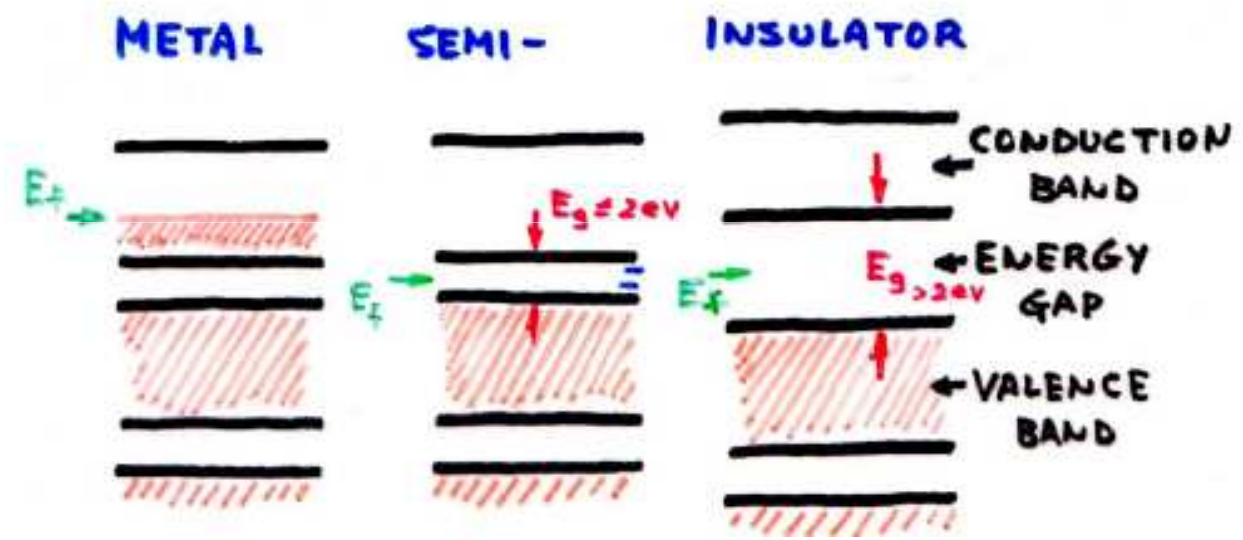
MATERIAL DIELEKTRIK

Dielektrik dapat dikelompokan pada bahan yang memiliki energi gap besar (resistivitas besar) sehingga termasuk bahan isolator.



Aplikasi

- Bahan isolator (stopping electricity)
- Kapasitor (Electricity storage)
- Sensor

Karakteristik Dielektrik

Klasik

- Permitivitas relatif ε_r

  Kemampuan polarisasi dan menyimpan energi

- Tangent of loss angle

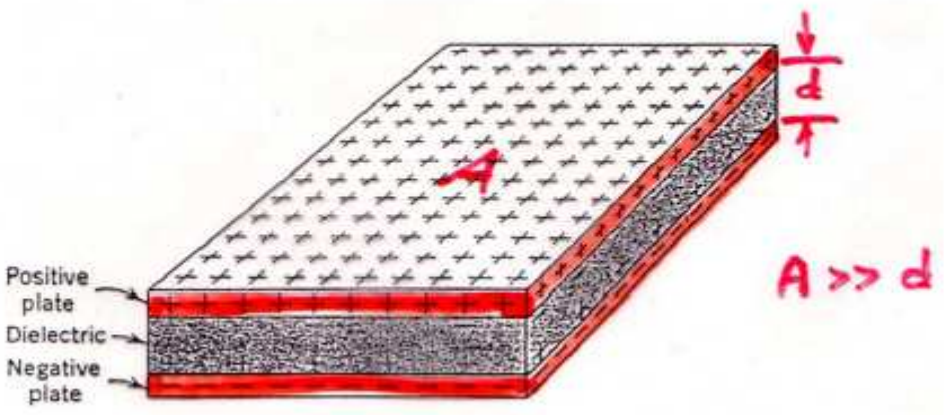
  Kehilangan energi (energy loss)

- Kekuatan dielektrik ξ_{maks}

  Kemampuan bertahan pada aplikasi tegangan tinggi

Karakteristik modern

1. *Electrostriction* – Electrical-mechanical property
2. *Piezoelectricity* – Mechanical-electrical property
3. Ferroelectricity – Polarisation/energy storage
4. *Pyroelectricity* – Thermo-mechanical-electrical property



C (capacitance) $\propto$ A

C $\propto$ 1/d

In vacuum:

C = ε_o(A/d)

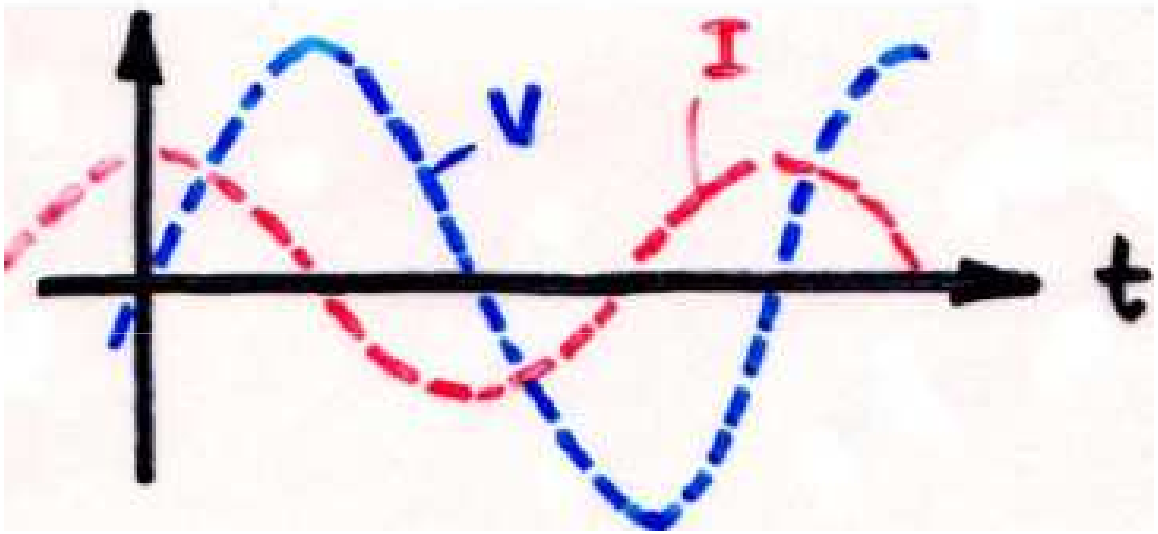
$C = \varepsilon_r \varepsilon_o \frac{A}{d}$ ε_r – relative permittivity

$= \varepsilon_r C_o$

↑ material increased C by a factor of ε_r

$\varepsilon_o = 8.85 \times 10^{-12}$ F/m

Tangent of loss angle



$V = V_0 \sin \omega t$

$I = CV_0 \omega \cos \omega t$

Dielektrik ideal : I mendahului V dengan fase 90^o

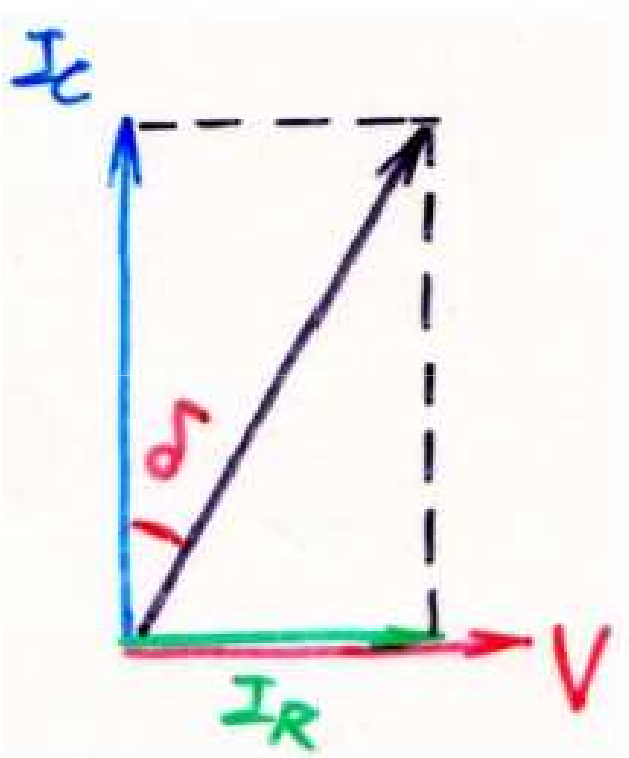
Dielektrik sesungguhnya (real) : I mendahului V dengan fase 90 - δ

$$\text{Power loss} \propto V_0^2 \varepsilon_r \tan\delta$$

$\varepsilon_r \tan\delta$ = loss factor

Untuk aplikasi kapasitor

$\tan\delta \downarrow\downarrow$



Kekuatan Dielektrik

$$\xi_{max} = (V/d)_{max}$$

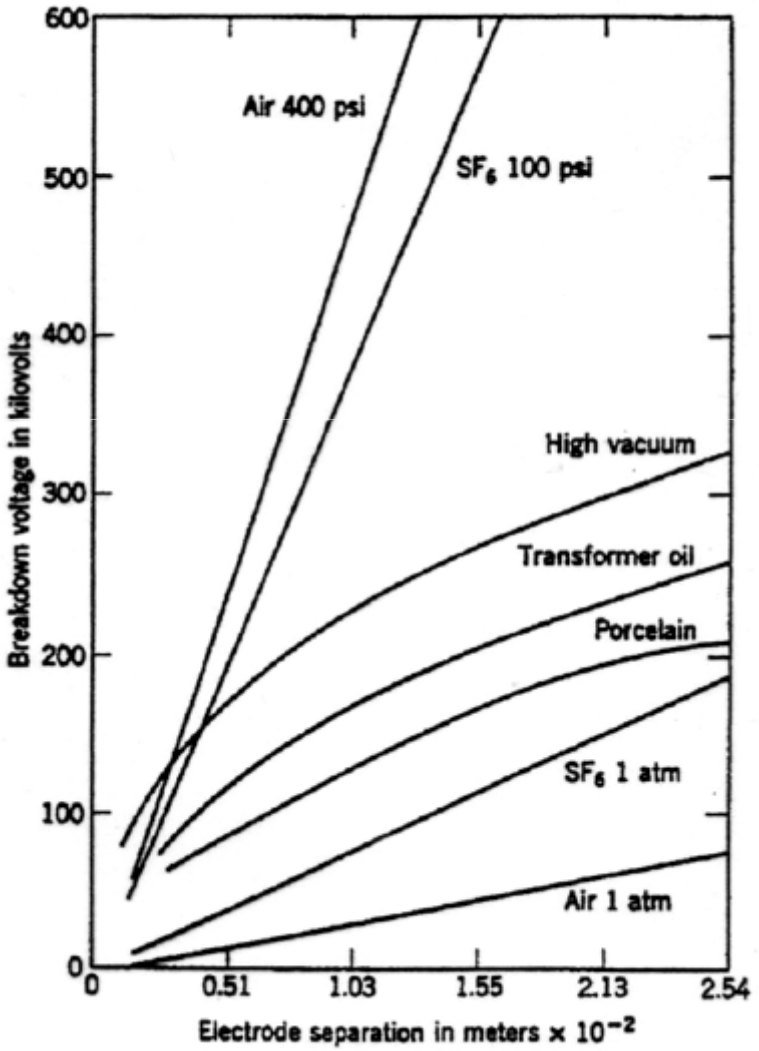
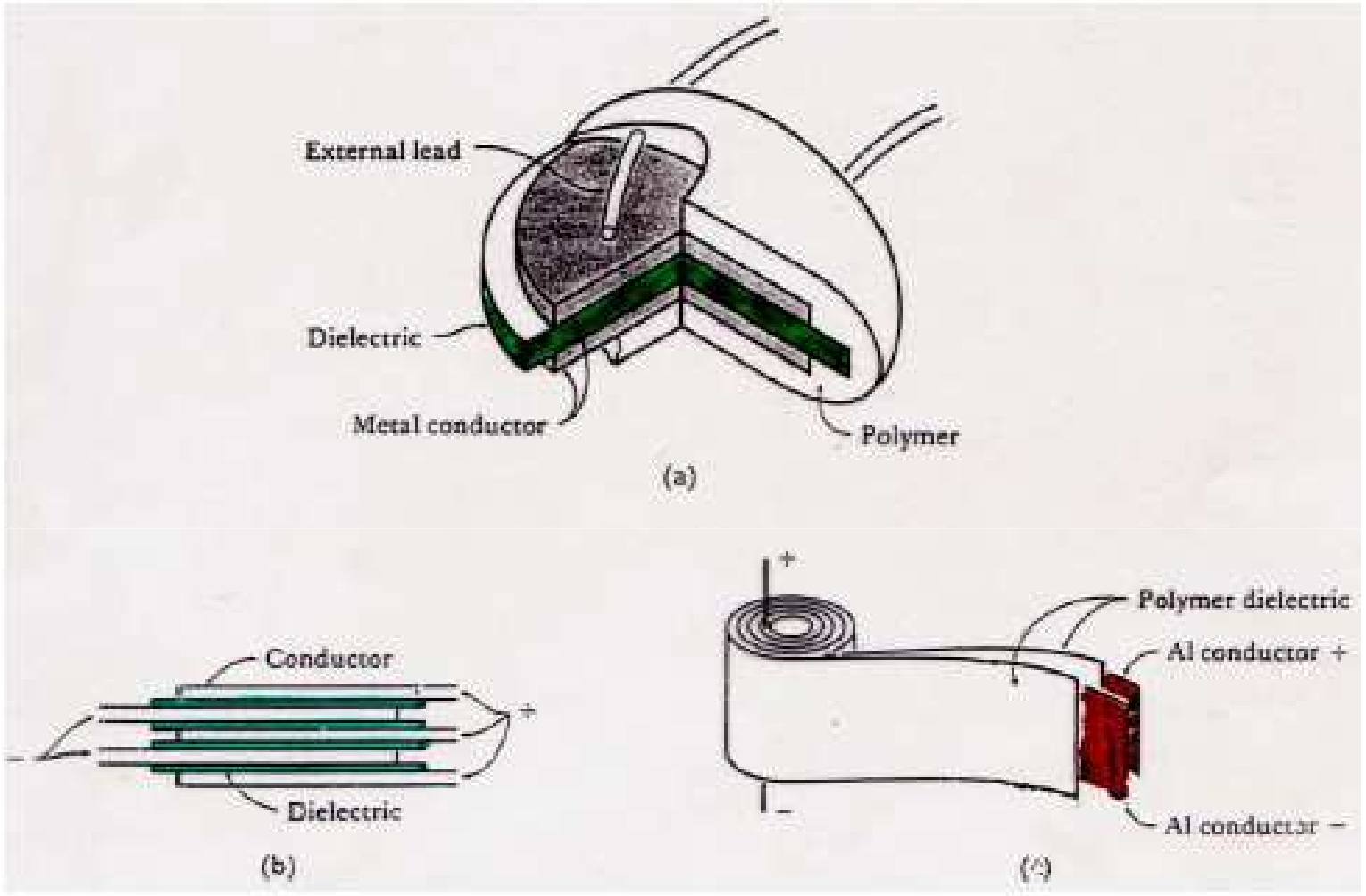


Table 18.5 Dielectric Constants and Strengths for Some Dielectric Materials

Material	*Dielectric Constant*		*Dielectric Strength (V/mil)*[a]
	60 Hz	*1 MHz*	
	Ceramics		
Titanate ceramics	—	15–10,000	50–300
Mica	—	5.4–8.7	1000–2000
Steatite (MgO–SiO_2)	—	5.5–7.5	200–350
Soda–lime glass	6.9	6.9	250
Porcelain	6.0	6.0	40–400
Fused silica	4.0	3.8	250
	Polymers		
Phenol-formaldehyde	5.3	4.8	300–400
Nylon 6,6	4.0	3.6	400
Polystyrene	2.6	2.6	500–700
Polyethylene	2.3	2.3	450–500
Polytetrafluoroethylene	2.1	2.1	400–500


External lead
Dielectric
Metal conductor
Polymer
(a)
Conductor
Dielectric
(b)
Polymer dielectric
Al conductor +
Al conductor –
(c)

Kapasitor dengan kapasitansi tinggi :

- Konstanta dielektrik tingi
- Luas plat yang besar atau berlapis
- Jarak antar plat yang kecil
- Kekuatan dielektrik yang tinggi
- tan δ yang kecil

Dipole dan Polarisasi

Polarisasi listrik merupakan peristiwa terinduksinya atom atau molekul membentuk dipole listrik yang terorientasi pada arah tertentu akibat adanya medan listrik.

$$P = Z\,e\,d$$

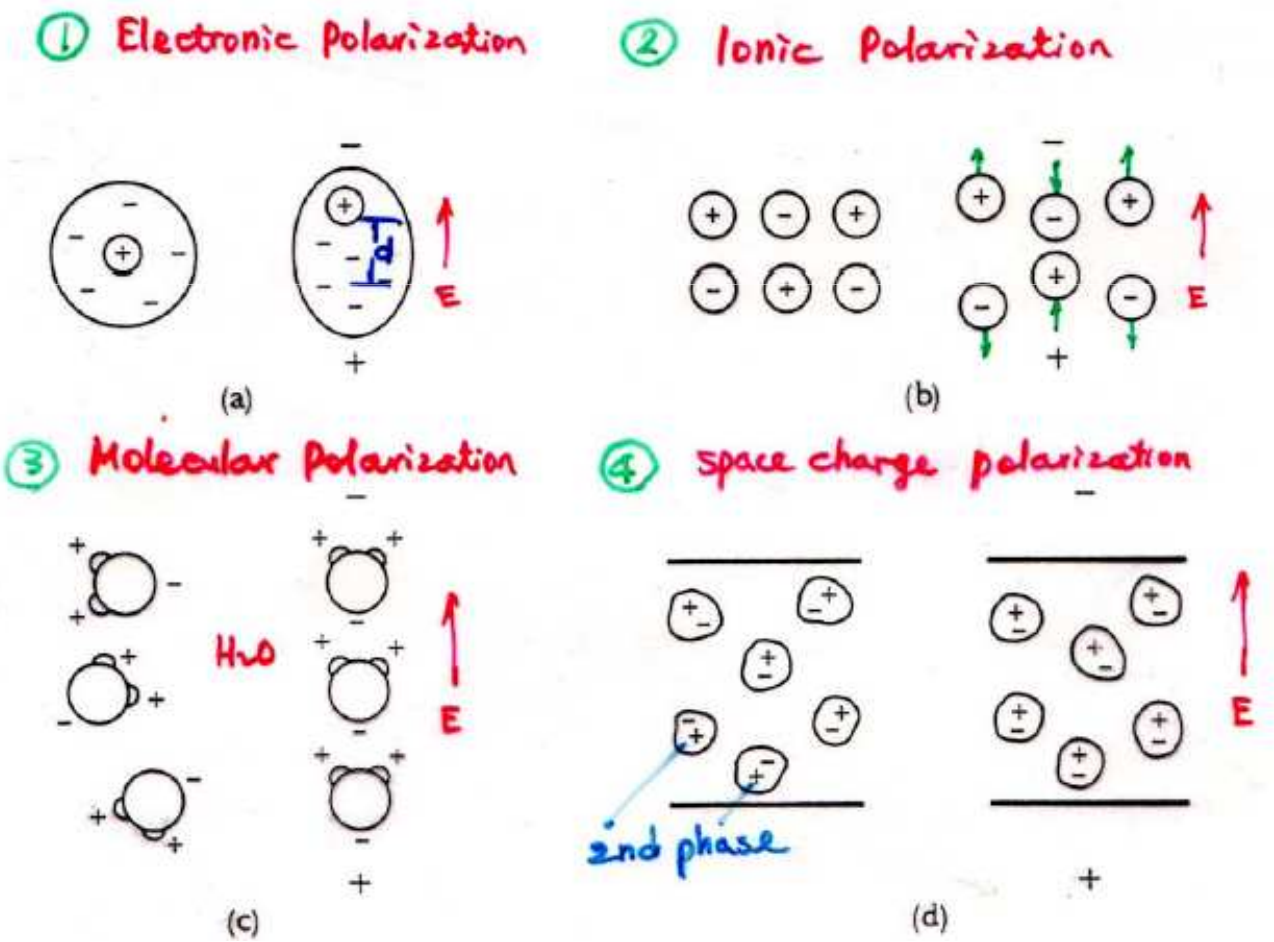
Z = number of charge centres per m^3

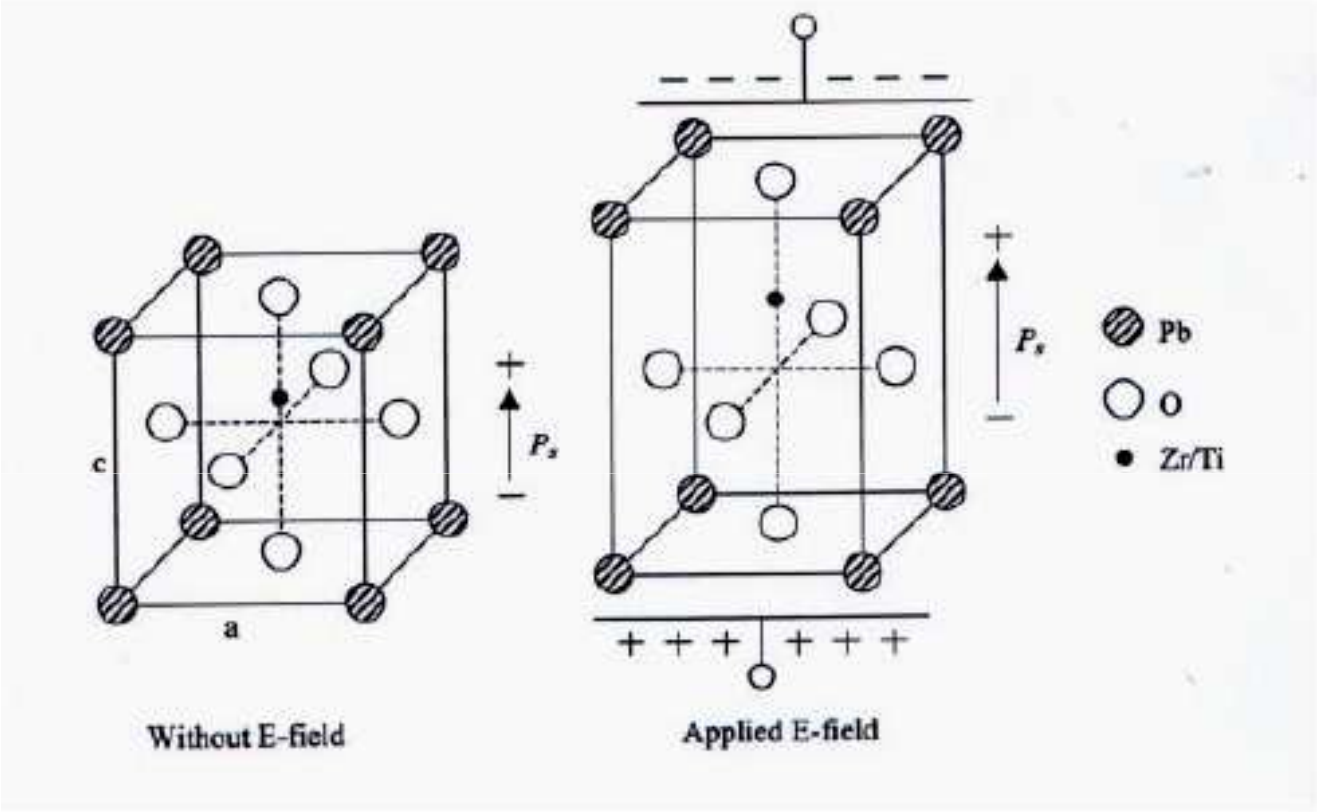
e = **e** charge = 1.6×10^{-19} C

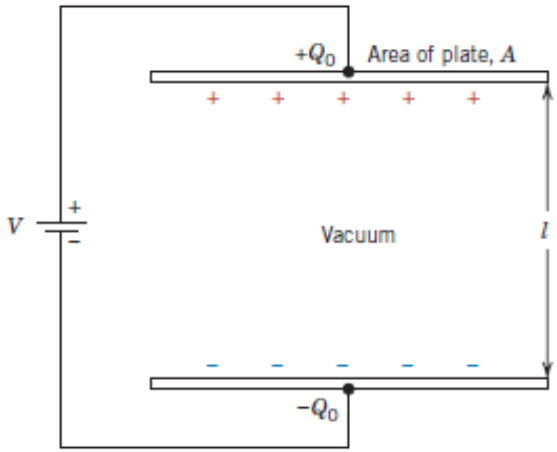
d = displacement between (+) and (-) centres

Polarisation mechanisms:

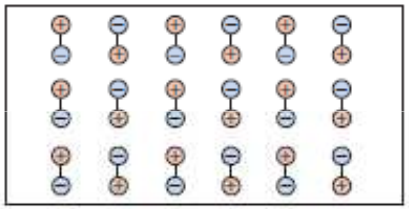
1. Electronic polarisation
2. Ionic polarisation
3. Molecular polarisation
4. Space charge polarisation



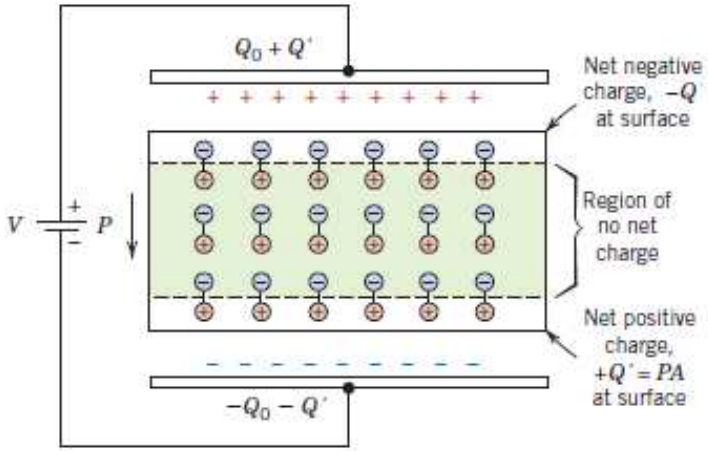

c
a
P_s
P_s
Pb
O
Zr/Ti
Without E-field
Applied E-field



(a)



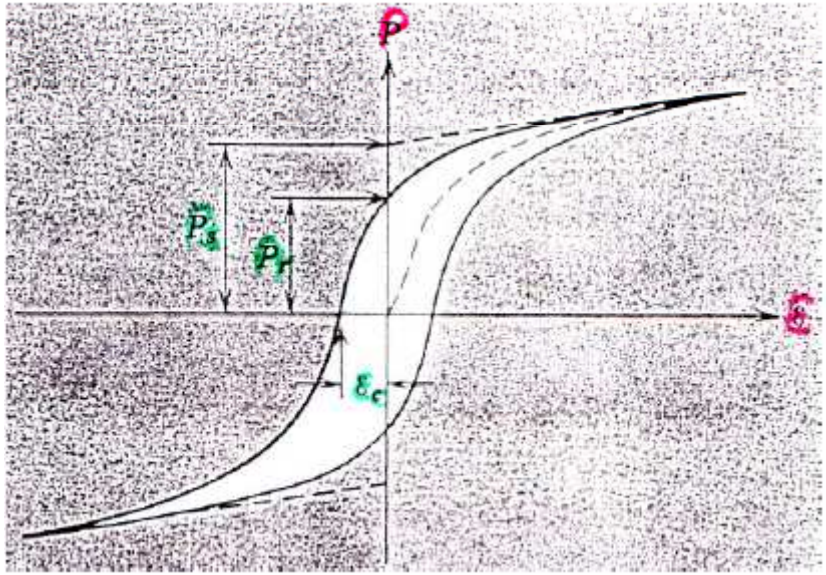
(b)



$$D = \epsilon_0 \mathscr{E} + P$$

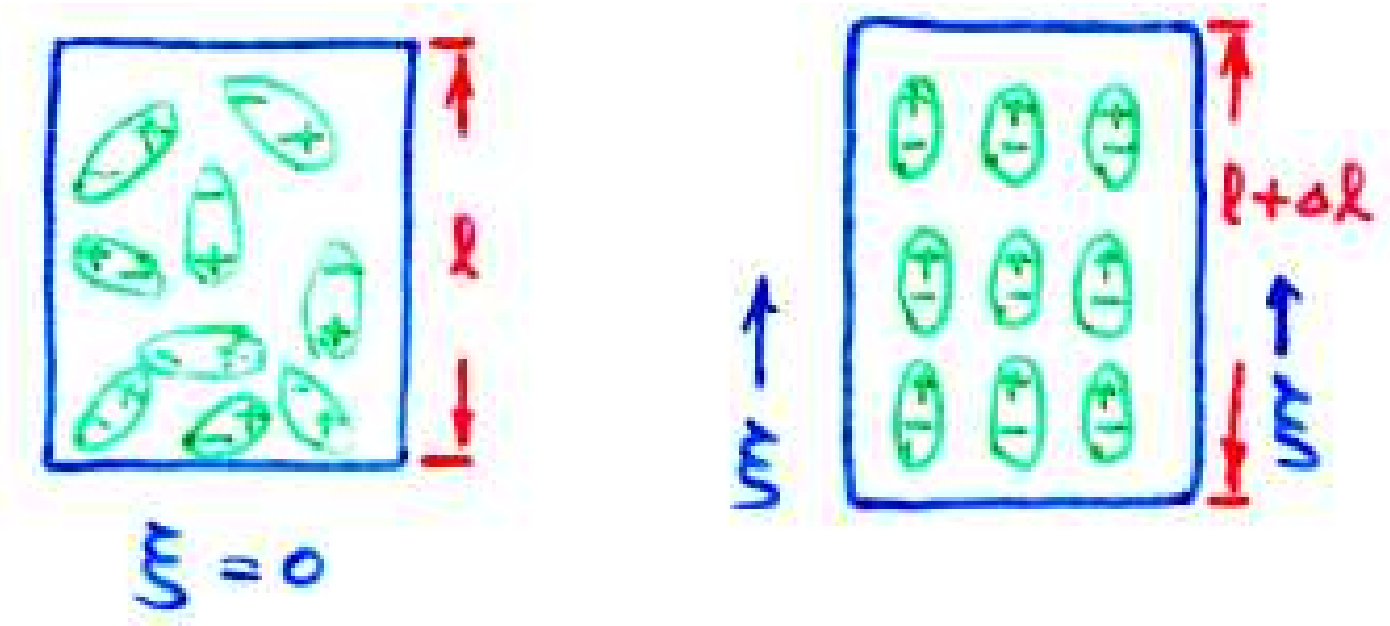
Feroelektrik

Terpolarisasinya dipole listrik akibat adanya medan listrik pada bahan dielektrik.



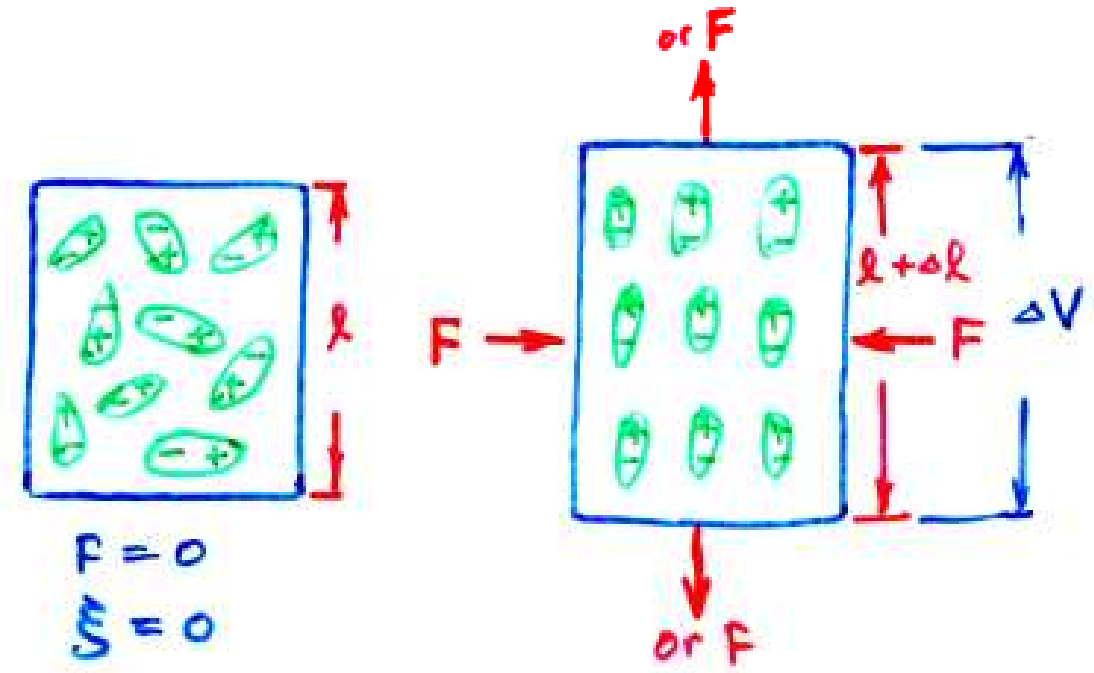
Elektrostriksi

Elektrostriksi merupakan peristiwa terpolarisasinya dipole listrik pada dielektrik akibat adanya medan listrik yang dilanjutkan dengan adanya perubahan dimensi material



Piezoelektrik

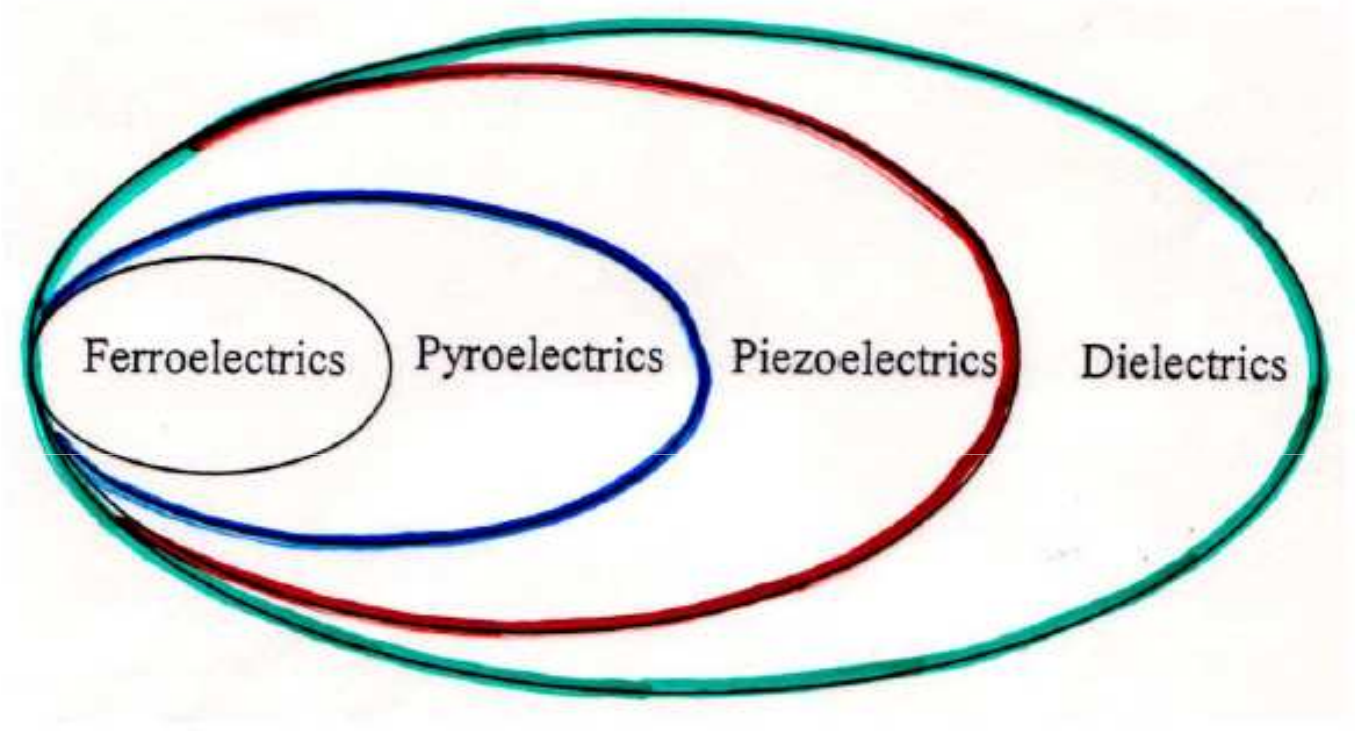
Terpolarisasinya dipole listrik pada dielektrik akibat adanya perubahan dimensi yang dapat menghasilkan tegangan listrik pada material dielektrik

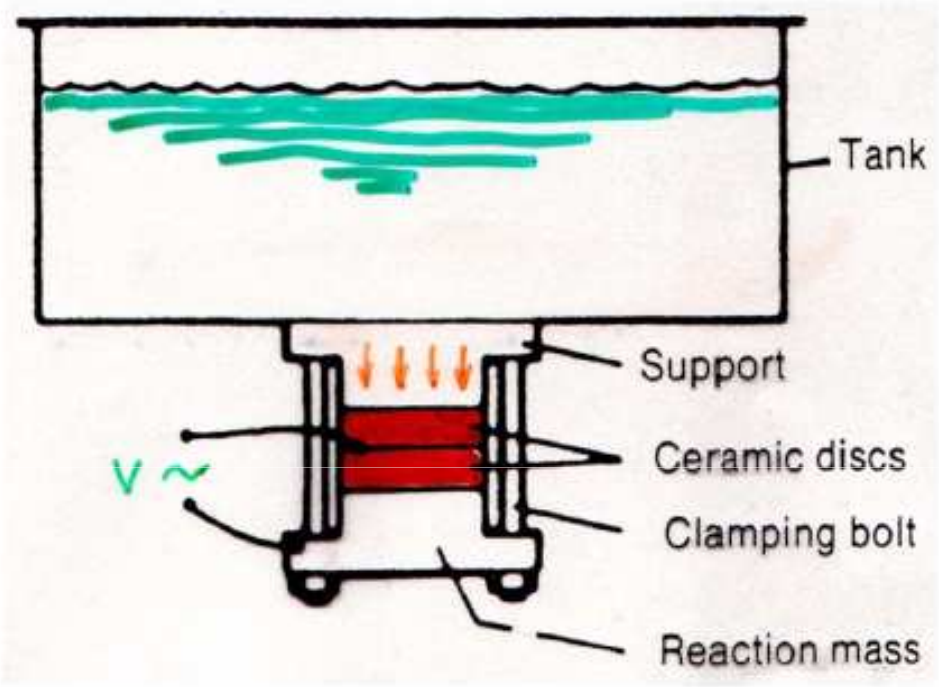


Pyroelektrik

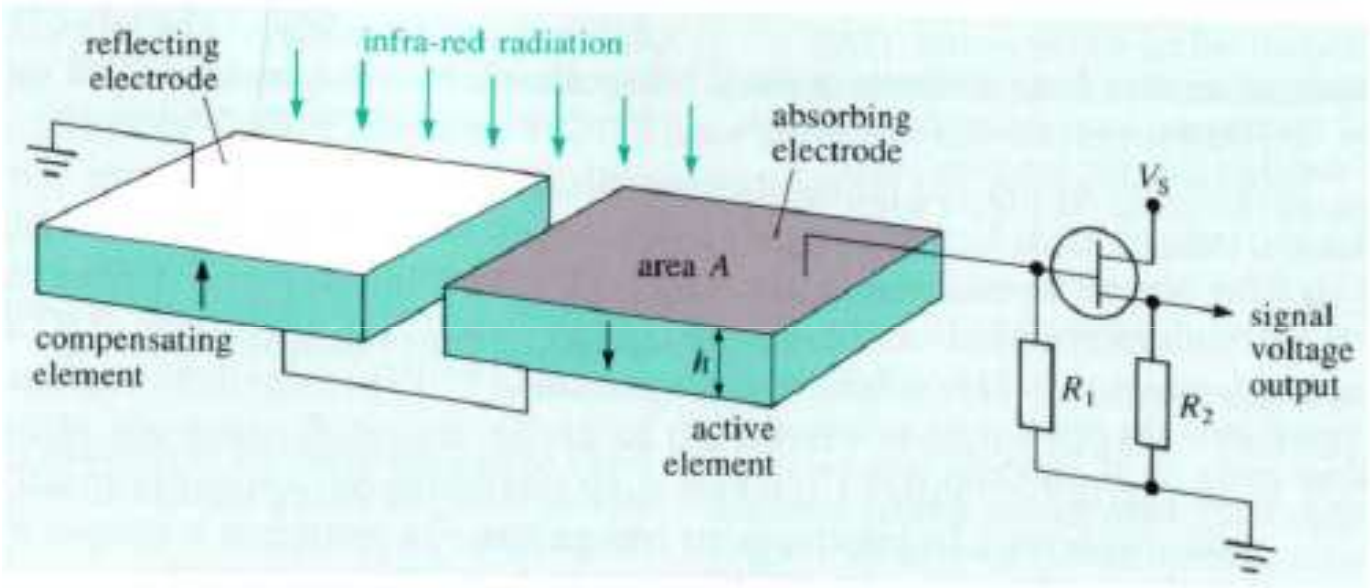
Terpolarisasinya dipole listrik akibat adanya pemanasan pada dielektrik yang diikuti dengan deformasi mekanik karena ekspansi termal

$$\Delta T \rightarrow \varepsilon \rightarrow \Delta P \rightarrow \Delta V$$


Ferroelectrics
Pyroelectrics
Piezoelectrics
Dielectrics



A simple weight sensor


reflecting electrode
infra-red radiation
absorbing electrode
area A
compensating element
h
active element
V_S
signal voltage output
R_1
R_2