

Yageo MLCC Introduction

MLCC PM Team

Oct. 2011

Introduction

Purpose

- To give overview of multilayer ceramic capacitors (MLCC)

Objectives

- To understand the theory and construction of MLCC
- To explain different MLCC types
- To describe current technology trends

Content

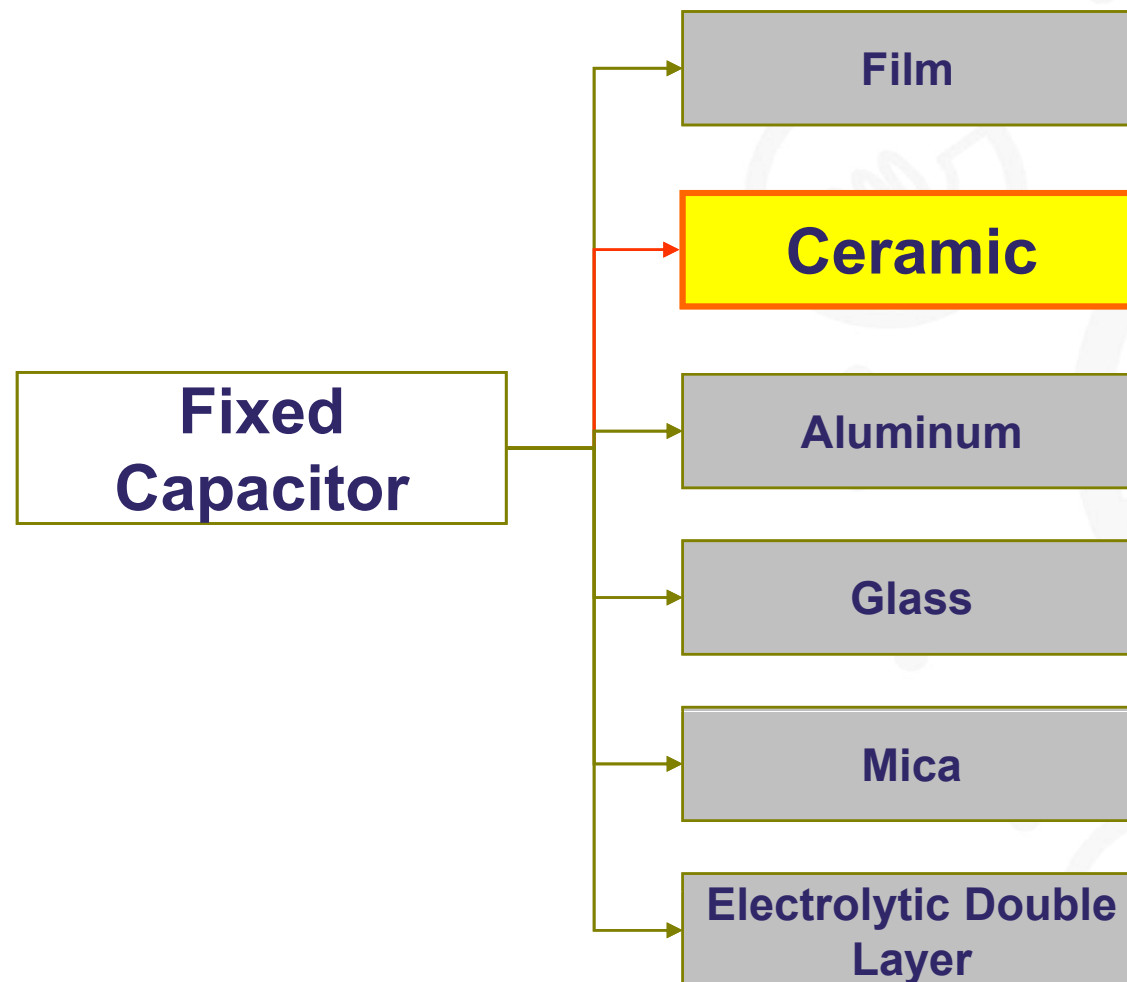
- 22 pages

Learning Time

- 10 minutes

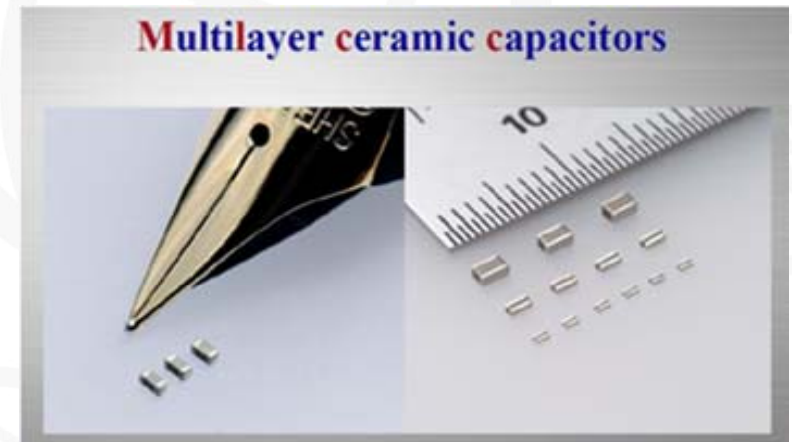
General Introduction of MLCC

Type of Capacitor



YAGEO product

Using Ceramic as the dielectric , metal baked with ceramic as inner electrodes , non-polarized and non-organic capacitors



General Introduction of MLCC

MLCC Features



- Wide capacitance range, extremely compact size
- Low inductance of capacitor for high frequency application
- Excellent solderability and resistance to soldering heat, suitable for wave and reflow soldering
- Adaptable to high-speed surface mount assembly

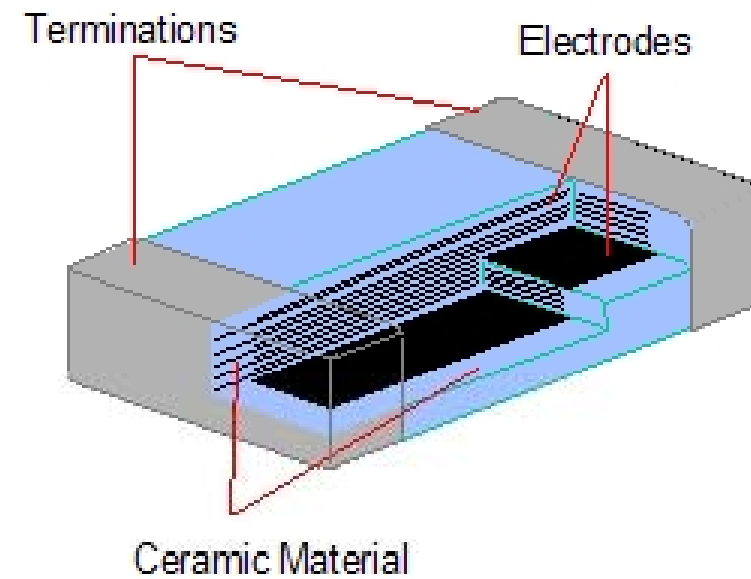
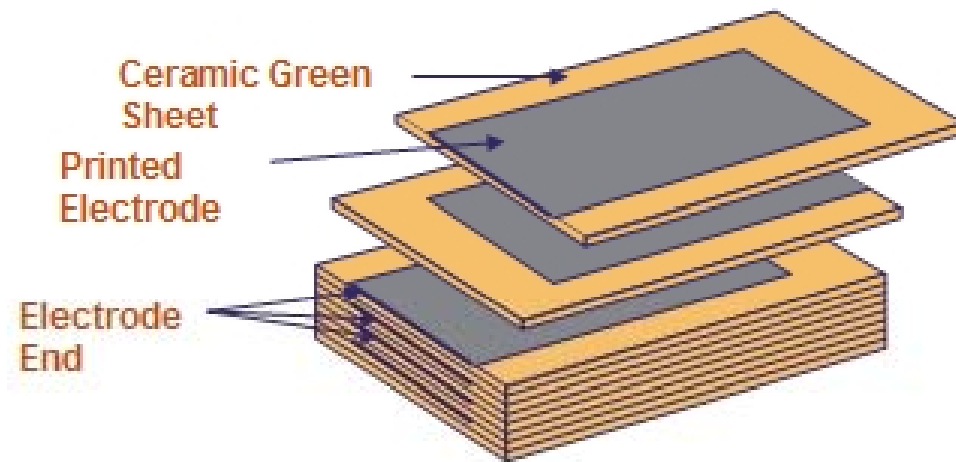
Unit of Capacitance

Microfarad (μF) $1\mu\text{F} = 1/1,000,000 = 0.000001 = 10^{-6} \text{ F}$

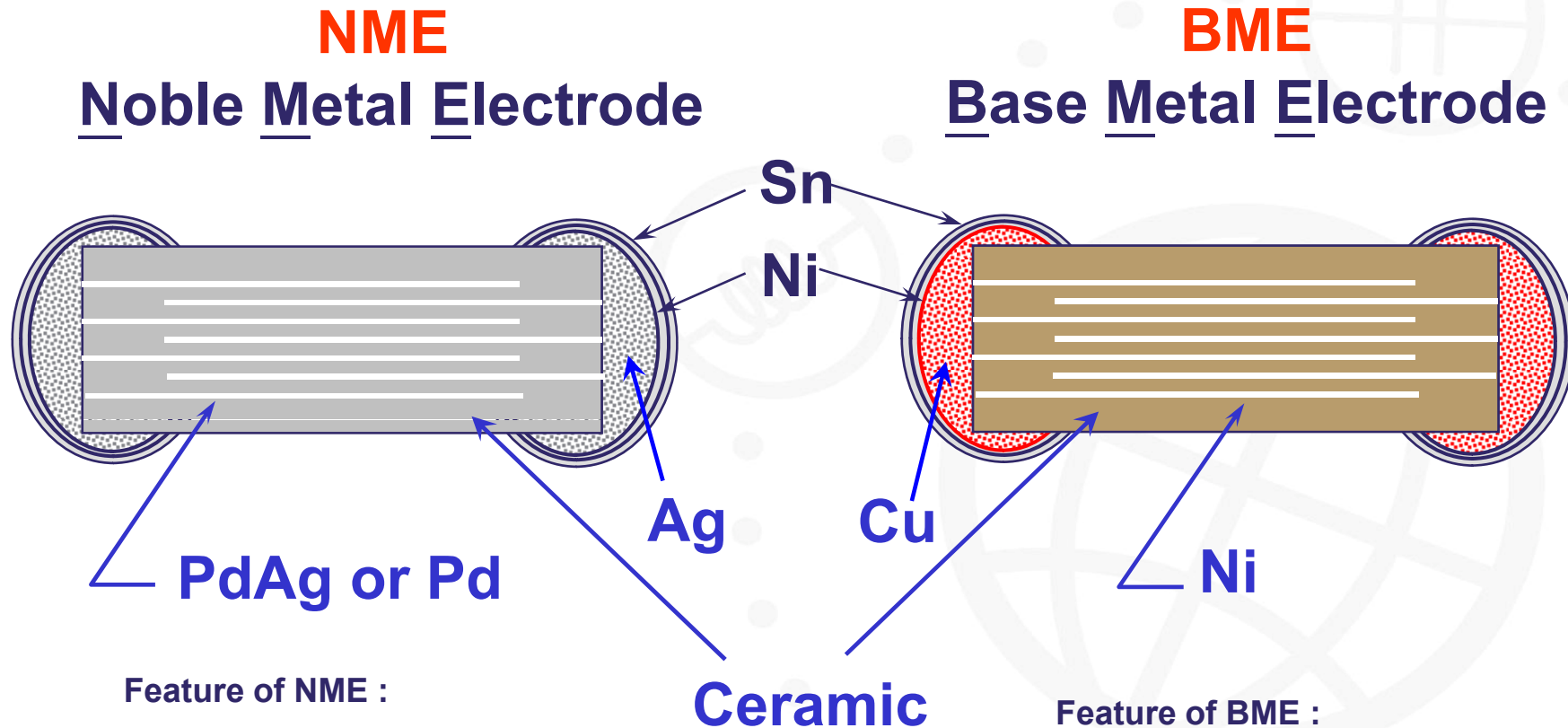
Nanofarad (nF) $1\text{nF} = 1/1,000,000,000 = 0.000000001 = 10^{-9} \text{ F}$

Picofarad (pF) $1\text{pF} = 1/1,000,000,000,000 = 0.000000000001 = 10^{-12} \text{ F}$

Construction of MLCC



MLCC Material and Construction



Feature of NME :

- * Process uncomplicated
- * Good Q factor

Fault of NME :

- * Cost expensive

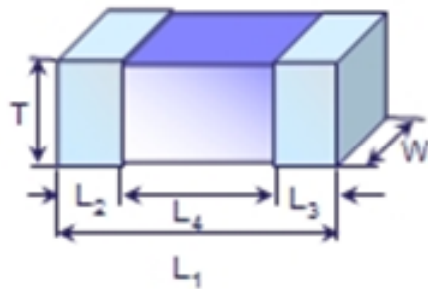
Feature of BME :

- * Cost cheaper than NME

Fault of BME :

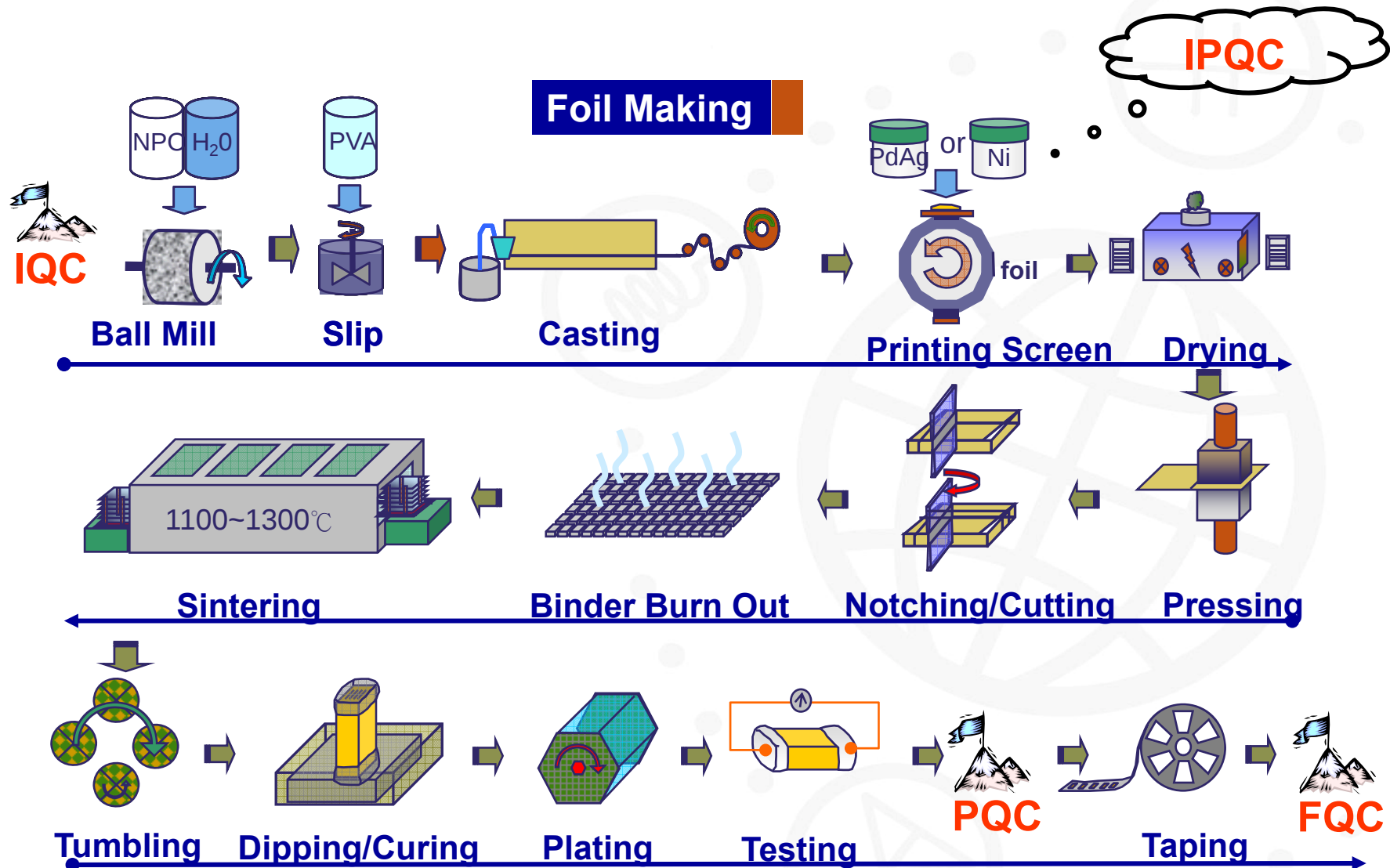
- * Equipment expensive.
- * Process complicated.

Construction – Dimensions of MLCC

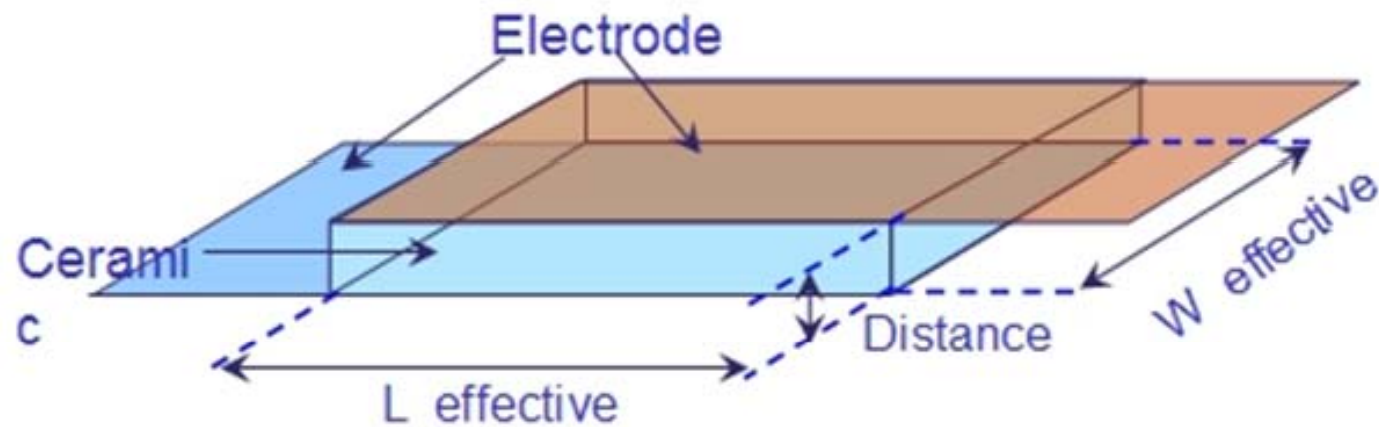


Size	L ₁	W	W		L ₂ and L ₃		L ₄
			Min	Max	Min	Max	Min
Dimensions in millimeters							
0201	0.5±0.03	0.3±0.03	0.27	0.33	0.120	0.20	0.20
0402	1.0±0.05	0.5±0.05	0.45	0.55	0.20	0.30	0.40
0603	1.6±0.10	0.8±0.07	0.73	0.87	0.25	0.65	0.40
0805	2.0±0.10	1.25±0.10	0.50	1.35	0.25	0.75	0.55
1206	3.2±0.15	1.6±0.15	0.50	1.75	0.25	0.75	1.40
1210	3.2±0.20	2.5±0.20	0.50	1.80	0.25	0.75	1.40
1812	4.5±0.20	3.2±0.20	0.50	1.80	0.25	0.75	2.20
Dimensions in inches							
0201	0.024±0.001	0.012±0.001	0.011	0.013	0.004	0.008	0.008
0402	0.040±0.002	0.020±0.002	0.018	0.022	0.008	0.012	0.016
0603	0.063±0.004	0.032±0.003	0.029	0.035	0.010	0.026	0.016
0805	0.079±0.004	0.049±0.004	0.020	0.053	0.010	0.030	0.022
1206	0.126±0.006	0.063±0.006	0.020	0.069	0.010	0.030	0.056
1210	0.126±0.006	0.098±0.008	0.020	0.072	0.010	0.030	0.056
1812	0.177±0.008	0.126±0.008	0.020	0.072	0.010	0.030	0.088

MLCC Process Flow



Capacitor Design



$$\text{Capacitance} = e e_0 \frac{A \times (N-1)}{D}$$

Unit : F (farad, from Faraday)

e = Permittivity of ceramic

$e_0 = 8.8419 \times 10^{-12}$ F/m

A = Area, ($L_{\text{eff}} \times W_{\text{eff}}$)

N = Number of electrode

D = Distance of electrode

Symbols of Temperature Coefficients (EIA)

Class I

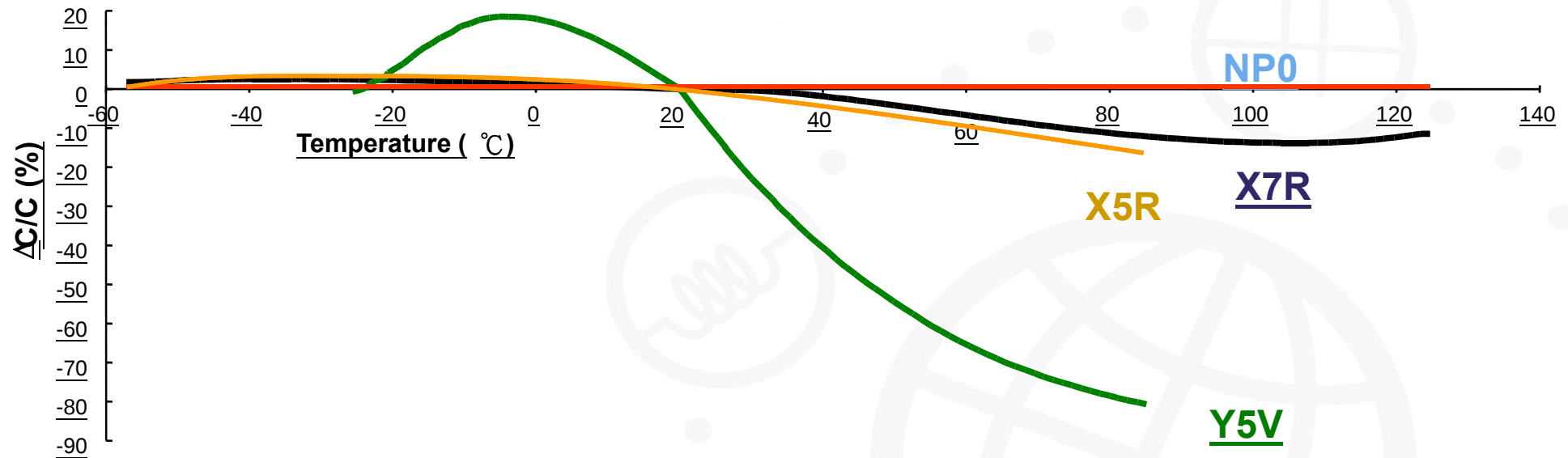
Significant figure of temp. coeff. of cap. (ppm/°C)	Symbol	Multiplier applied to significant figure	Symbol	Tolerance of temp. coeff. (ppm)	Symbol
0	C	-1	0	±30	G
0.3	B	-10	1	±60	H
0.8	L	-100	2	±120	J
0.9	A	-1000	3	±250	K
1.0	M	-10000	4	±500	L
1.5	P	1	5	±1000	M
2.2	R	10	6	±2500	N
3.3	S	100	7		
4.7	T	1000	8		
5.6	V	10000	9		
7.5	U				

Symbols of Temperature Coefficients (EIA)

Class II

Low temp. (°C)	Symbol	High temp. (°C)	Symbol	Max. Cap. change over temp. range (%)	Symbol
+10	Z	+45	2	±1.0	A
-30	Y	+65	4	±1.5	B
-55	X	+85	5	±2.2	C
		+105	6	±3.3	D
		+125	7	±4.7	E
		+150	8	±7.5	F
		+200	9	±10	P
				±15	R
				±22	S
				+22 to -33	T
				+22 to -56	U
				+22 to -82	V

Temperature Characteristics vs Ceramic Material



Type	NP0(COG)	X7R	X5R	Y5V
Class	1	2	2	2
Temperature range	-55~+125°C	-55~+125°C	-55~+85°C	-25~+85°C
Cap change	± 30ppm/°C	±15%	±15%	-82~+22%
Features	1. Ultra-stable 2. Tight tolerance available. 3. Low ESR. 4. Good frequency performance. 5. No aging of capacitance.	1. Semi-stable and high K. 2. High volumetric efficiency. 3. High reliable in high temperature application. 4. High insulation resistance.		1. High volumetric efficiency. 2. Non-polar construction. 3. General purpose, High K.

MLCC Type Introduction – NP0 (C0G)

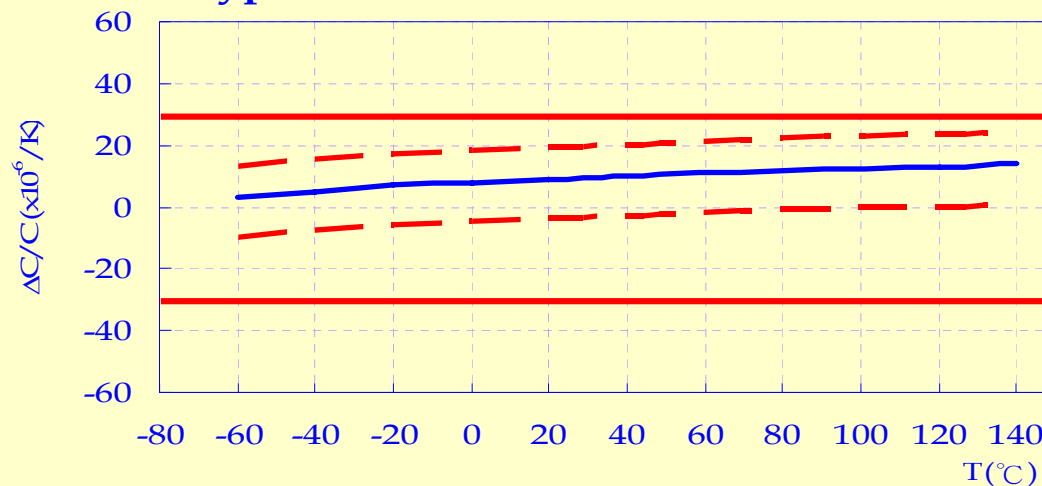
Description

- **Classification : Class 1**
- **Characteristic: Temperature Compensation**
- **Application temperature: -55°C ~ +125°C**
- **Temperature characteristic: $\pm 30\text{ppm}/^\circ\text{C}$**

Features

- ✓ **Ultra-stable on capacitance**
- ✓ **Tight tolerance available**
- ✓ **Low ESR**
- ✓ **Good frequency performance**
- ✓ **No aging of capacitance**

Typical TC Curve of NPO Deilectrics



Recommended Circuit

- **Band Pass Filter Circuit**
- **Coupling Circuit**
- **Temp. Compensation Circuit**

MLCC Type Introduction – X7R, X5R

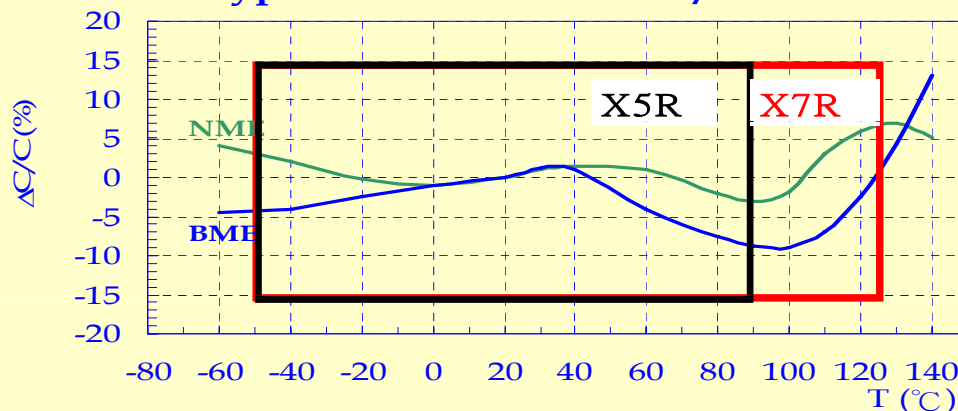
Description

- Classification : Class 2
- Characteristic: High dielectric constant
- Application temperature:
X7R : -55°C ~ +125°C
X5R : -55°C ~ +85°C
- Temperature characteristic: $\pm 15\%$

Features

- ✓ Semi-stable on capacitance and high K
- ✓ High volumetric efficiency
- ✓ High reliable in high temperature application
- ✓ High insulation resistance

Typical TC Curve of X7R/X5R Deilectrics



Recommended Circuit

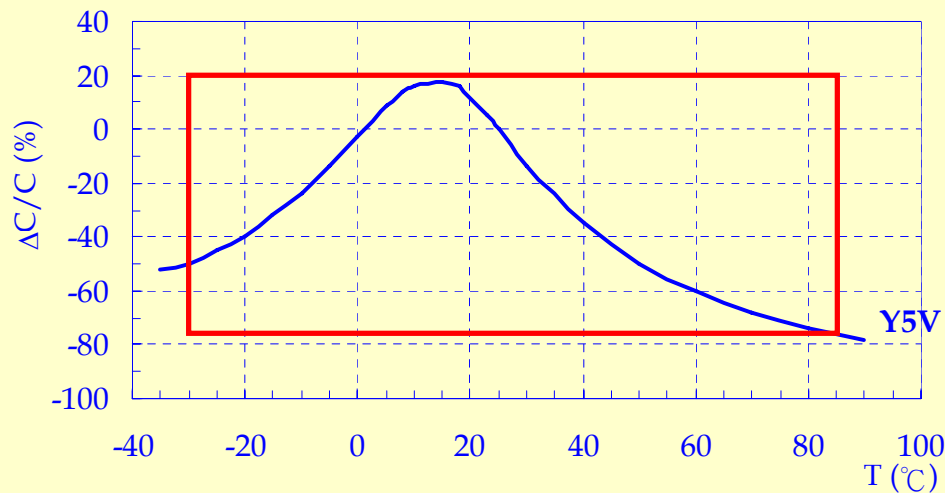
- By-Pass Circuit
- Decoupling Circuit
- Resonance Circuit

MLCC Type Introduction – Y5V

Description

- **Classification : Class 2**
- **Characteristic: High dielectric constant**
- **Application temperature: $-30^{\circ}\text{C} \sim +85^{\circ}\text{C}$**
- **Temperature characteristic: $-82\% \sim +22\%$**

Typical TC Curve of Y5V Deilectrics



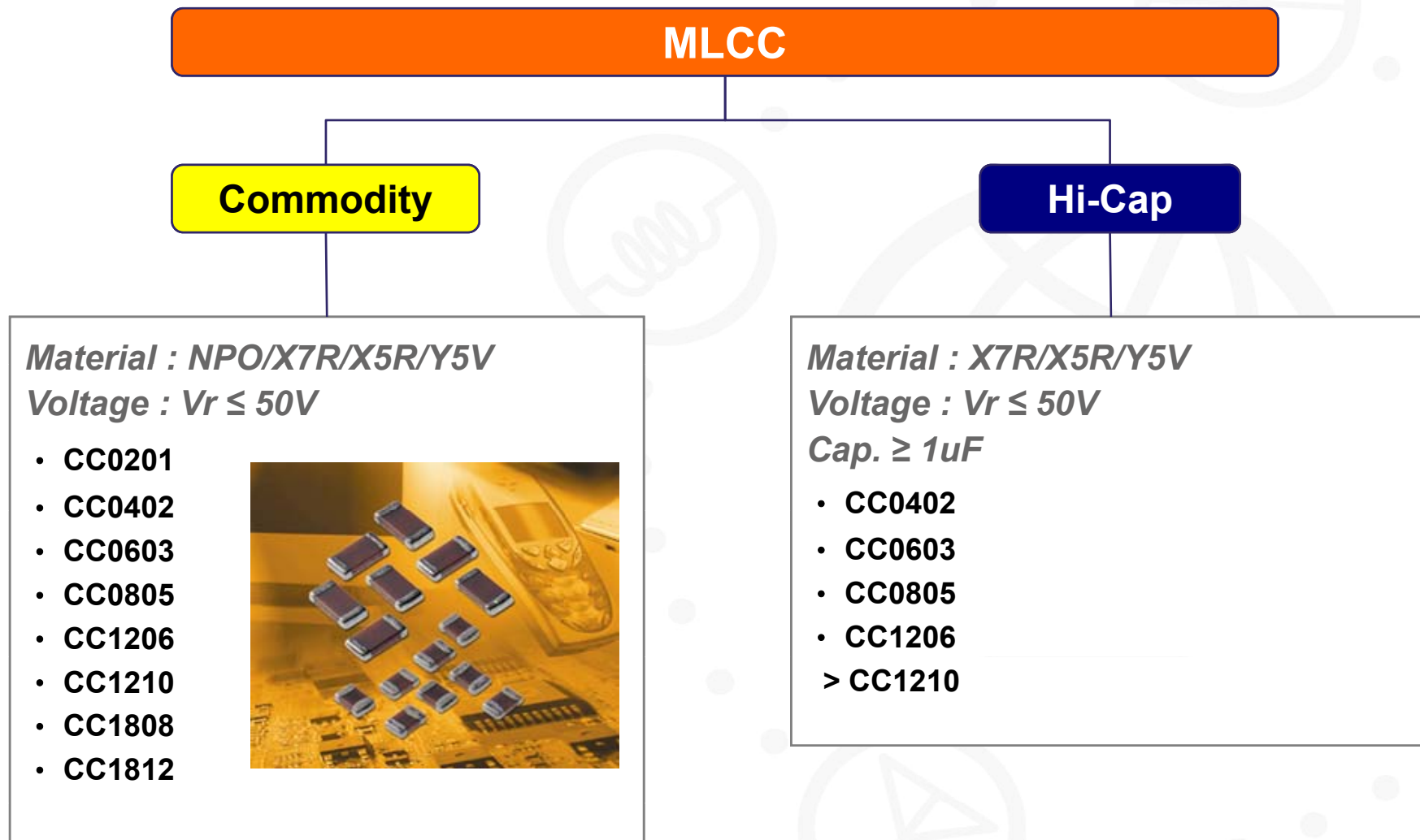
Features

- ✓ **High volumetric efficiency**
- ✓ **Non-polar construction**
- ✓ **General purpose, High K**

Recommended Circuit

- **By-Pass Circuit**
- **Decoupling Circuit**
- **Resonance Circuit**

Yageo MLCC Product Overview



Yageo MLCC Product Overview



Commodity & Hi Cap

Features

- Applicable for reflow / wave soldering
- High reliability and no polarity
- RoHS & Halogen free compliant
- Supplied in tape on reel

Definition

- Capacitance 0.22pF to 100uF
- Voltage : 6.3V,10V,16V,25V,50V

Product description

- Material : NPO,X7R,X5R,Y5V
- Size : 0201~1812

Applications

- General electronic equipment



Specialty - HV Series

Features

- Capable of operating at high voltage levels
- For high frequency snubber
- Decoupling/ Smoothing function

Definition

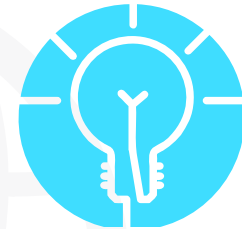
- Capacitance : 0.47pF ~ 1uF
- Voltage : 100V ~ 3KV

Product description

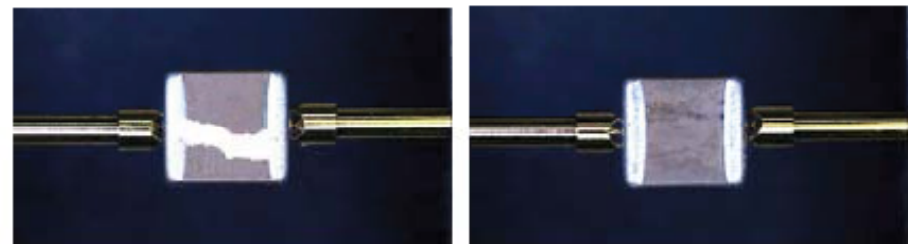
- Material : NPO/X7R
- Size : 0402~0603

Applications

- Lighting
- Power
- LCD
- Digital Consumer



Arcing in high voltage operation



Typical surface arcing on MLCC's between termination-to-termination (show in polarized lighting)

Specialty – Soft termination

Features

- Flexible termination system
- Leaded-free termination meet
- Improved resistance to thermal stresses
- Increased mechanical performance

Definition

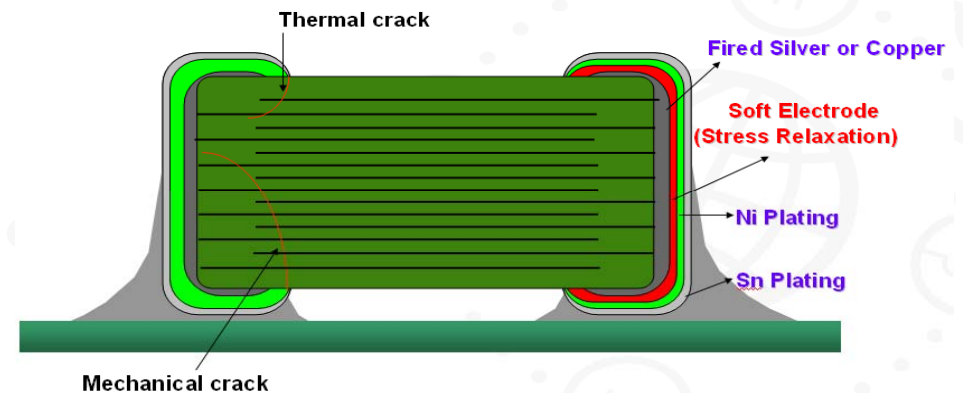
- Capacitance : 100pF – 1uF
- Voltage : 16V~630V

Product description

- Material : X7R
- Size : 0402~1206

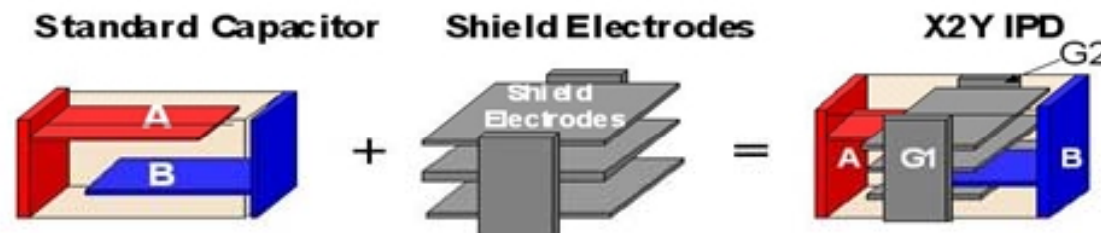
Applications

- High flexure stress circuit boards
- Switch power supplies
- Telecom base station



X2Y - Series

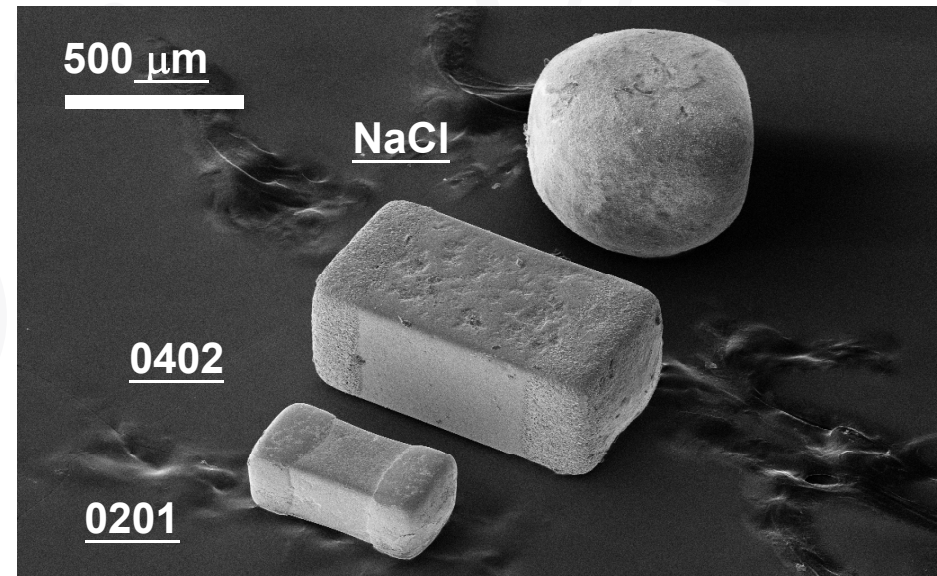
X2Y® Technology takes the standard two-plate multi-layer capacitor technology and inserts three electrodes which surround each plate. The three new electrode plates are then commonly terminated to the sides of the component forming a new type of four terminal device.



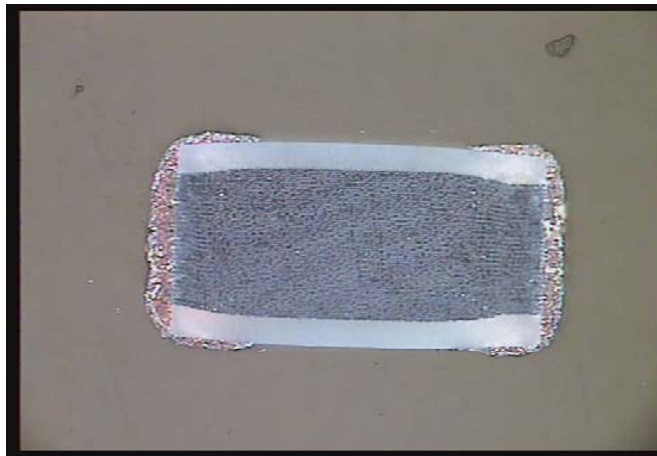
X2Y Technology takes the standard two-plate MLCC and inserts three electrodes surrounding each plate. The three new electrode plates are then commonly terminated to the sides of the component forming a new type of four terminal device. The X2Y series has advantages in filtering and decoupling circuits compared to similar devices. In filtering, X2Y can meet EMI specs with a single component solution and can filter over a broad frequency range. In decoupling, X2Y can provide high speed decoupling with low inductance to reduce the overall number of components.

01005 MLCC Technology Development

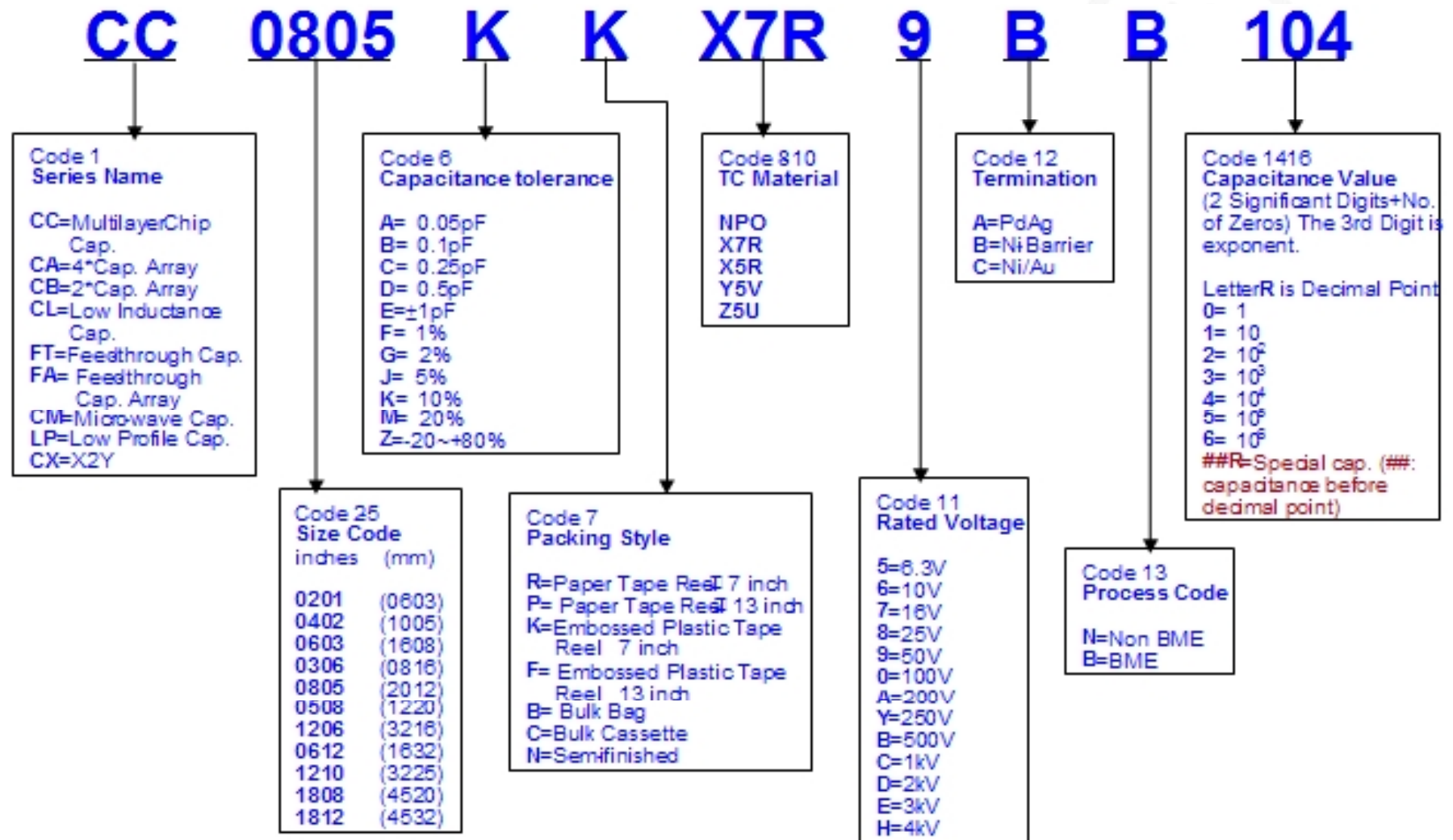
Human Hair and 01005 MLCC



The 01005 size MLCC is 1/3 the bulk of 0201 and Takes up 1/15 the space required for a 0402 MLCC



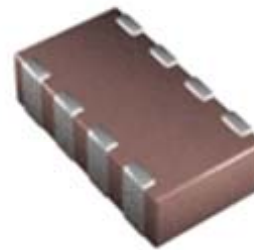
Coding Rule of CTC for Yageo MLCC



This illustration shows the coding rules of clear test code (CTC) in the Yageo MLCC market. It outlines how a Yageo part number is defined and shows the part number to component value conversion.

Summary

- Yageo offers many types of capacitors including high voltage X2Y, low inductance, and ultra small size MLCC
- Class I and II capacitors differ in many ways including accuracy, efficiency and temperature
- Yageo's miniaturization is leading to higher, thinner, smaller, shorter designs



In summary, Yageo has been releasing quality, technologically advanced , multi-layer ceramic capacitors and have many products for the future. They offer many types of capacitance including high voltage, X2Y, low inductance, and ultra small MLCC . Class I, II capacitance differ in many ways including accuracy, efficiency and temperature. Lastly, Yageo's miniaturization is leading to higher, thinner, smaller, shorter designs

Innovative Service Around the Globe **YAGEO**

Thank you