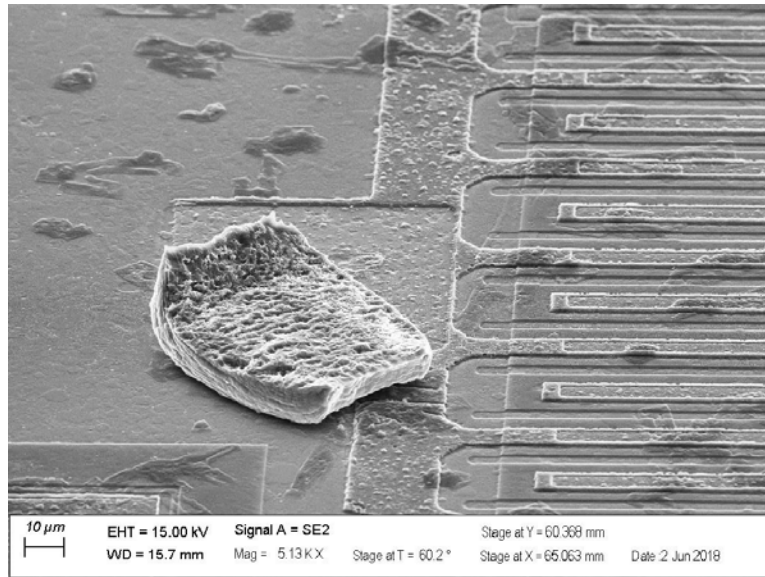
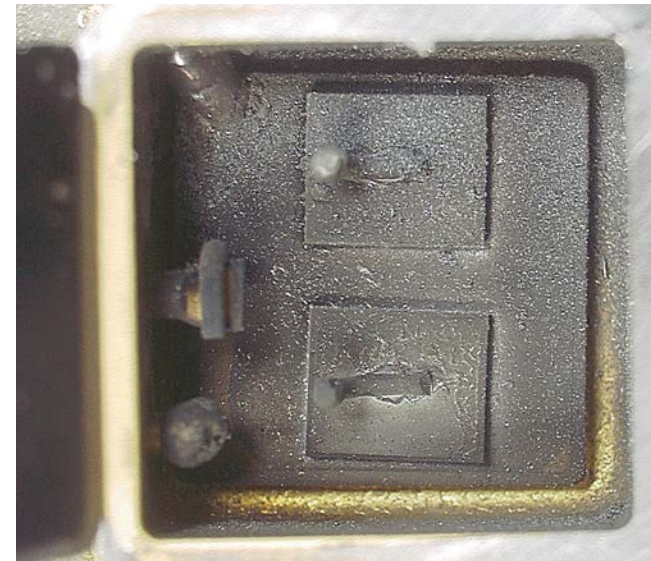


NASA GSFC EEE Parts: DPA and FA Summary

Destructive Physical Analysis



Failure Analysis



Lyudmyla Panashchenko

Failure Analysis Engineer

NASA GSFC Code 562 EEE Parts and Packaging

June 17, 2020

Selection of Parts for DPA

- NASA GSFC projects follow EEE-INST-002 for selection and testing of EEE parts
- EEE-INST-002 defines when DPA should be performed based on combination of factors that includes commodity type, quality level of part type selected and project level (risk tolerance)

Table 2 SCREENING REQUIREMENTS FOR HYBRID MICROCIRCUITS (Page 2 of 2)

Screen	Test Methods and Conditions	Level 1			Level 2			Level 3	
		K	H	Non-QML 5/	K	H	Non-QML 6/	H	Non-QML 6/
12. Radiographic 7/	MIL-STD-883 , Method 2012		X	X		X	X	X	X
13. External Visual 1/	MIL-STD-883, Method 2009			X			X	X	X
14. Destructive Physical Analysis (DPA)	MIL-STD-883, Method 5009	X	X	X	X	X	X	X	X

Table 3A CERAMIC CAPACITOR QUALIFICATION REQUIREMENTS 1/ (Page 2 of 3)

Inspection/Test	Test Methods, Conditions, and Requirements	Quantity (Accept Number)		
		Level		
		1	2	3
Group 4 Humidity Steady State, Low Voltage 6/	MIL-STD-202 , Method 103, Condition A and MIL-PRF-123, Group B	12(0) X	5(0) X	N/A
Group 5 Solderability	MIL-STD-202, Method 208	5(0) X	3(0) X 5/	N/A
Destructive Physical Analysis	EIA-469	X		

About S-311-M-70

- DPA commonly performed per MIL-STD-1580:

Destructive Physical Analysis for
Electronic, Electromagnetic, and
Electromechanical Parts

- NASA GSFC uses an internal S-311-M-70 document based on MIL-STD-1580 with several amendments:

- Sample size
- Prohibited Materials Analysis (PMA)
- Capacitors
- Ferrite beads

<https://landandmaritimeapps.dla.mil/programs/milspec/ListDocs.aspx?BasicDoc=MIL-STD-1580>

MIL-STD-1580C
31 October 2019
SUPERSEDING
MIL-STD-1580B
CHANGE 3
4 March 2014

DEPARTMENT OF DEFENSE TEST METHOD STANDARD

DESTRUCTIVE PHYSICAL ANALYSIS
FOR
ELECTRONIC, ELECTROMAGNETIC,
AND ELECTROMECHANICAL PARTS

<https://nepp.nasa.gov/index.cfm/21612>

ORIGINATOR: Bruce Meinhold, MEI Technologies Inc.	DATE	FSC: 59GP
REVIEWED: Alix Duvalsaint, QSS Group Inc.		Specification for the Performance of Destructive Physical Analyses (DPA)
CODE 562 APPROVAL: Marcellus Proctor, NASA GSFC		
ADDITIONAL APPROVAL: Dr. Henning Leidecker, NASA GSFC		
ADDITIONAL APPROVAL:		S-311-M-70
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GODDARD SPACE FLIGHT CENTER GREENBELT, MARYLAND 20771		
CAGE CODE: 25306		

Tests Most Commonly Performed During Destructive Physical Analysis (DPA)

External Visual

External Prohibited Materials Analysis (PMA)

X-Ray

PIND

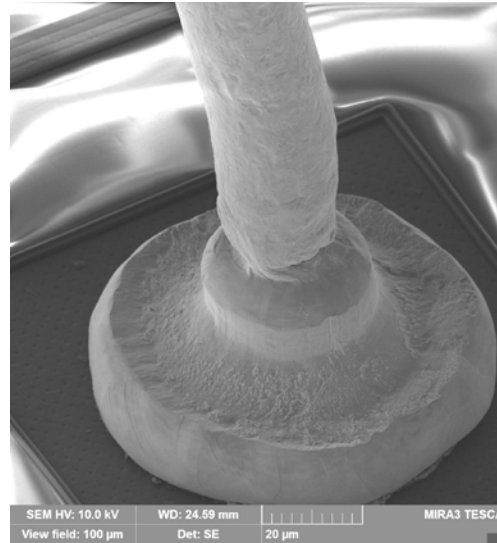
Hermeticity

Internal Gas Analysis (IGA)

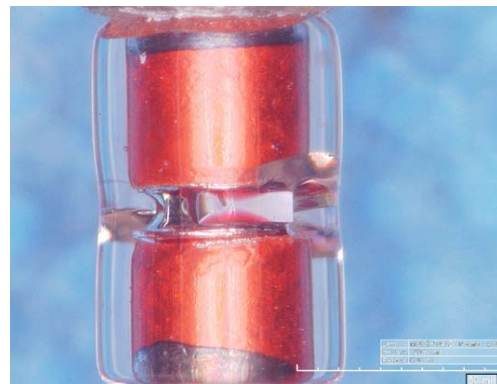
Internal Visual

Wire Pull

Die Shear

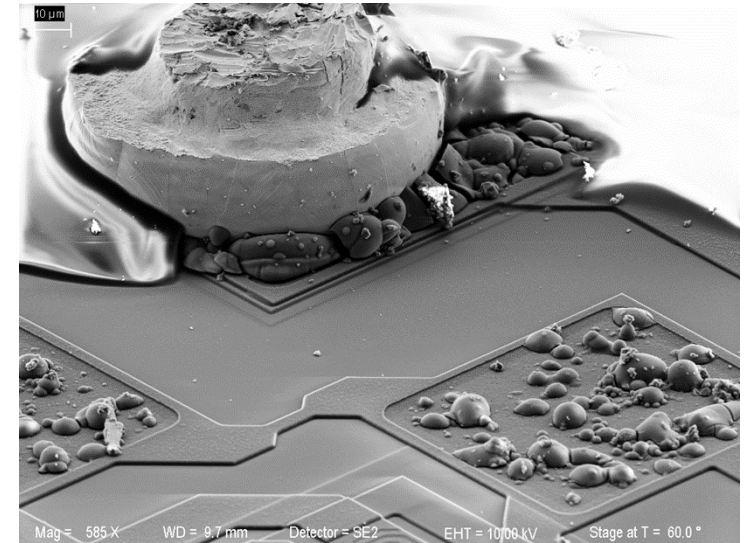


Wire necking above the gold ball bond – reduced wire pull strength



Gross Leak failure of diode – red dye penetrated through a crack to the die

NEPP ETW 2020

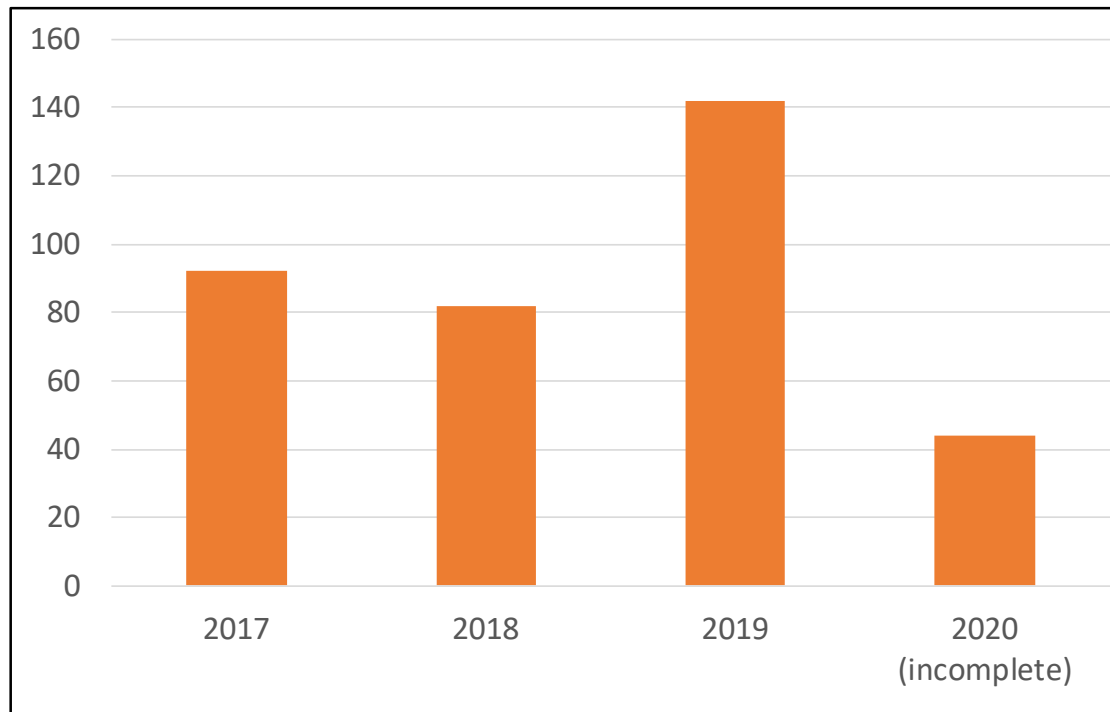


Corrosion of aluminum pad due to moisture ingress and elevated temperature exposure during screening

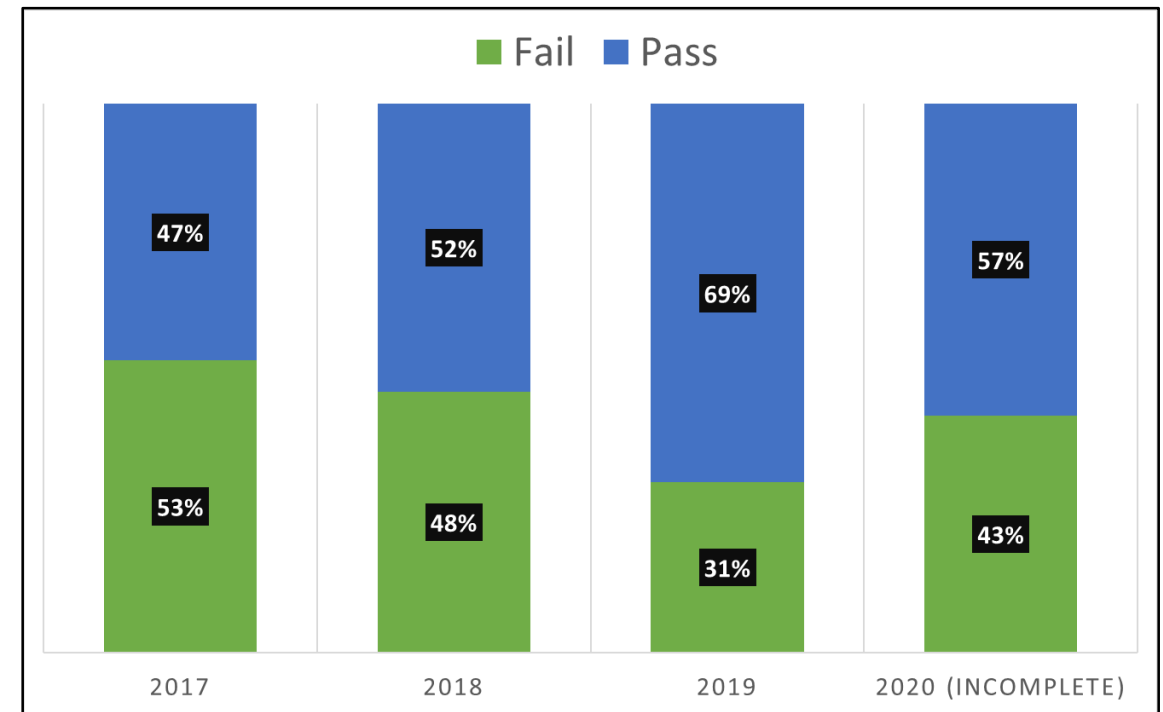
Statistics of DPAs for 2017-2020*

(*) stats for 2020 are incomplete

Total number of DPAs per year



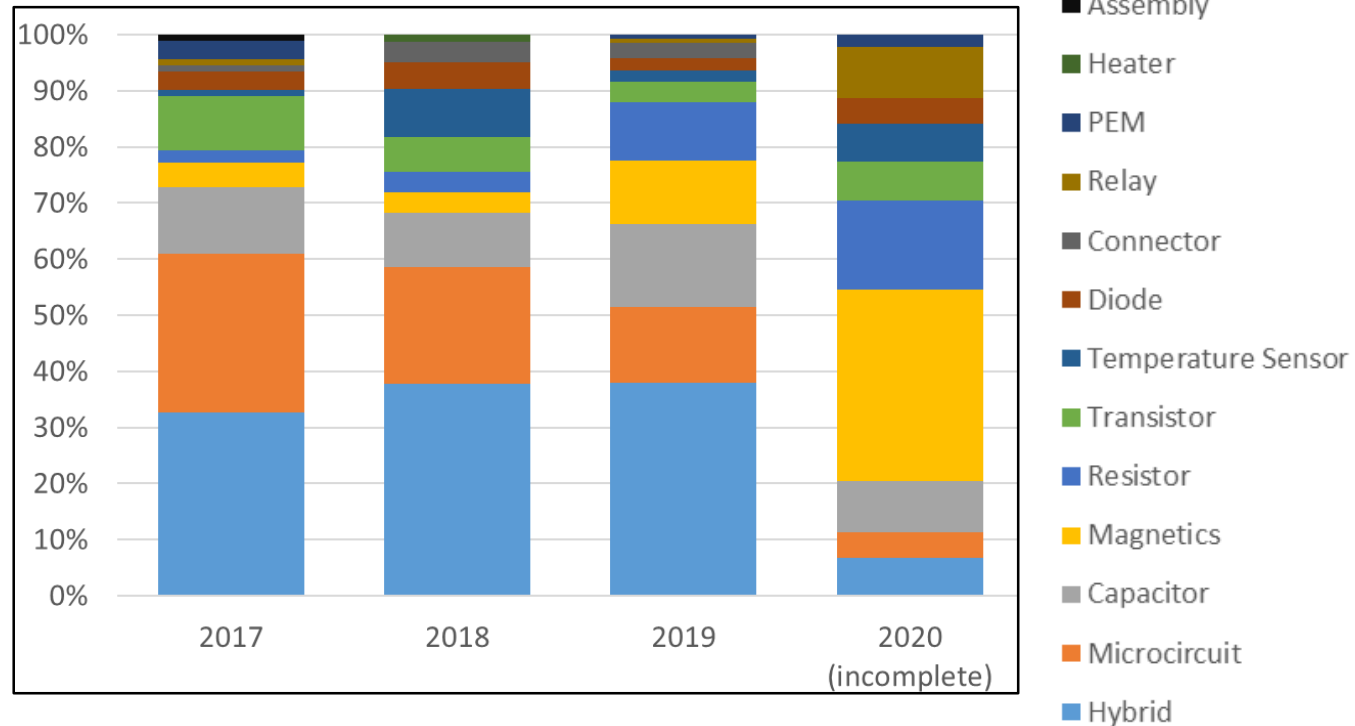
Overall DPA Failure Rate



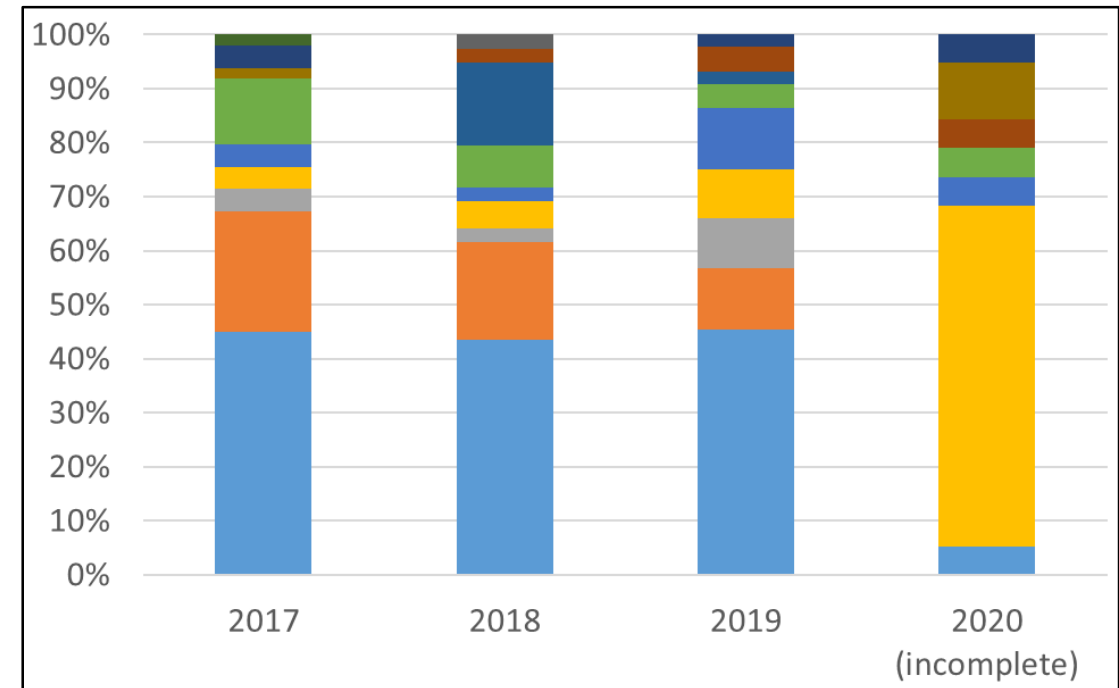
DPA Failures for 2017-2020*

(*) stats for 2020 are incomplete

DPA Failures by Part Type



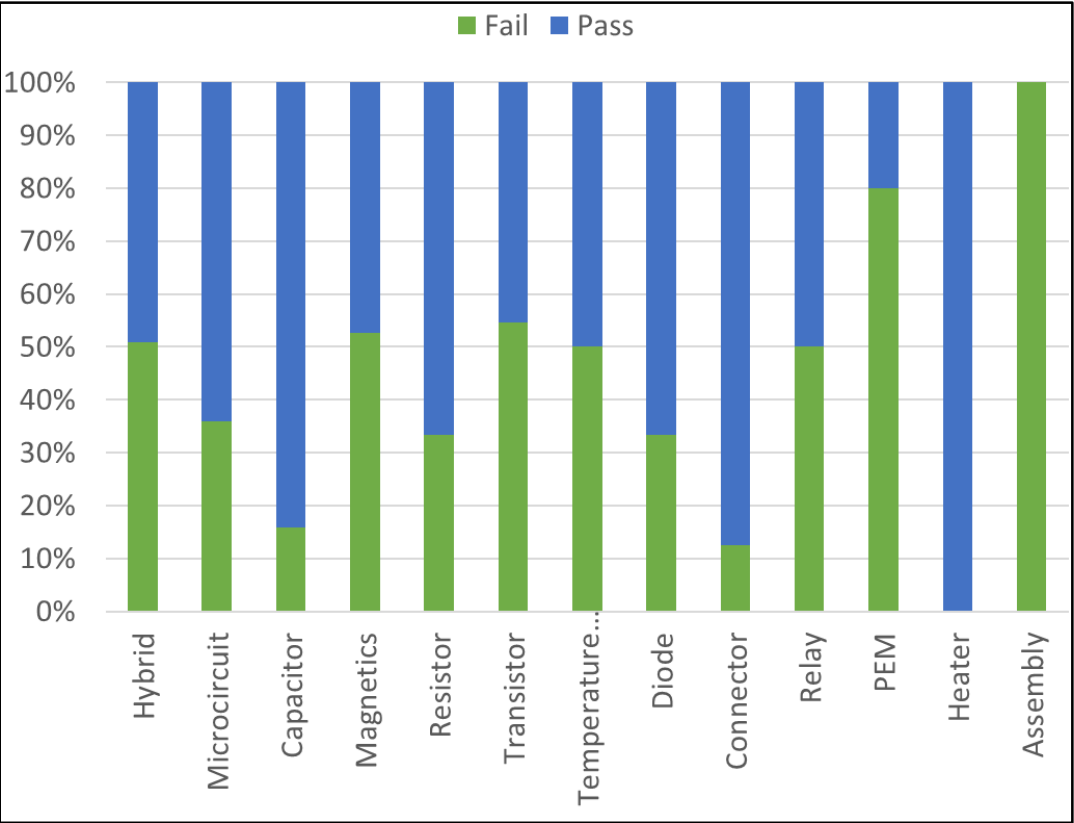
DPA Failure Rate by Part Type



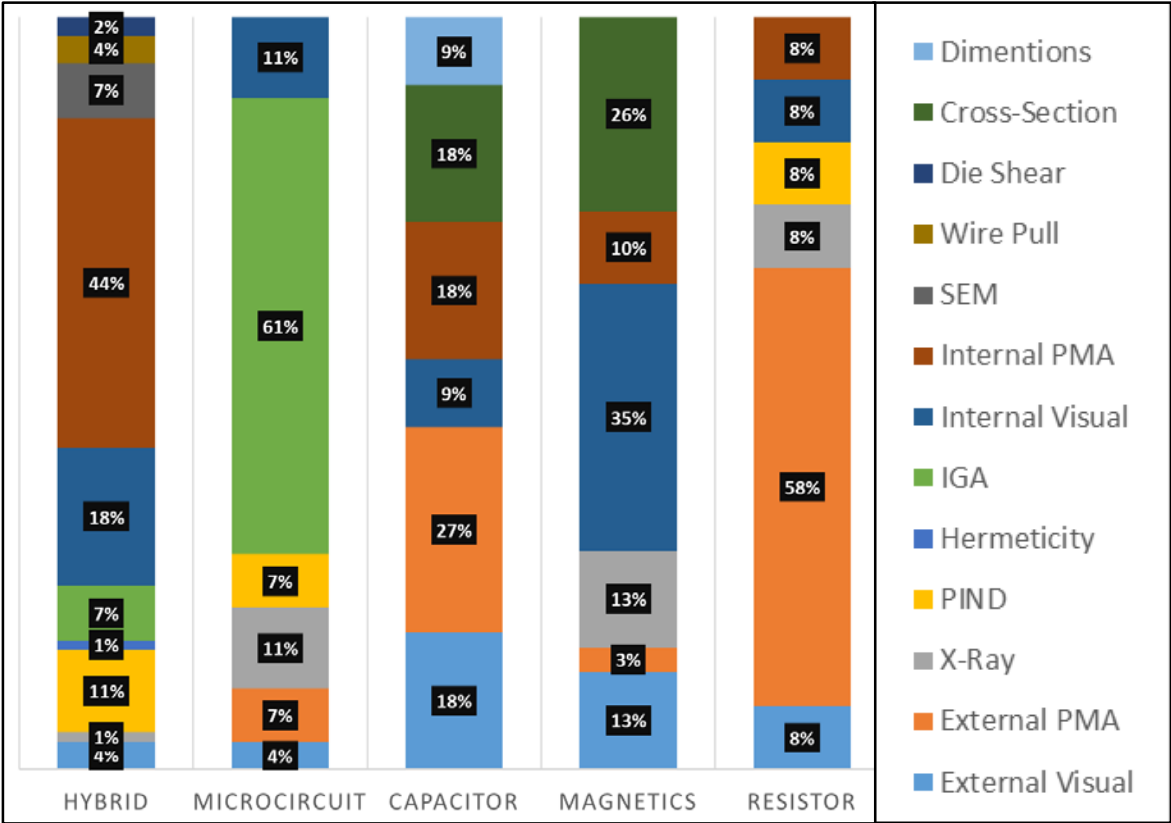
Failures Rate by Part Type 2017-2020*

(*) stats for 2020 are incomplete

DPA Failure Rate by Part Type
(2017-2020 Lumped)

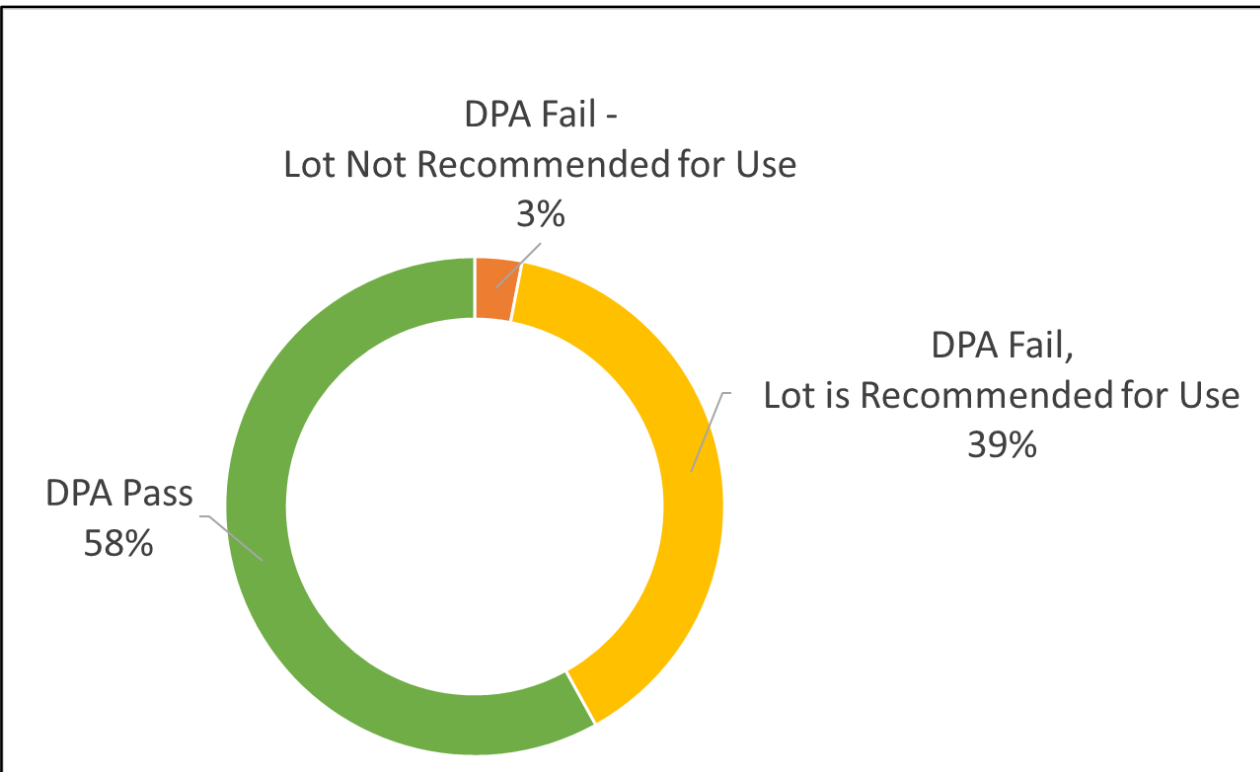


Breakdown of DPA Failures within a Part Type by
Test Type
(2017-2020 Lumped)



Disposition of DPAs for 2017-2020*

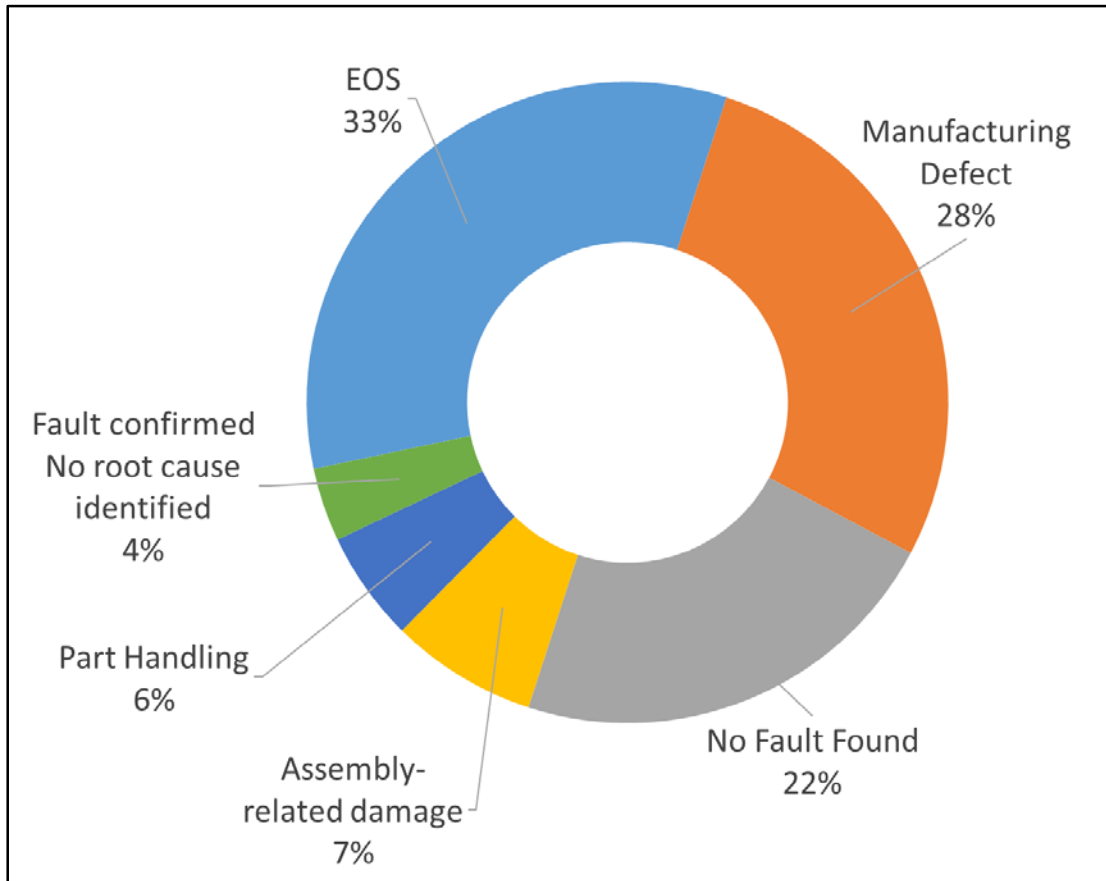
(*) stats for 2020 are incomplete



- DPA failures per S-311-M-70 (based on MIL-STD-1580) are dispositioned by a Failure Review Board to assess risk to the flight project
- Through review of data and/or performing additional testing, a lot may be deemed acceptable for use
- Examples of lots that failed DPA but were accepted for use
 - Failure of a transistor for external prohibited materials analysis (PMA) accepted as-is after solder dip is performed on the entire lot
 - Failure of a hybrid for internal prohibited materials analysis (PMA) accepted as-is for some vendors with known use of Pb-free materials inside the part
 - Failure of a hybrid for Internal Gas Analysis (IGA) showing fluorocarbon is accepted as-is after manufacturer demonstrates the fluorocarbon came from cleaning solution used prior to lid seal

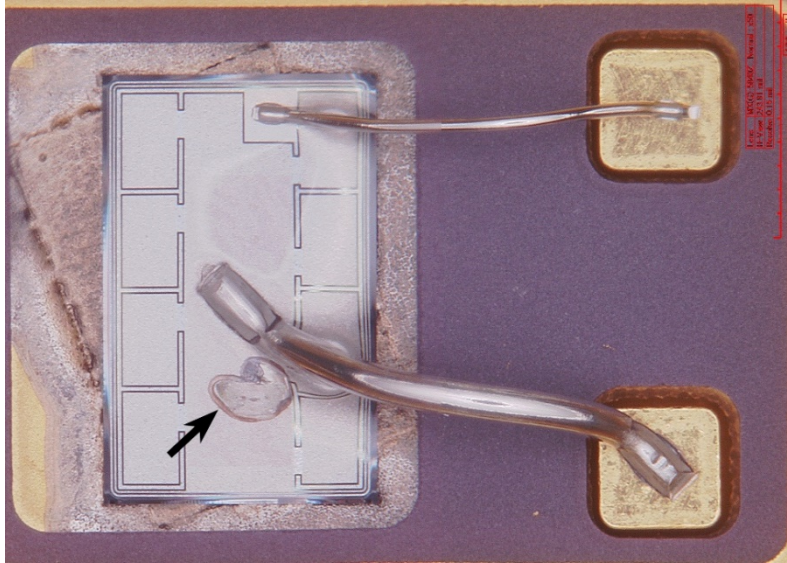
Statistics of FAs for 2017-2020*

(*) stats for 2020 are incomplete

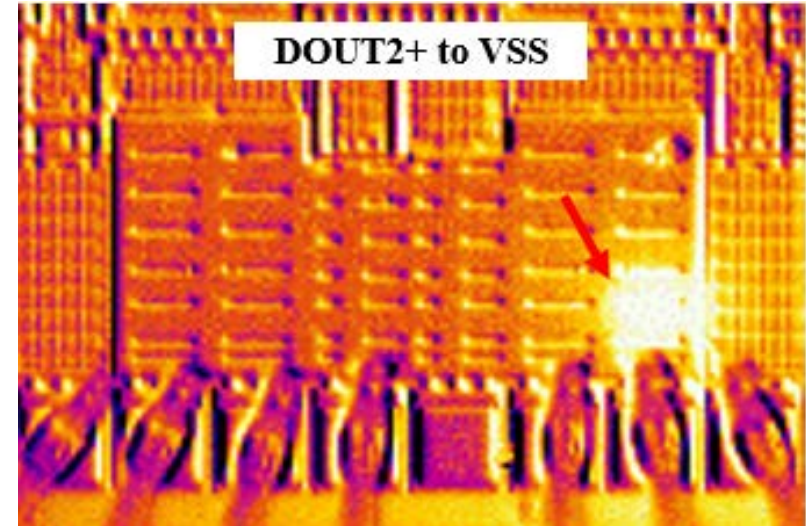


- Perform ~20 failure analyses (FA) a year, mostly for NASA GSFC projects
- FA is usually requested when EEE part has been identified as suspect or faulty during assembly inspection or testing
- Most common EEE parts in FA:
 - Microcircuits - 26%
 - Capacitors - 26%
 - Hybrids - 11%
- Most common failure categories:
 - Electrical Over Stress (EOS) – 33%
 - Manufacturing Defects – 28%

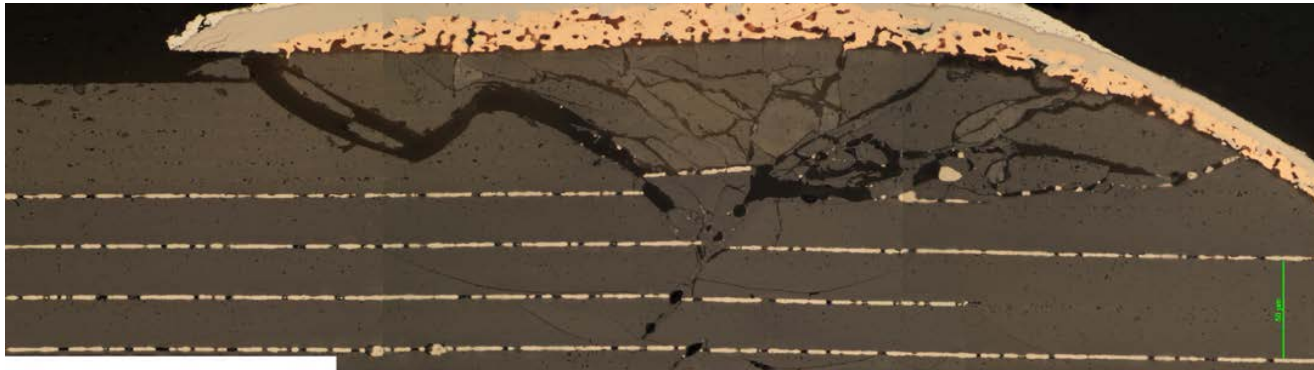
Examples of FA: Electrical Overstress Failures (EOS)



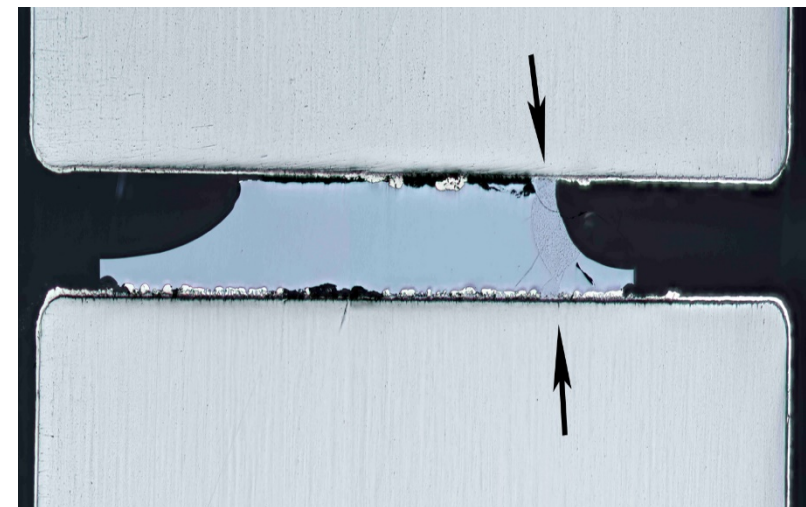
MOSFET die overstressed by external electrical stimulus



Infrared image of die showing hot spot after an ESD event

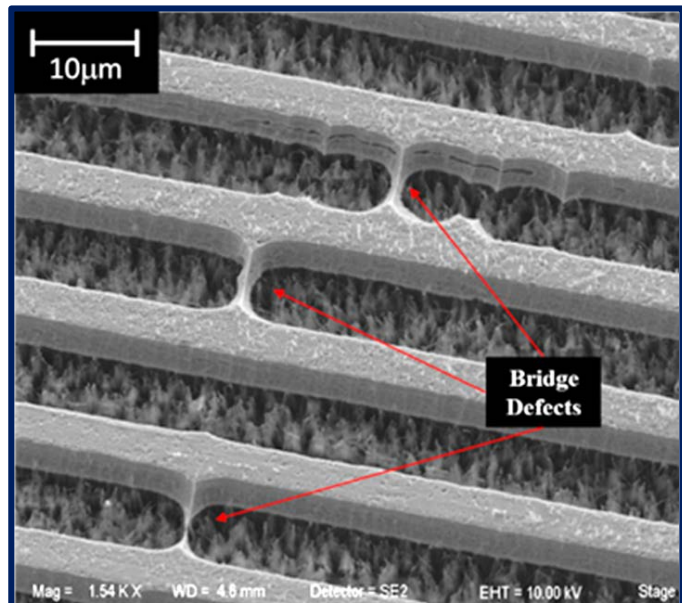


Multilayer ceramic chip capacitor with cracking as a result of internal short



Rectifier diode with an electrical short

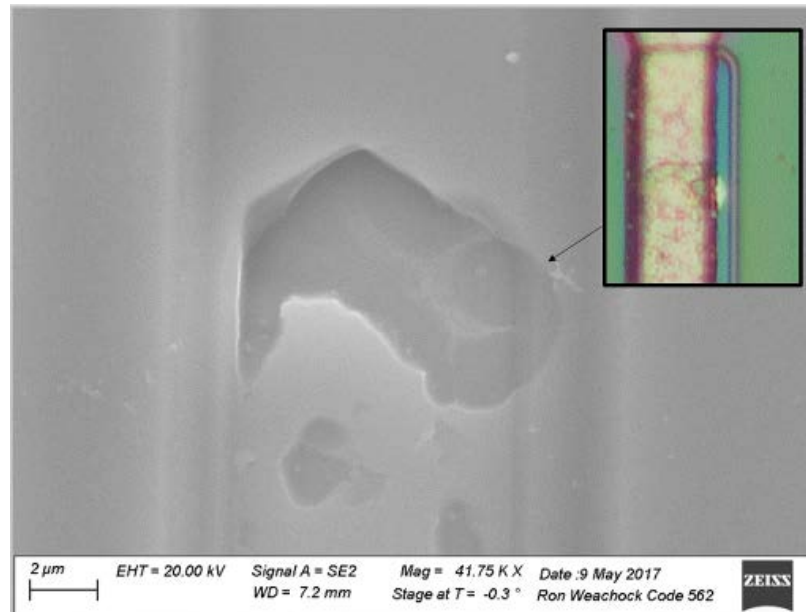
Examples of FA: Manufacturing Defects



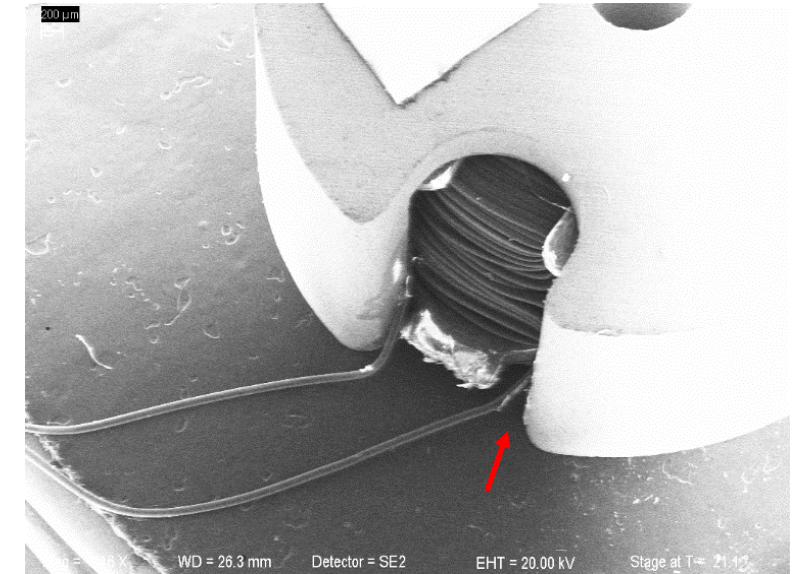
Fractured Bridge #2



Nichrome resistor with defects in etched pattern



Aluminum diffusing into the silicon indicating a high temperature event

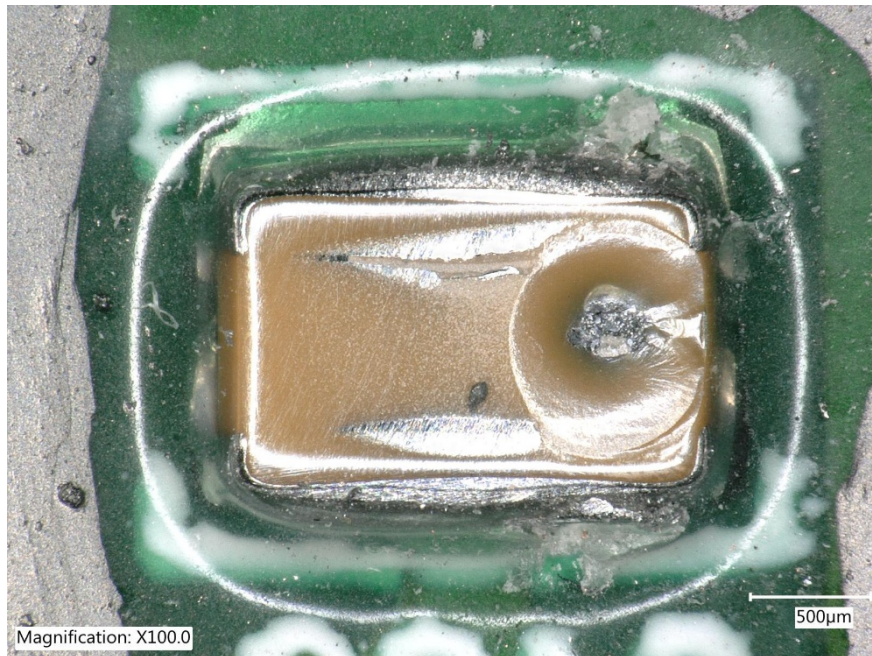


Magnetic device with wire pinched at the body and rubbing through the insulation

Summary/Conclusions

- DPA based on MIL-STD-1580 is a key element of GSFC Parts Selection/Screening Protocols per EEE-INST-002
 - Overall rate of non-conformances found during DPA for the past 4 years has been 42%
 - GSFC employs a DPA Failure Review Board to review/disposition lots that do not pass DPA
 - Options include reject lot, use as-is or screen/reprocess for the observed condition to provide assurance for the intended application
 - 3% of all lots are rejected for flight use
- FA in support of NASA programs
 - Hybrids and Capacitors make up 52% of all FAs
 - EOS and Manufacturing defects account for 61% of FA findings

Questions?



Multilayer ceramic chip capacitor with a cone-shaped piece of top plate separated after internal electrical short

Acronyms

CSAM	C-Mode Scanning Acoustic Microscopy
DPA	Destructive physical Analysis
EOS	Electrical Over Stress
EEE Parts	Electrical, Electronic and Electromechanical Parts
ESD	Electro Static Discharge
FA	Failure Analysis
GSFC	Goddard Space Flight Center
IGA	Internal Gas Analysis
NASA	National Aeronautics and Space Administration
PIND	Particle impact Noise Detection
PEM	Plastic Encapsulation Microcircuit
PMA	Prohibited Materials Analysis