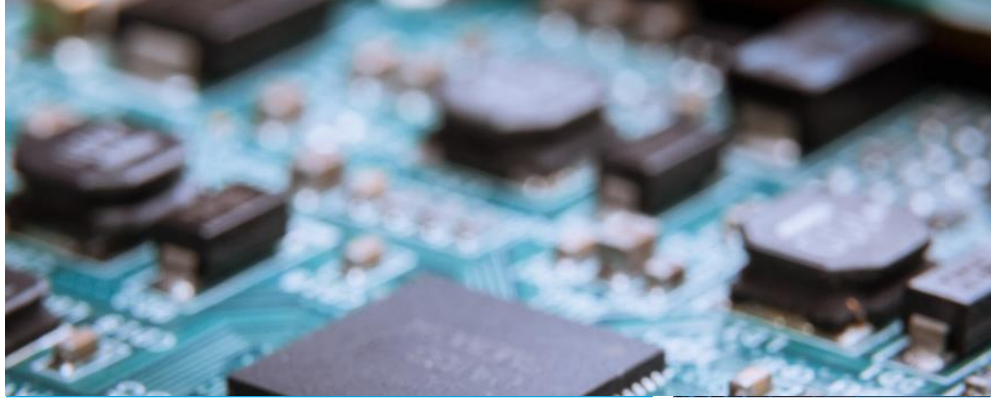

MLCC PRODUCT GRADES

From Commercial to Space Applications

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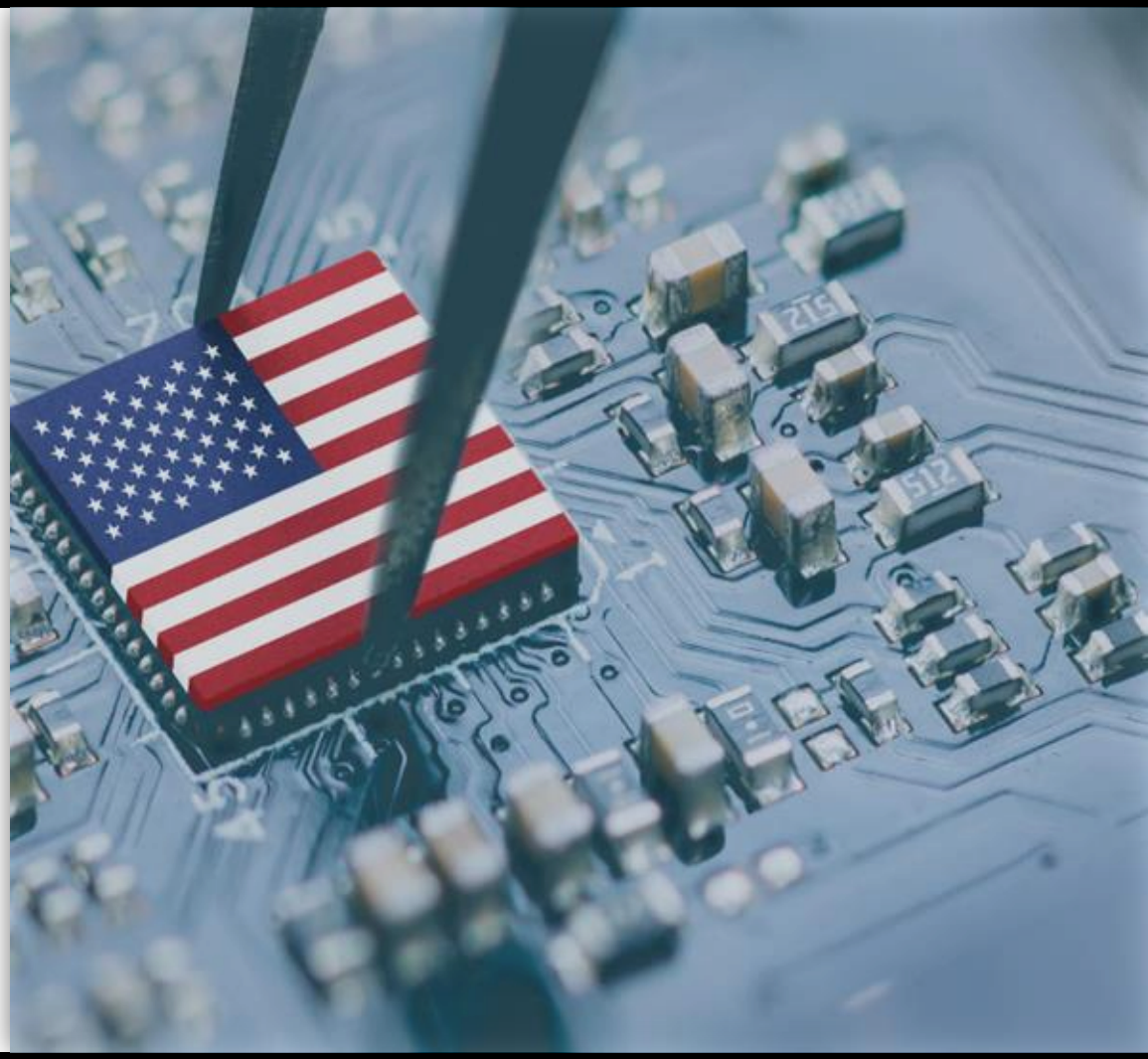
MLCC PRODUCT GRADES

From Commercial to Space Applications

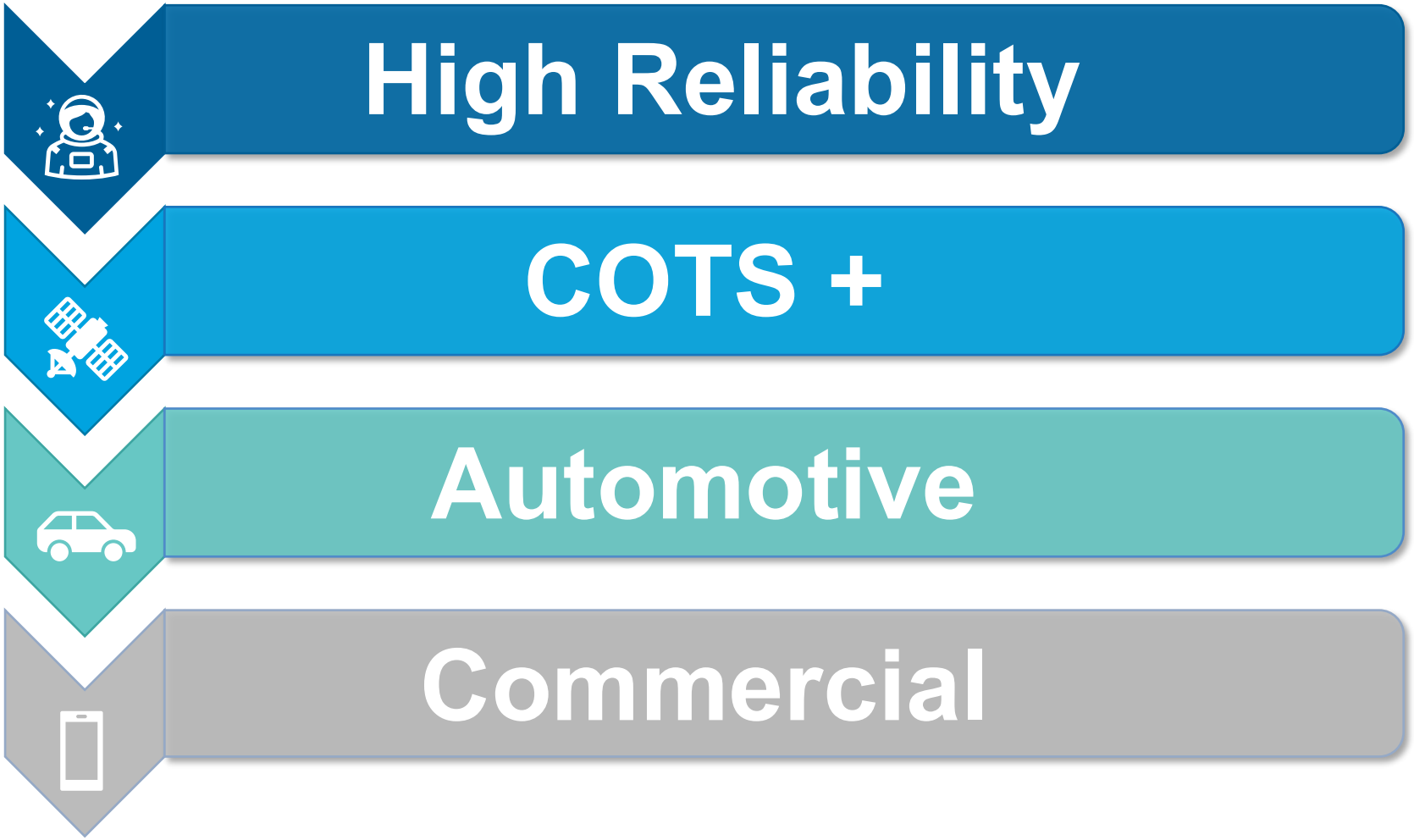
Agenda

- Product Grade Classification
- Product Grade Overviews
- MLCC Fundamentals



MLCC PRODUCT GRADES

From Commercial to Space Applications



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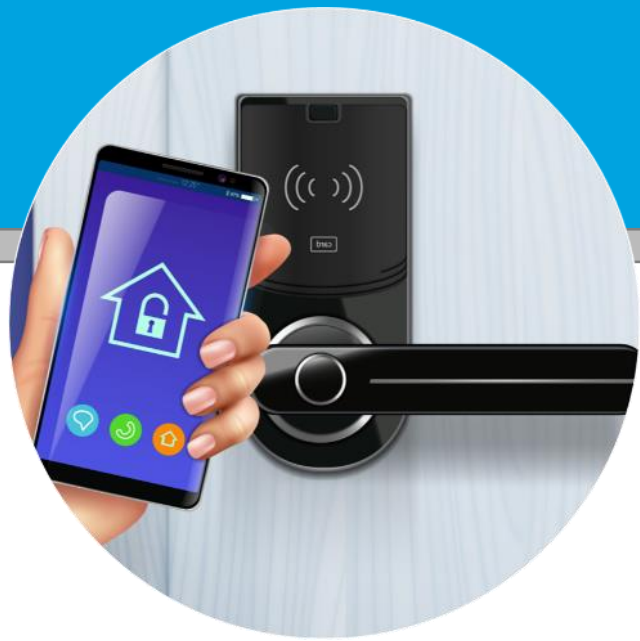
Commercial Grade

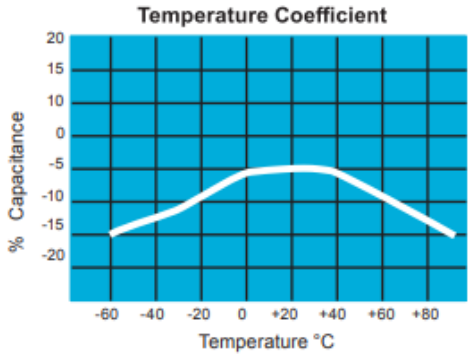


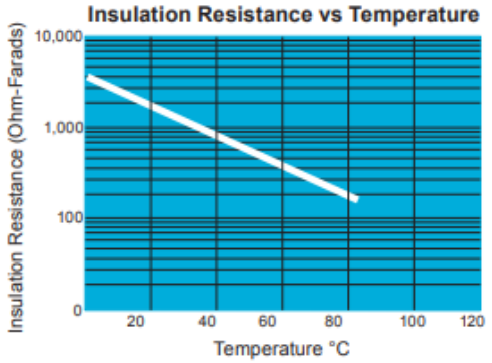
- **Typical Standard**: Manufacturer Specified
  - Only meets minimum requirements (TCC, RV, etc) lot-to-lot

- **Overview**
  - Designed for consumer and industrial applications
  - Generally small sizes & Lower Voltage
  - Manufactured and Subcontracted Sources
  - **Limited level of Change Control**
  - Development focused on very high CV

- **Typical Screening:**
  - Capacitance & DF
  - Voltage
  - Insulation Resistance
  - Visual Inspection

Example of Typical X5R





MLCC PRODUCT GRADES

Automotive Grade

- **Typical Standard**: AEC-Q200

- **Overview**
  - Designed for Automotive Applications
  - 2220 and Smaller Case Sizes
  - Similar CV range to Commercial Grade
  - **Medium level of Change Control**
  - Emphasis on Reliability (AECQ-200 Qualified)
  - Production Part Approval Process (PPAP)

- **Typical Screening**
  - Capacitance & DF
  - Voltage
  - Insulation Resistance
  - Visual Inspection

AEC-Q200 Grade	Ambient Operating Temperature Range
0	-40°C to +150°C
1	-40 to +125 °C
2	-40 to +105 °C
3	-40 to +85 °C
4	0 to +70°C

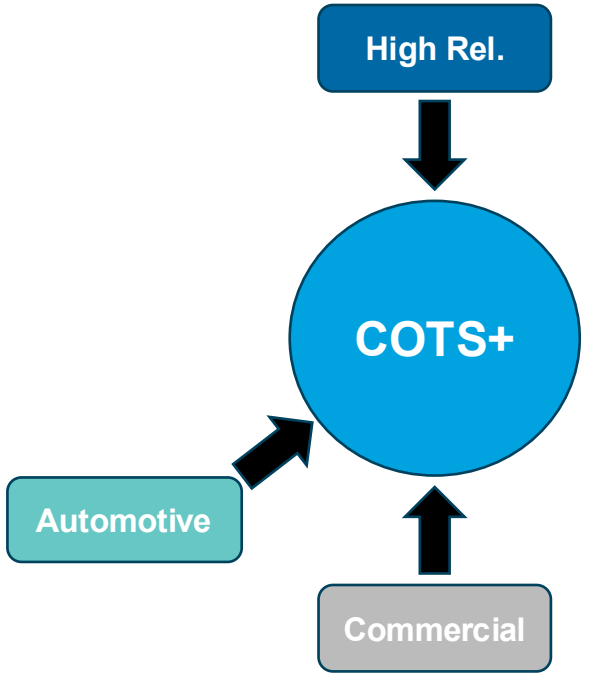
MLCC PRODUCT GRADES

COTS+ Grade

- **Typical Standard:** Manufacturer determined
  - *'Up-screened' Auto/Commercial*
  - *'Down-screened' High Reliability*

- **Overview**
  - Established reliability applications
  - CV range similar to Auto or Military
  - Custom lot release testing
  - **Medium level of Change Control**
  - AECQ-200/Mil Tested

- **Typical Screening:**
  - Capacitance & DF
  - Voltage
  - Insulation Resistance
  - Voltage Conditioning (Burn-In)
  - Visual Inspection



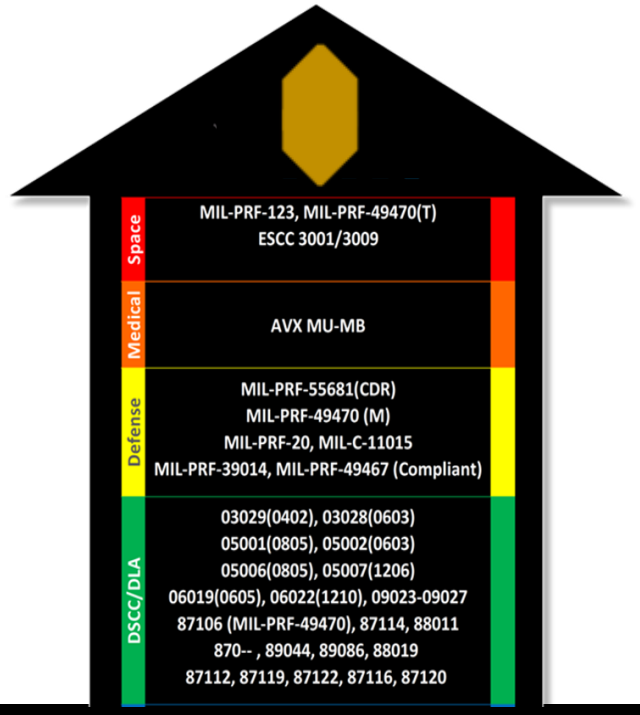
MLCC PRODUCT GRADES

High Reliability Grade

- **Typical Standard:** MIL Spec or Source-Controlled Drawing

- **Overview**
  - Designed for Highest Reliability Applications
  - Passes any applicable MIL, ESA, NASA qualifications (up to 4,000-hour life test)
  - Smaller Range than Automotive (but expanding)
  - Each lot: Life Testing and Burn-In
  - **High level of Change Control & <u>Traceability</u>**

- **Typical Screening:**
  - Capacitance & DF
  - Voltage
  - Insulation Resistance
  - Voltage Conditioning (Burn-In)
  - Thermal Shock
  - Ultrasonic Scan
  - Visual Inspection
  - +Additional Reliability Testing

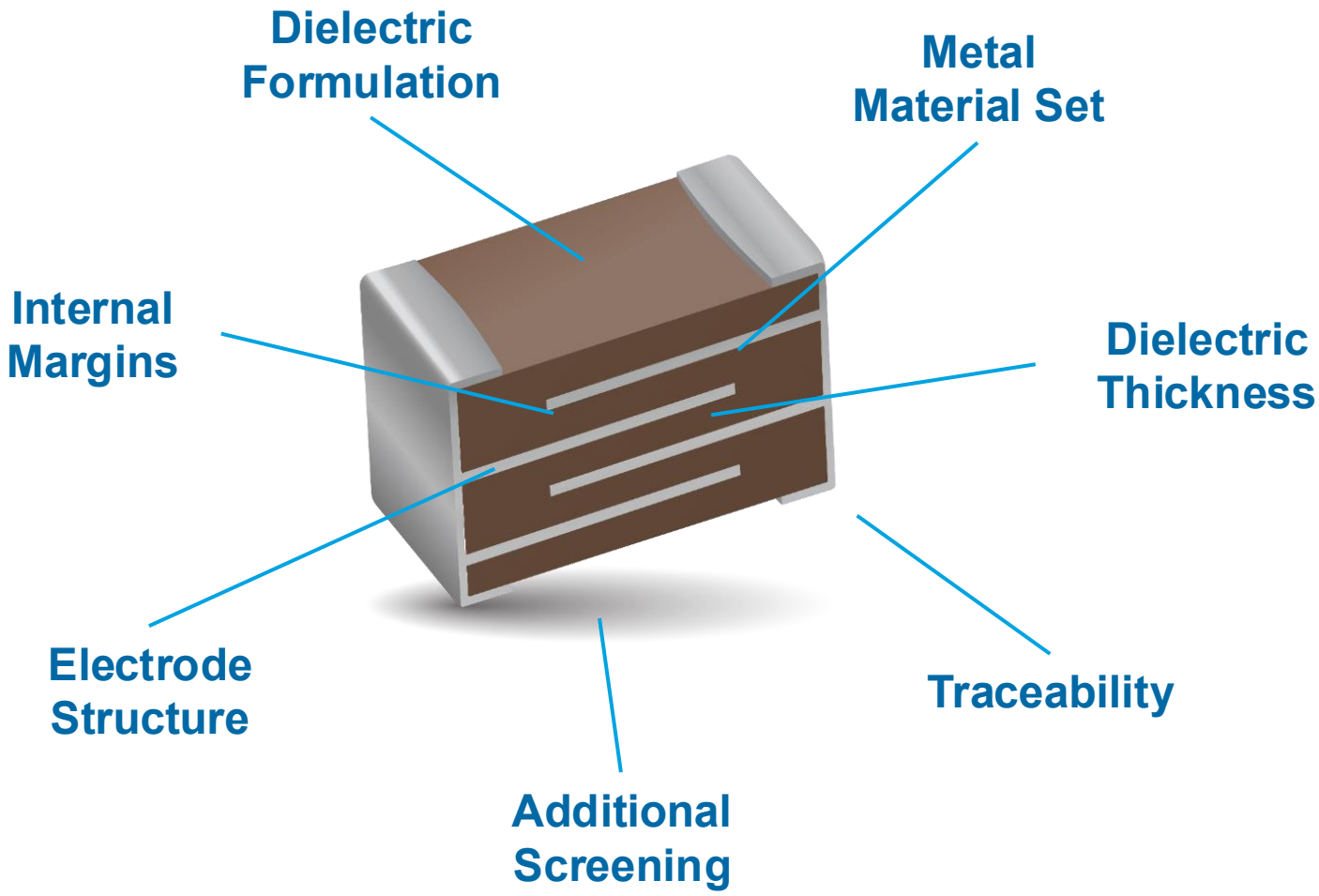


MLCC PRODUCT GRADES

What Determines Product Grade?

MLCC = Multilayer Ceramic Capacitor

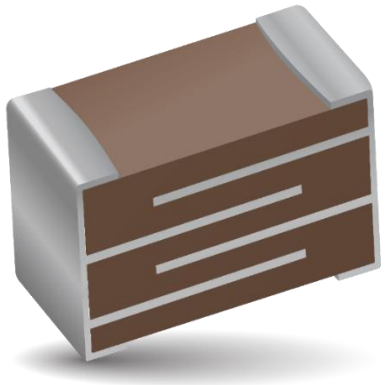
- ✓ Materials
- ✓ Internal Design
- ✓ Screening
- ✓ Documentation



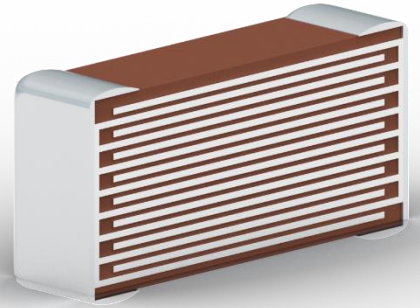
MLCC PRODUCT GRADES

Metal Material Set

Precious Metal Electrode (PME)



Base Metal Electrode (BME)

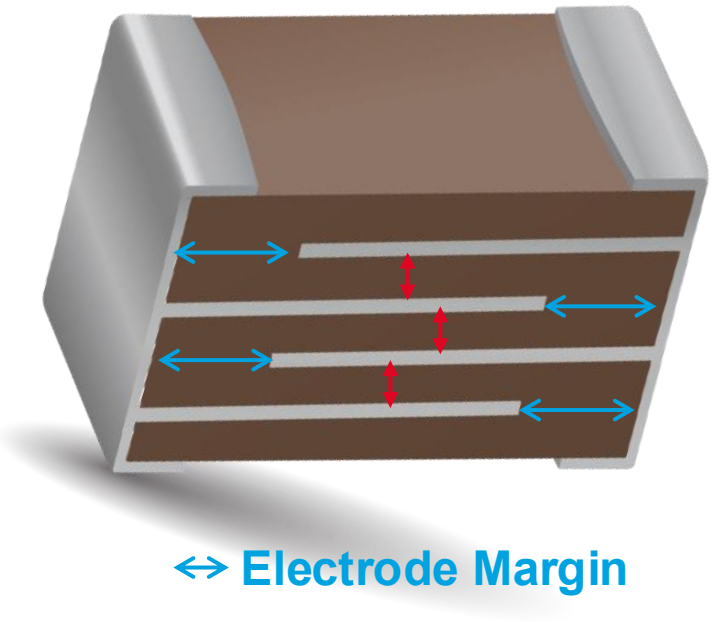


Parameter	PME	BME
Number of layers	Relatively Low, <100	Very High, ~1,000
End Margins	Relatively large	As thin as practical
Dielectric Thickness	Relatively thicker	Very Thin
Case Sizes	Non-Standard CC 1-6	EIA 0805, 1210, etc.

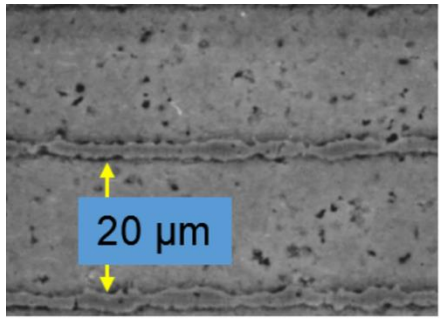
MLCC PRODUCT GRADES

Dielectric Thickness and Margins

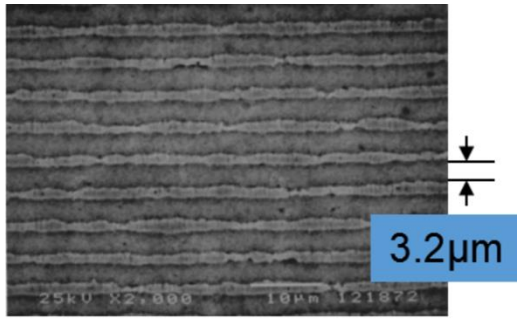
- Across similar dielectrics, the electrode margin and dielectric thickness of any given MLCC will have a direct impact on the reliability of a part.
- Generally, the higher the reliability, the more robust these internal dimensions will be.
- Which is why commercial grade products tend to have higher CV!



Some High Reliability MLCCs can have a dielectric thickness > 0.005" (~130 µm)



1206 X7R 0.1uF / 50V

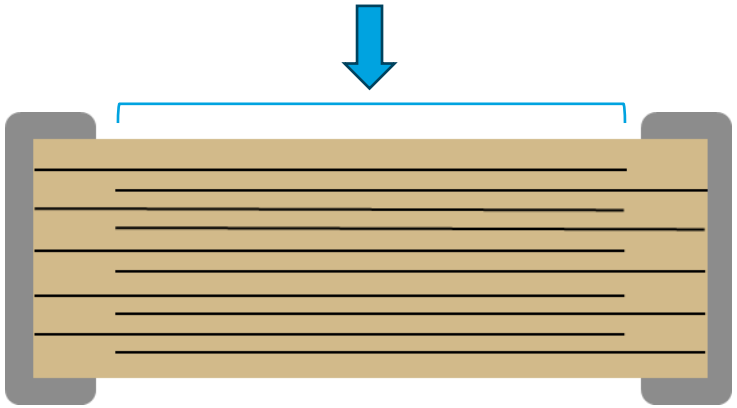


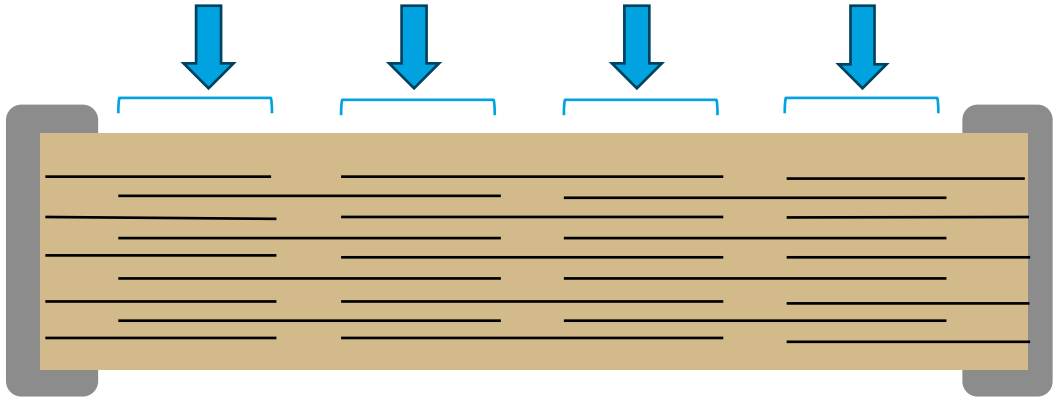
1210 X5R 100uF / 6.3V

MLCC PRODUCT GRADES

Internal Electrode Structure

- The internal electrode structure can be adjusted to account for higher voltages and general reliability concerns.
- By adjusting the single, continuous electrode, into a cascade or "**floating electrode**" design each of those sections acts effectively as a capacitor in series
- This allows for **higher voltage** ratings and even may allow the chip to **fail as an open instead of short**.

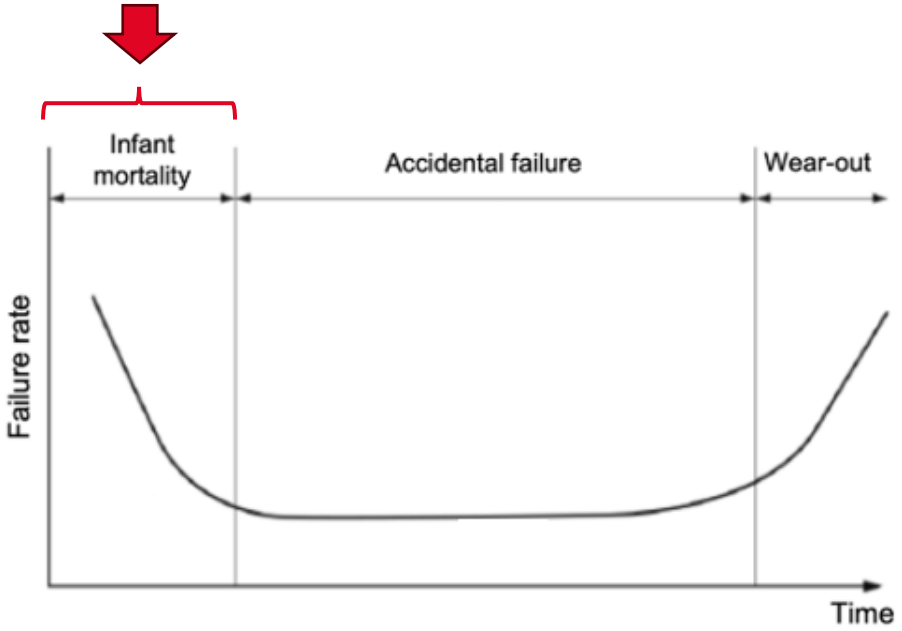




MLCC PRODUCT GRADES

Additional Screening

- Generally, all MLCCs will get the following screening:
  - Capacitance & Dissipation Factor (DF)
  - Voltage
  - Insulation Resistance
  - Visual Inspection
- Additional screening/testing is added to MLCCs either by the manufacturer or 3rd parties to help reduce the **infant morality rate** during operating life
- Some examples include
  - High Temperature Insulation Resistance (HTIR)
  - Voltage Conditioning (Burn-In)
  - Thermal Shock
  - Ultrasonic Scan
  - *Temperature and Humidity Bias (THB)
  - *Life Test
  - *And Much More…*



*Tests are not 100% of the lot

MLCC PRODUCT GRADES

From Commercial to Space Applications

		Commercial	Automotive	COTS+	High Reliability
	Primary Specification	Manufacturer's	AEC-Q200	Variable	MIL-PRF, DLA DSCC, etc.
	Design / Construction	Standard	Standard	Standard/Robust	Robust
	MFG Site (by part)	Multiple	1 – 2	1 – 2	1
IN-PROCESS	100% Cap Test	✓	✓	✓	✓
	100% DWV (Volt) Test	✓	✓	✓	✓
	100% IR Test	✓	✓	✓	✓
	100% Visual Inspection	✓	✓	✓	✓
	Ultrasonic Scan			*Optional*	✓
	Thermal Shock / Cycle			*Optional*	✓
	Voltage Conditioning (125°C)		*Optional*	✓	✓
	Hot IR (125°C)			*Optional*	✓
	Dielectric Voltage Breakdown				✓
	PCN Required		✓	✓	✓
	Documentation Retention		✓	*Variable*	✓

* table can vary depending on the manufacturer/series

THANK YOU.