ENGINEERING PHYSICS

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Class # 55

- ***Polarization mechanisms in dielectrics***
- ***Non Linear dielectrics - $BaTiO_3$ structure and origin of non-centro symmetry of charges, phase changes***
- ***Piezo electric materials - Pyro electric materials properties and applications***
- ***Ferro electric hysteresis and application as memory materials***

Piezo electric materials - Pyro electric materials properties and applications

Class #55

- *Piezo electric effect - direct and inverse*
- *Piezo electric transducer*
- *Piezo electric materials – examples and applications*
- *Pyroelectric effect*
- *Pyro electric materials- examples and applications*

Piezo electric materials - Pyro electric materials properties and applications

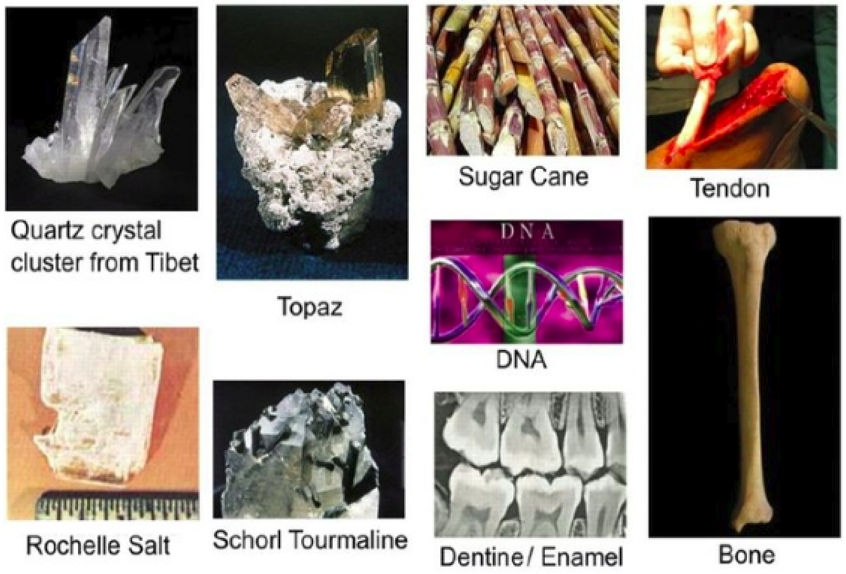
- ***Suggested Reading***

1. The Science and Engineering of Materials, Sixth Edition, Chapter 19, Donald R. Askeland, Pradeep P. Fulay and Wendelin J. Wright, 2010, Cengage Learning, Inc.

2. Learning material prepared by the Department of Physics

Piezoelectric Materials

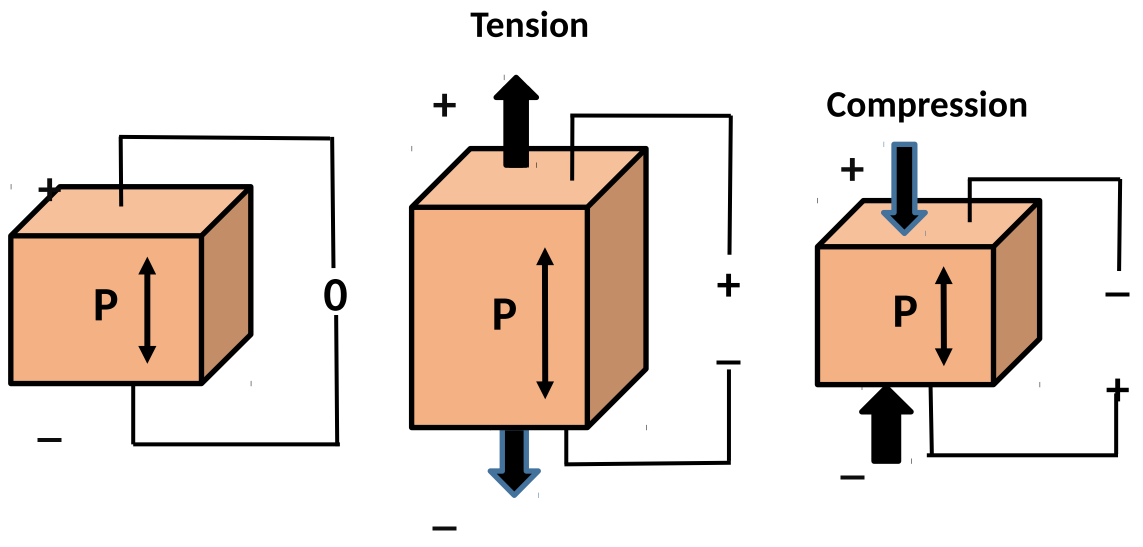
- ***Piezoelectric effect shows a linear coupling between electrical and mechanical fields***
- ***These are non linear dielectrics***
- ***Discovery: Pierre and Jacques Curie in 1880***



Source:S.Pramanik et.al, January 2013, International journal of electrochemical science 8(6):8863-8892

Direct and converse peizo electric effect

- *Direct piezoelectric effect: Mechanical stress → Voltage*
- *Inverse piezoelectric effect: Electrical voltage→ mechanical strain*
- *Piezoelectric effect is very small*



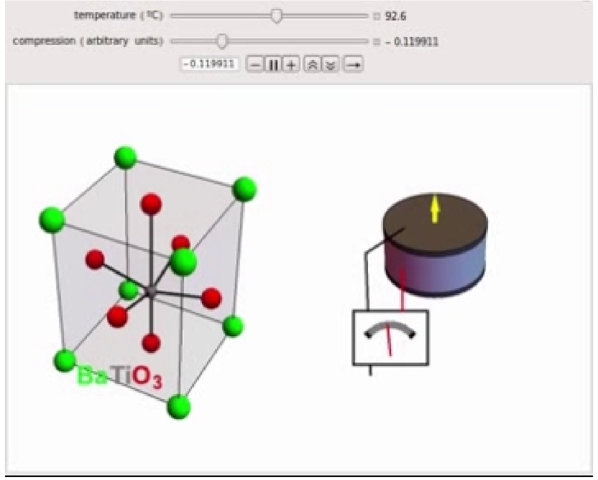
Piezo electric transducer

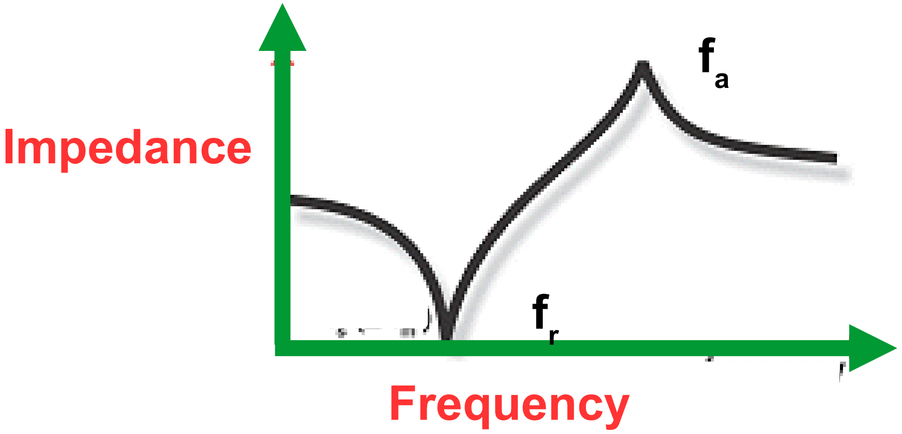
- *In presence of AC electric field dimensions change according to frequency*

- *These act as transducers, conversion coefficient* $k = \sqrt{\frac{E}{\epsilon}}\, d$

where E is the Young's modulus and d is the strain coefficient and ε *is the dielectric constant*

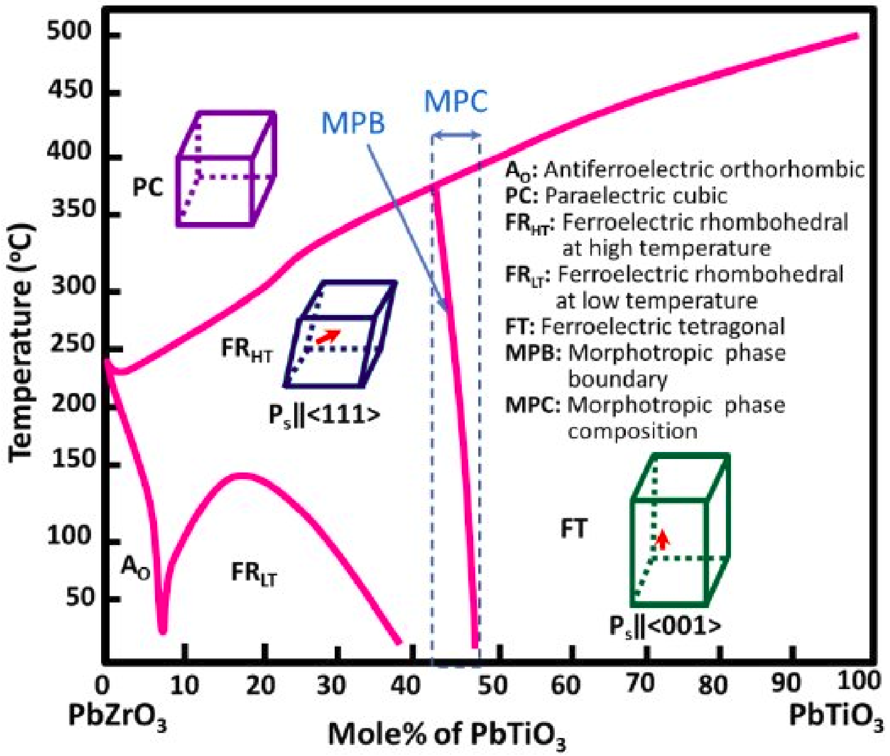
- *Shape and volume determines resonance frequency*





Examples of peizo electric materials

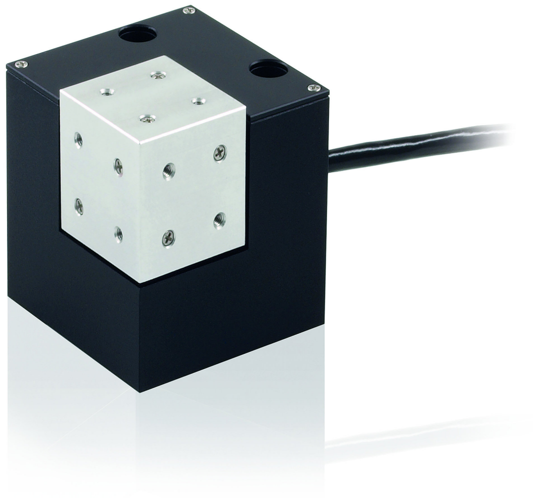
- ***Widely used peizoelectric material: PZT: (Pb(Zr,Ti)O_3)***
- ***Others include BaTiO_3, SiO_2, ZnO, and polyvinylidene fluoride***



Source: S.Pramanik et.al, January 2013, International journal of electrochemical science 8(6):8863-8892

Peizoelectric applications

- *Sensors and crystal oscillators*
- *Spark igniters*
- *Micro balance*
- *Transducers in electronic drum*
- *Microphones and speakers*
- *Electromechanical actuators*
- *Ultrasonic cleaners*

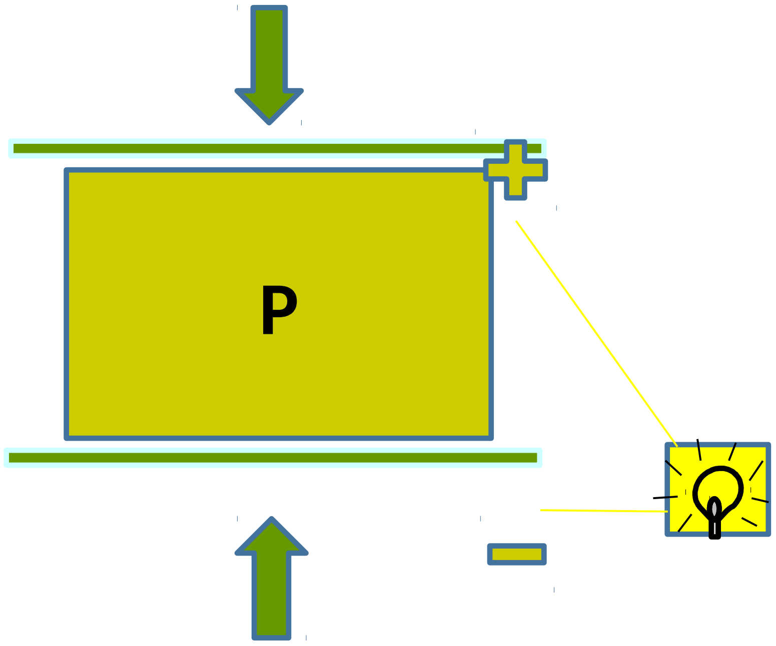


XYZ actuator

https://www.pi-usa.us/en

Pyroelectric materials

- ***Pyroelectric effect: Relation between the changes in temperature and polarization***
- ***Change in polarization gives rise to a voltage across the crystal***



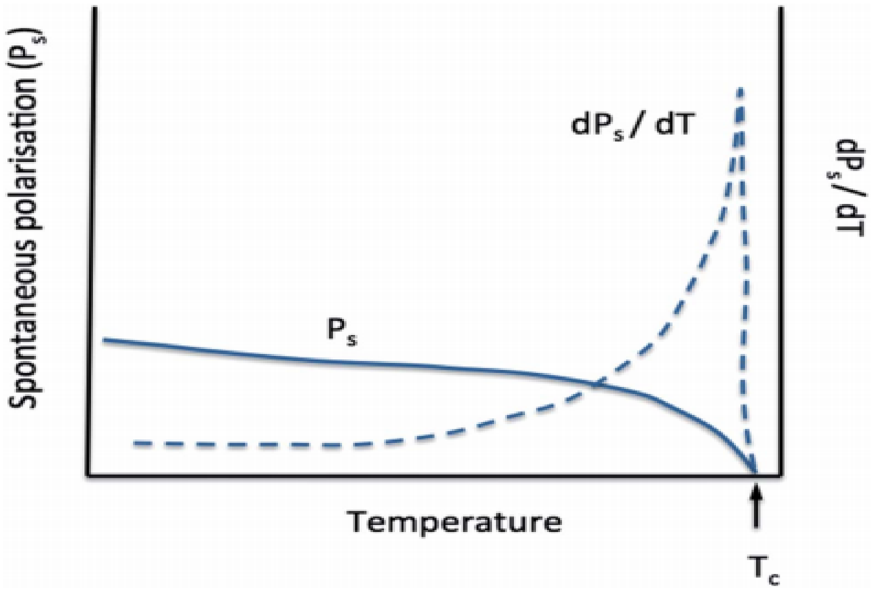
Pyroelectric materials

- *Change in temperature alters the positions of the atoms slightly modifying the polarization*
- *Temporary voltage develops across the crystal*
- *If the temperature is kept constant, voltage drops to zero*
- *There exists a polar axis with a direction that is fixed by symmetry*
- *Pyroelectrics are also referred to as polar dielectrics*
- *It could involve primary or secondary effect depending on whether the material is clamped or not*

Pyroelectric materials

- *Pyroelectric coefficient is described as the change in the spontaneous polarization vector P_s with temperature T*

$$p_i = \frac{\partial P_s}{\partial T}$$ *where p_i is a vector property*



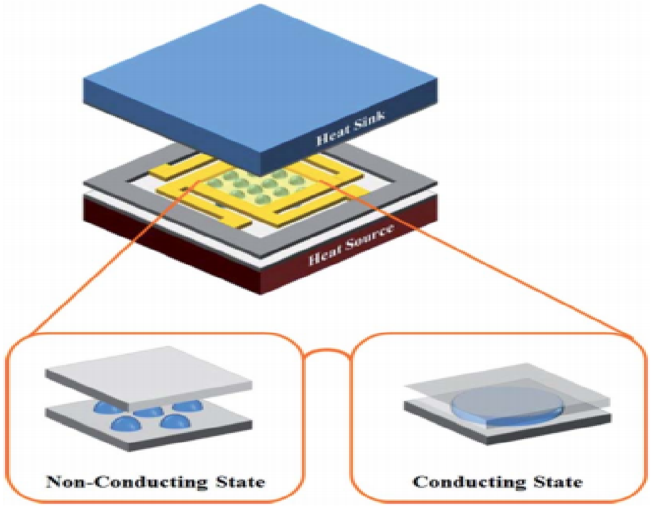
Source: Pyroelectric materials and devices for energy harvesting applications, C. R. Bowen et.al, Energy &Environmental Science, 2014

Pyroelectric materials - examples

Material	*P ($\mu Cm^{-2}K^{-1}$)*
PZT	*-380*
Barium titanate	*-200*
Lithium tantalate	*-176*
Polyvinyl fluorides	*-31*
Zinc oxide	*-9.4*
Gallium nitride	*-4.8*
Cadmium suplhide	*-4*

Applications

- *Products ranging from fire alarms to intruder detectors.*
- *Energy harvesting*
- *Thermal imaging*
- *PIR – based motion detectors*
- *Radiometry*
- *Solar energy pyroelectric converter*
- *Detection and protection of wildlife*
- *PIR remote-based thermometer*



Class #55 …….. Quiz….

The concepts related to this class which are true are…

1. Application of electric field induces strain in a piezo electric material
2. Materials with centre of symmetry can exhibit piezo electric effect
3. Transducer converts one form of energy into another
4. In a pyroelectric material, the voltage developed due to change in temperature remains constant if the temperature is maintained constant
5. Pyroelectric effect is significant in polar dielectrics

THANK YOU

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