Film Capacitor

Version 8 June 22, 2007

Rubycon Corporation
Rubycon Electronics Inc.
Technical Group

1. Principle and Basic Theory of Capacitor

・What is the Capacitor?

When voltage is applied between facing conductors, the insulator (or space) sandwiched between them will cause dielectric polarization by electrostatic induction, thus leading to the accumulation of electric charges (charging). The capacitor is a device (part) that performs this charging and discharging of accumulated charges as its function.

・Electrostatic capacity and energy

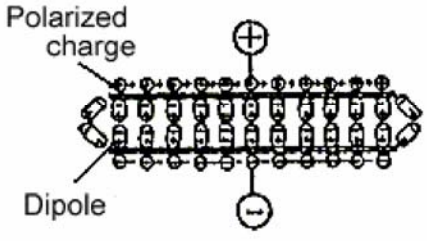
$$C = \varepsilon_0 \varepsilon_s \frac{S}{d}$$

$$Q = C \times E$$

$$W = \frac{1}{2} C \times E^2$$

- C : Electrostatic capacity (F)
- ε_0 : Permittivity in vacuum 8.8554×10^{-12} (F/m)
- ε_s : Relative permittivity
- S : Effective electrode area (m^2)
- d : Distance between electrodes (m)
- Q : Charge (C)
- E : Voltage (V)
- W : Energy (J)

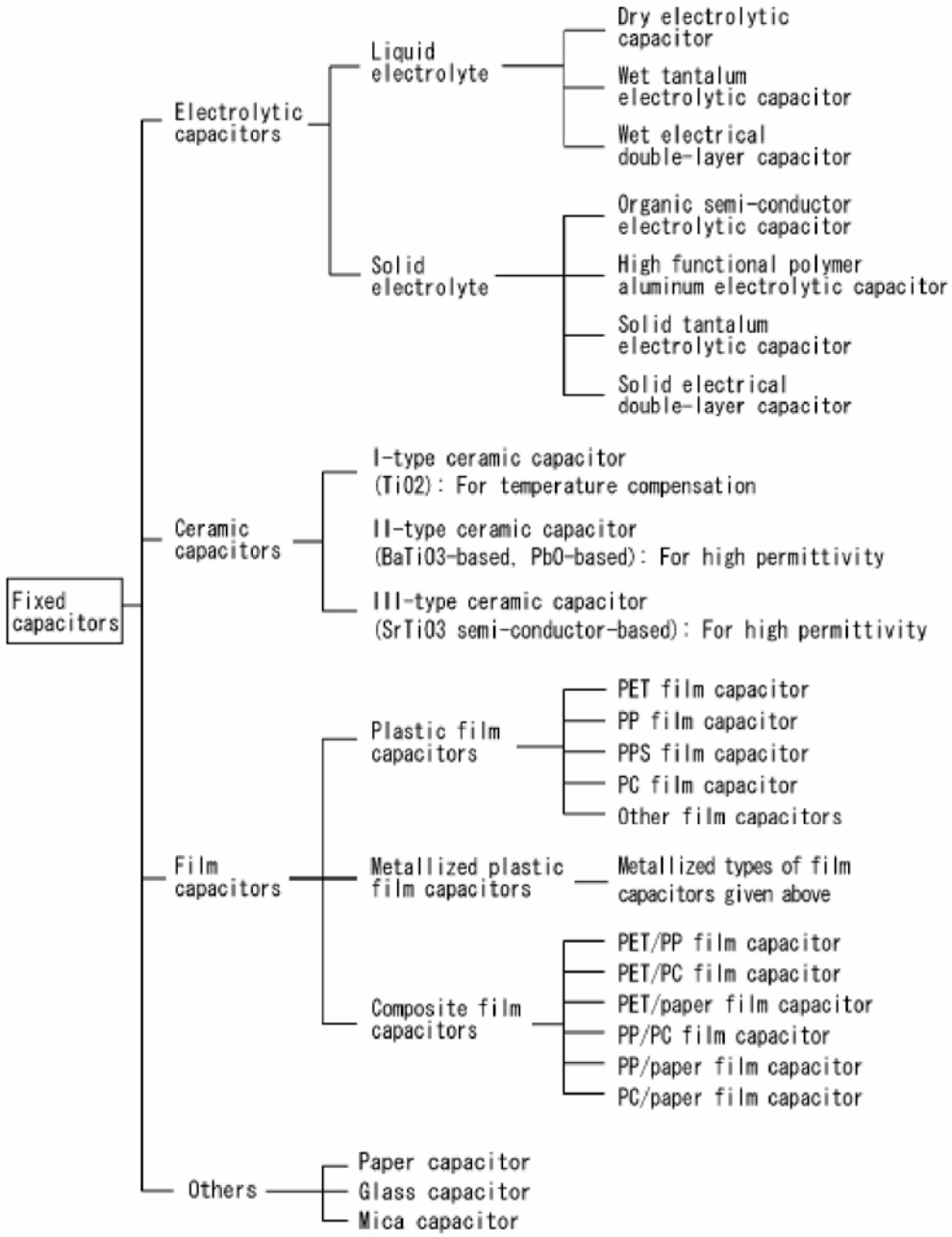
Fig. 1 Schematic of Polarization



Polarized charge Dipole

2. Kinds of (Fixed) Capacitors

・Fixed capacitors



・Comparison of characteristics among various kinds of capacitors (Summary)

Characteristics / Kinds	Miniaturization	Frequency characteristics	Temperature characteristics	High voltage	High capacity	Service life	Cost/capacity
Aluminum electrolytic	◎	×	×	○	◎	×	◎
Tantalum electrolytic	◎	○	○	○	○	○	○
Laminated ceramic	○	◎	×	○	○	◎	×
Film	×	◎	○	◎	○	◎	×
Organic semi-conductor	○	○	○	×	○	○	○
Functional polymer	○	◎	○	×	○	○	○

Superior←◎○×→Inferior

3. Kinds of film capacitors

・Classification by dielectrics

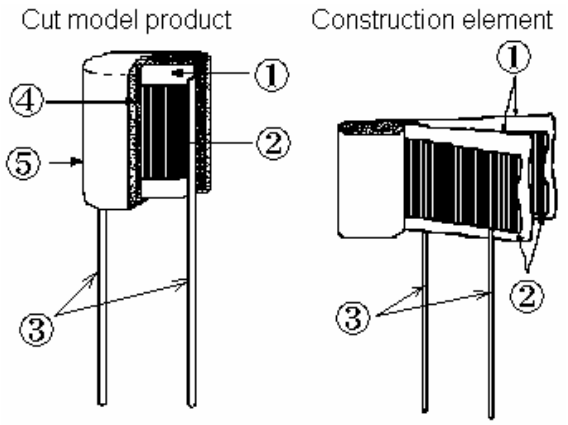
Description of dielectrics	Abbreviation	Remarks
Polyethylene phthalate	PET	Brand name “Miler” (Du-Pont) is famous.
Polypropylene	PP	—
Polyphenylene sulfide	PPS	—
Polyethylene naphthalate	PEN	—
Other	—	—

・Classification by electrodes

Kinds of electrodes	Material
Metal foil electrode	Aluminum, tin, copper, etc.
Evaporated electrode	Aluminum, zinc, etc.

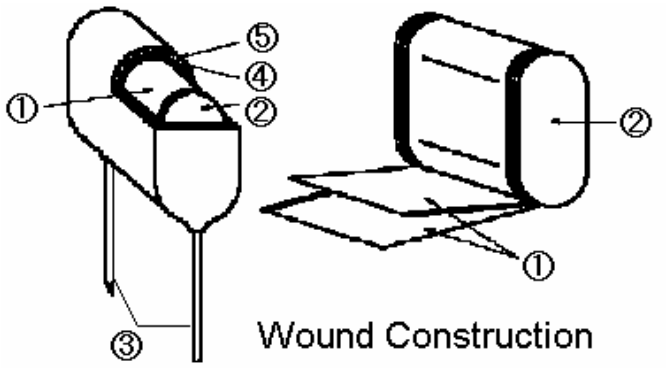
・Classification by element structures

1) Foil electrode tab structure



1. Dielectric film
2. Aluminum foil
3. Lead wire
4. Undercoating resin
5. Outer coating resin

2) Evaporated electrode extended foil structure



1. Metallized film
2. Metallicon
3. Lead wire
4. Undercoating resin
5. Outer coating resin

・Classification by armoring

Resin dipping
Tape wrapping resin sealing
Non-metallic case resin sealing
Metallic case hermetic sealing
Resin molding
Simple armoring (chips for surface mounting)

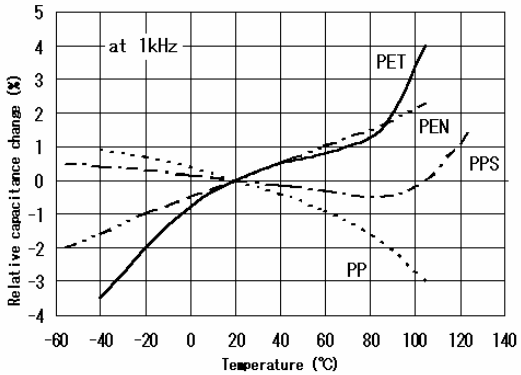
4. Characteristics and performance

・Physical properties of dielectric films

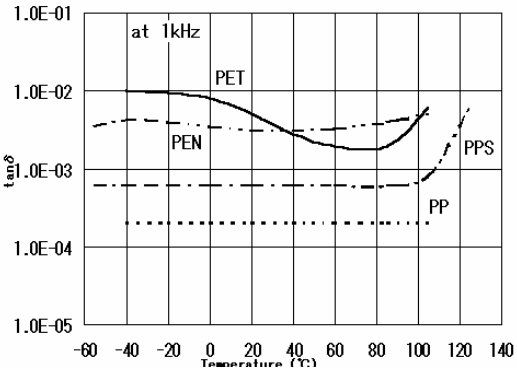
Characteristics	PET	PP	PPS	PEN
Thickness (μm)	1.0 - 25	3.0- 25	1.5 - 25	1.0 - 25
Maximum operating temperature(°C)	120 - 130	80 - 105	130 - 140	120 – 140
Permittivity (1kHz@20°C)	3.2	2.2	3.0	2.9
Dielectric loss tangent (1kHz@20°C)	0.003	0.0002	0.0006	0.004
Volume resistivity (Ωcm)	$>10^{18}$	$>10^{17}$	$>10^{17}$	$>10^{17}$
Coefficient of water absorption (%@75%RH)	0.4	<0.01	0.05	0.3
Glass transition point (°C)	69	0	92	121
AC breakdown voltage (kV/mm)	120 - 280	200 - 400	180	300

・Electrical characteristics

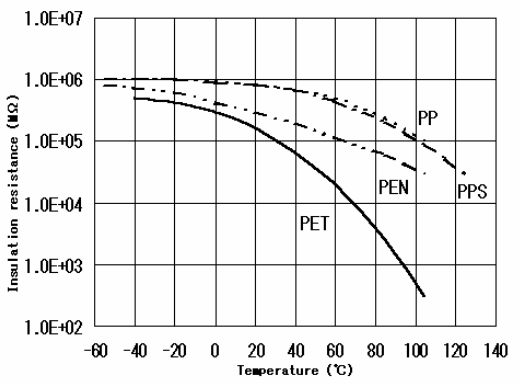
1) Electrostatic capacity-temperature characteristics



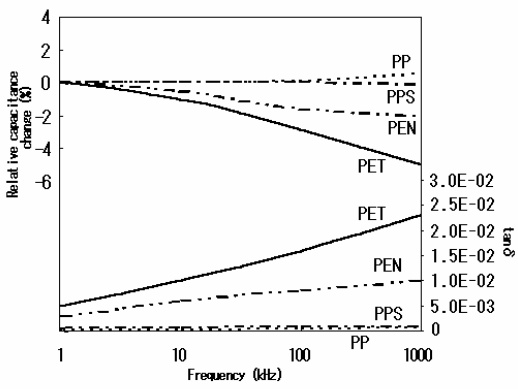
2) Dielectric loss tangent-temperature characteristics



3) Insulation resistance-temperature characteristics



4) Frequency characteristics



・Features of various kinds of films

Item	PET	PP	PPS	PEN
Cost	◎	○	×	○
Miniaturization	◎	△	○	◎
Heat resistance	○	○	◎	◎
Moisture resistance	△	◎	○	△
Solvent resistance	○	○	○	○
Temperature characteristics	△	○	◎	△
Low loss (low tan δ)	△	○	○	△