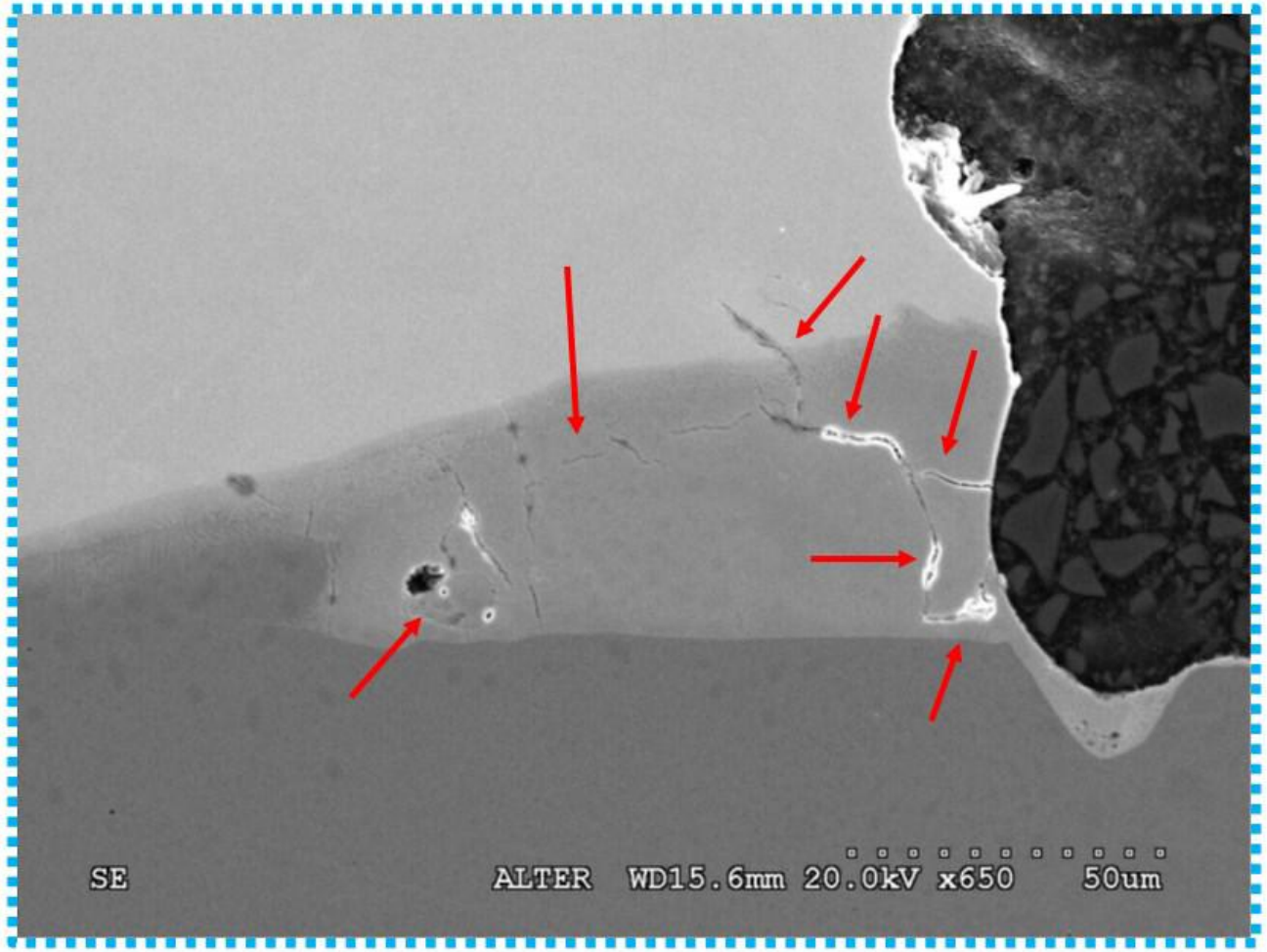
Catastrophic failures in surge current testing

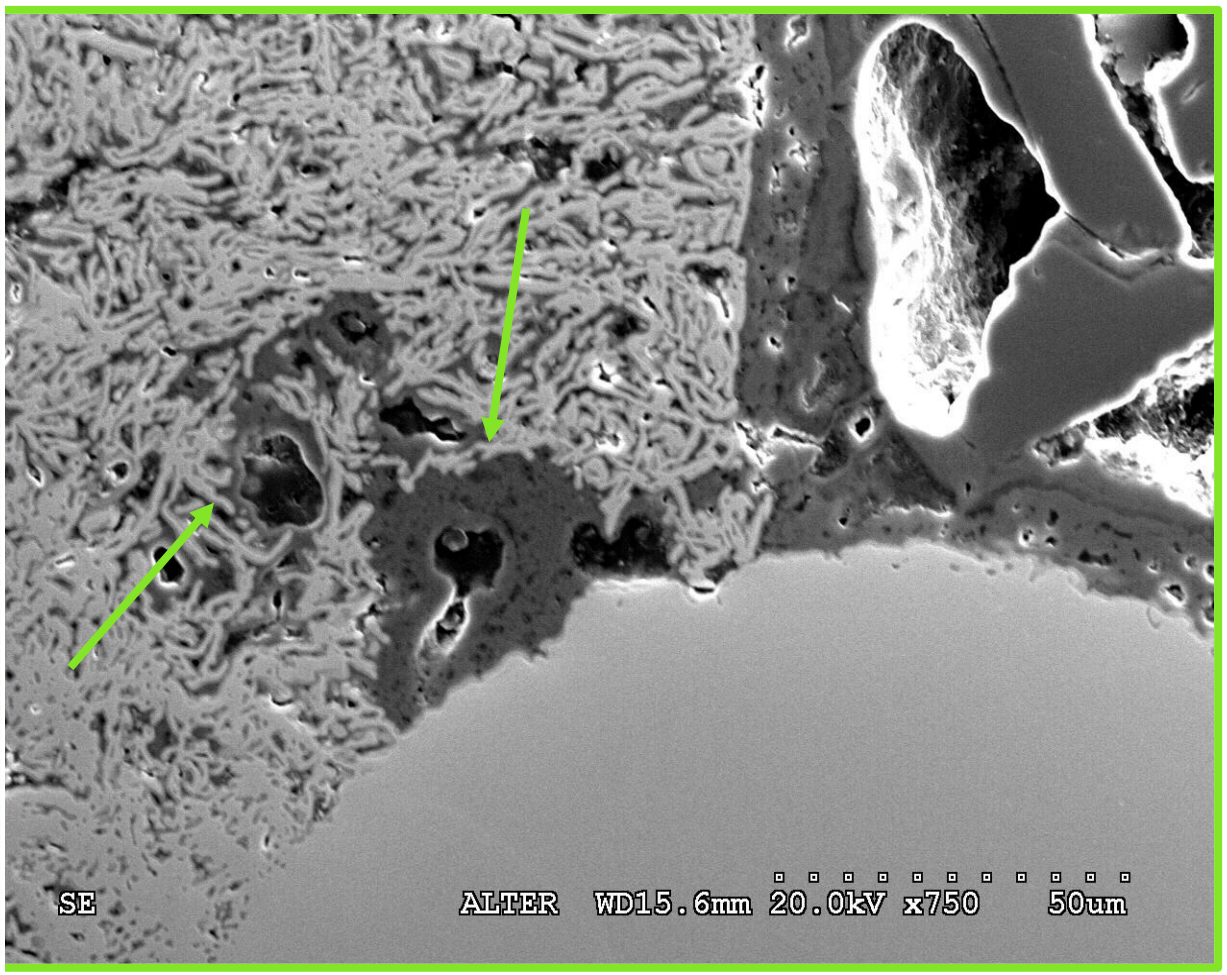
OOS = Out of specification

Lot	Capacitance (µF)	Voltage (V)	Surge test	Burn in
1	1	50	1 reject (electrical failure)	
2	1	50		
3	1	50		
4	4,7	50		1 reject (DCL OOS)
5	4,7	50		
6	4,7	50		1 reject (electrical failure)
7	10	50		5 rejects (DCL OOS)
8	10	50		
9	10	50		
10	47	35		
11	47	35		2 rejects (C OOS) ; 1 reject (DF OOS)
12	47	20		
13	100	20	1 reject (catastrophic)	
14	100	20		
15	100	20		

PHASE 4 (PART 1) : FAILURE ANALYSIS

- SN 15 (Lot 6, 4.7 µF, 50 V, Vishay): rejected after the burn-in test





PHASE 2 : SCREENING

- Surge current test according to ESCC 3012 8.3
- Burn-in : 168h, +125°C, DC rated voltage according to ESCC 3012 8.5

Excessive leakage
OOS capacitance values
OOS dissipation factor

Catastrophic failures in surge current testing

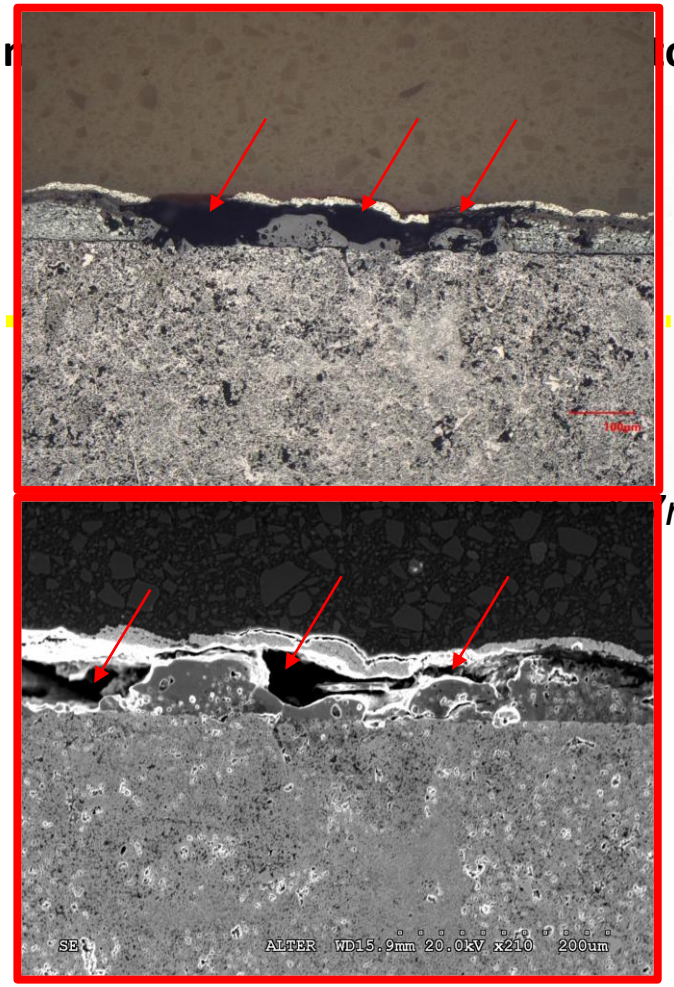
OOS = Out of specification

Lot	Capacitance (µF)	Voltage (V)	Surge test	Burn in
1	1	50	1 reject (electrical failure)	
2	1	50		
3	1	50		
4	4,7	50		1 reject (DCL OOS)
5	4,7	50		
6	4,7	50		1 reject (electrical failure)
7	10	50		5 rejects (DCL OOS)
8	10	50		
9	10	50		
10	47	35		
11	47	35		2 rejects (C OOS) ; 1 reject (DF OOS)
12	47	20		
13	100	20	1 reject (catastrophic)	
14	100	20		
15	100	20		

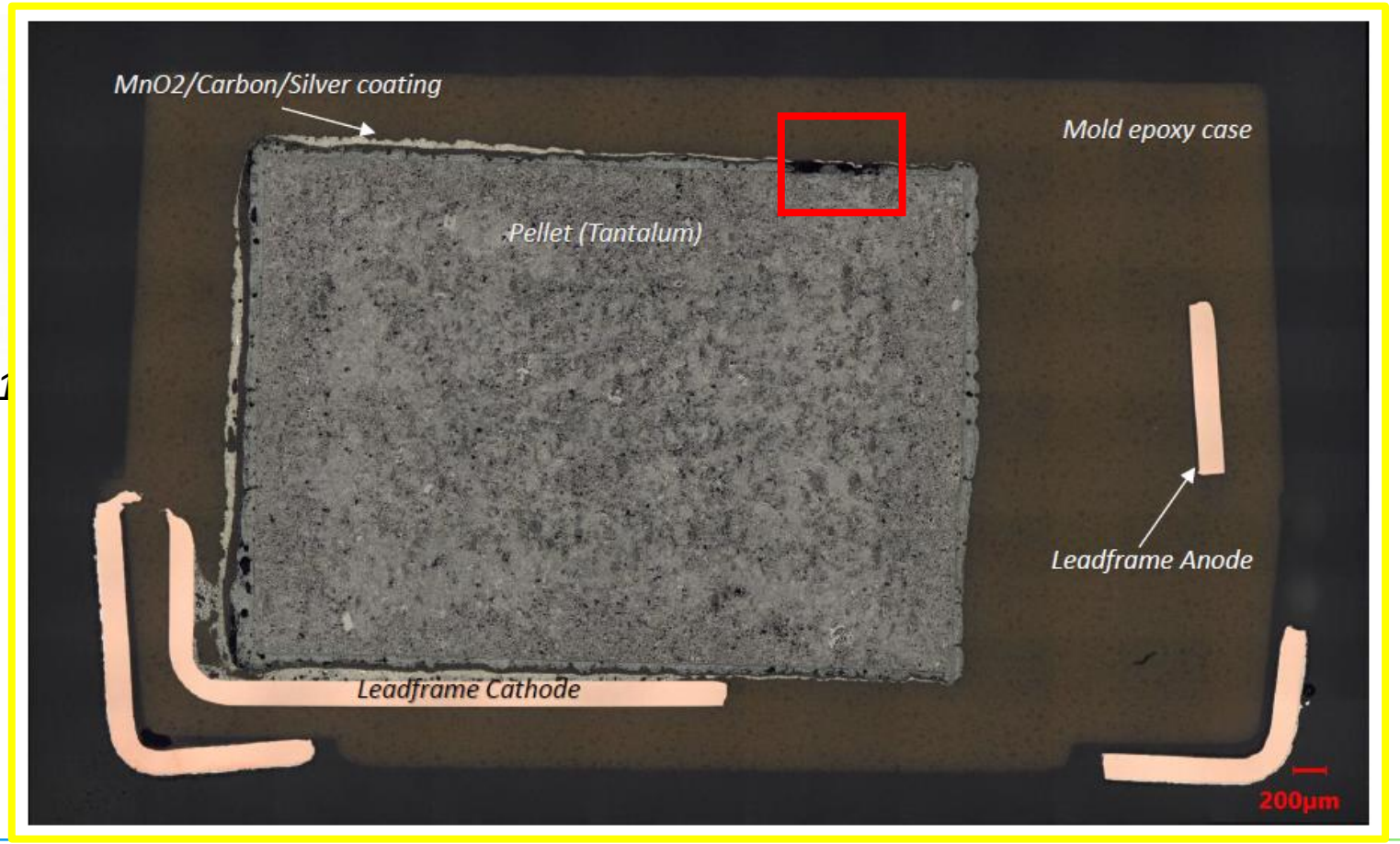
PHASE 4 (PART 1) : FAILURE ANALYSIS

- SN 81 (Lot 11, 47 µF, 35 V, Kyocera AVX) : exceeded the dissipation-factor limit in screening (14%)

Lock-In **o X-Ray images) :**



mA – 1



PHASE 3 : LIFE TESTING

- According to ESCC 3012 8.16 for all lots:
  - 2000h, 85°C, Ur
  - 2000h, 125°C, Uc

Excessive leakage
OOS capacitance values
OOS dissipation factor

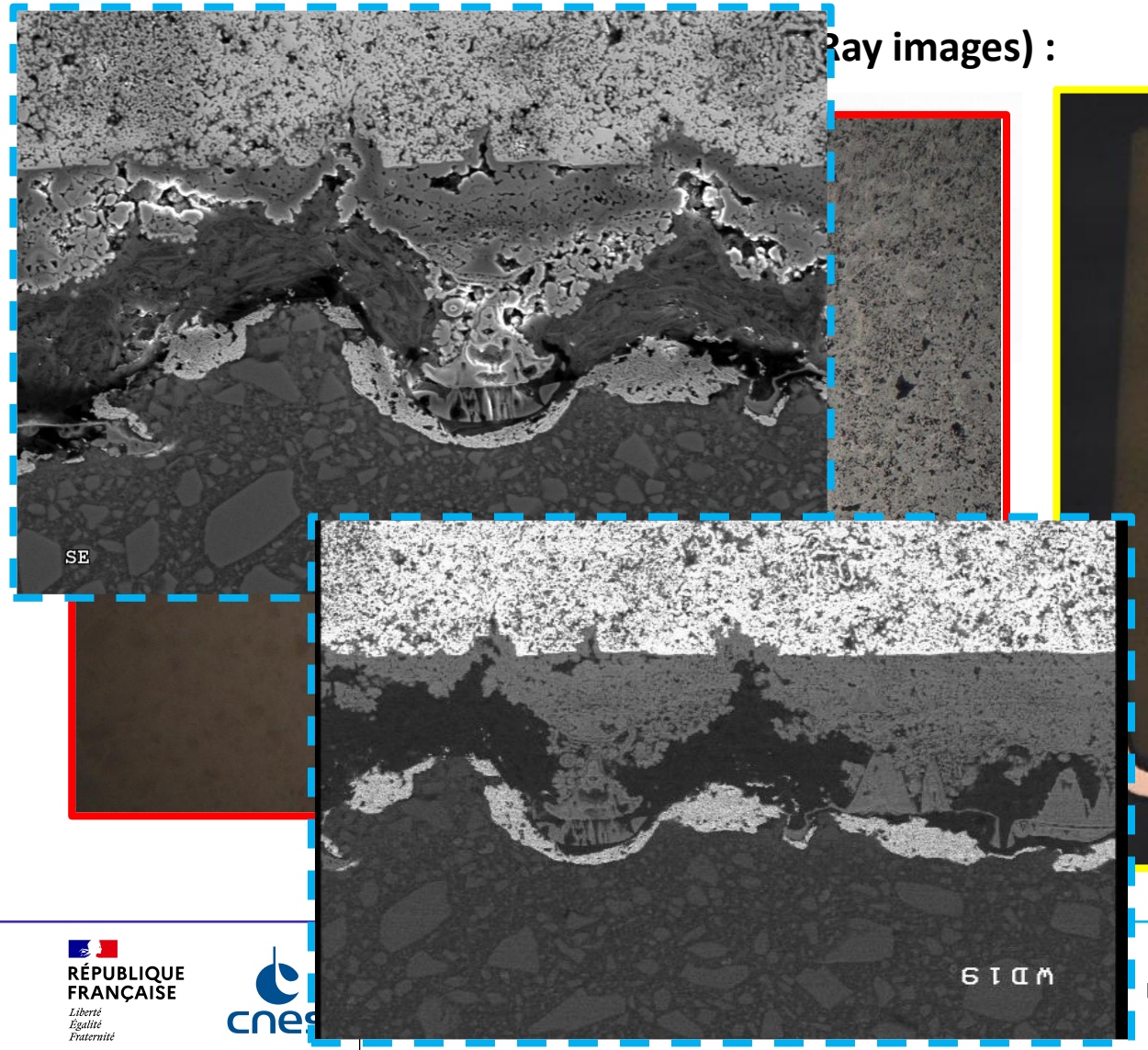
Lot	Capacitance (µF)	Voltage (V)	2000h 85°C Ur	2000h / 125°C Uc
1	1	50		
2	1	50		
3	1	50		
4	4,7	50	1 reject (DCL OOS)*	
5	4,7	50		
6	4,7	50		
7	10	50		1 reject (C OOS)
8	10	50		
9	10	50		
10	47	35		
11	47	35	1 reject (C OOS) + 1 reject (DF OOS)	1 reject (C OOS)*
12	47	20		
13	100	20		
14	100	20		
15	100	20		
			* These parts were alreday OOS after screening	

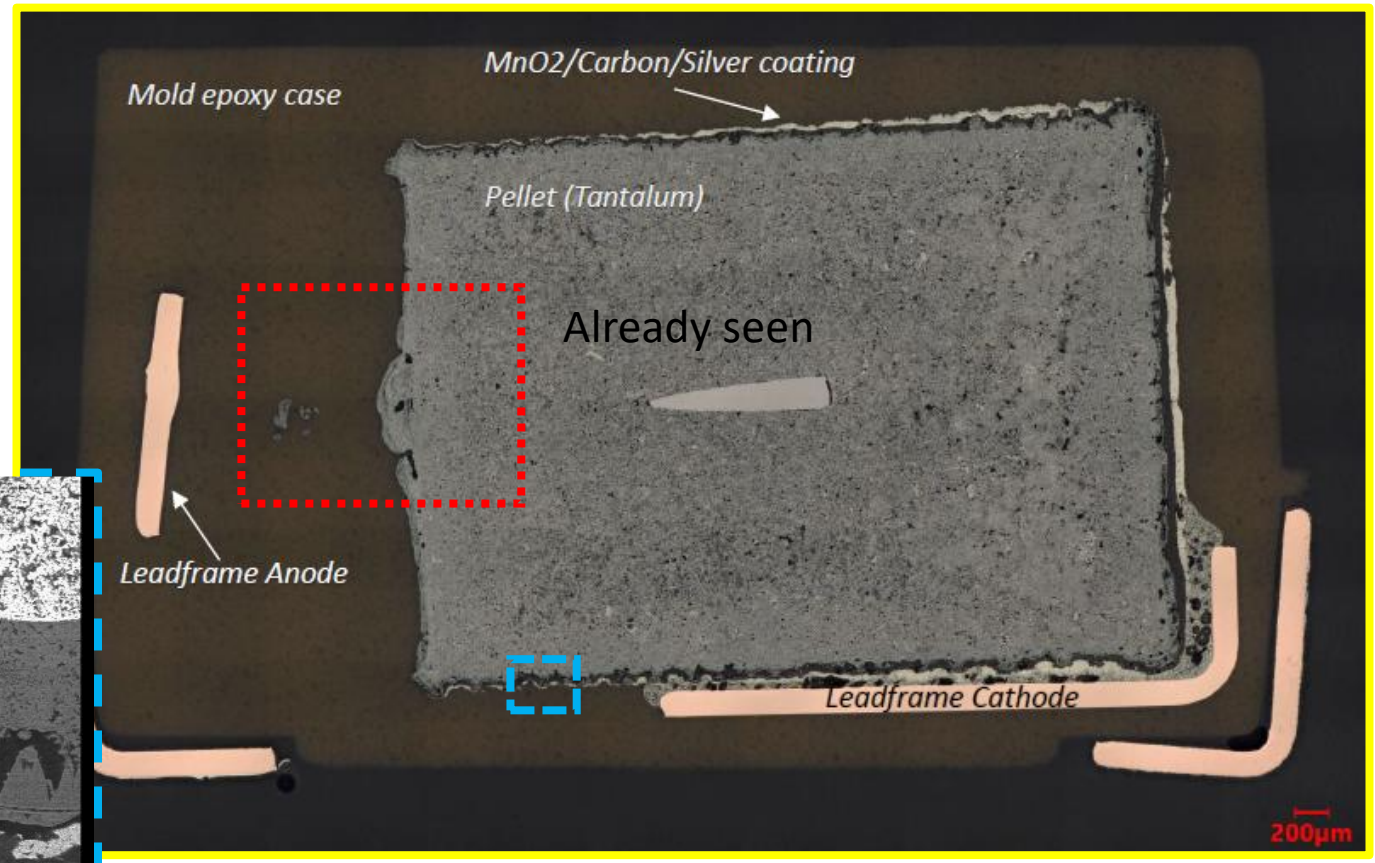
OOS = Out of specification

PHASE 4 (PART 2) : FAILURE ANALYSIS

- SN 43 (Lot 11, 47 µF, 35 V, Kyocera AVX): rejected during the life test (C=41µF instead of 47µF)

ay images) :





CONCLUSION

Select trusted COTS : Tantalum parts with proven space-heritage data and maintain strict lot traceability, or apply the full ECSS-Q-ST-60-13 flow for critical subsystems

ACKNOWLEDGMENTS

ALTER

Laurent Guillot
Guilhem Vidal
Rodolphe Sellier
Frédéric Tilhac
Xavier Wiedemann



ANY QUESTION ?

THANK YOU FOR YOUR ATTENTION!

© CNES/ESA/Arianespace/Optique Vidéo CSG/S Martin, 2022