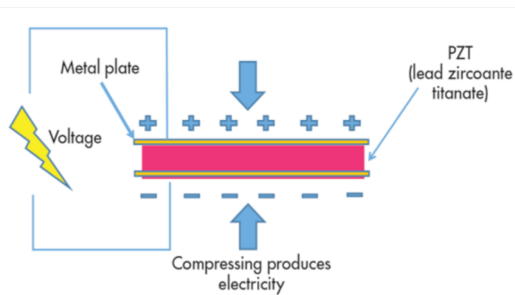


# Piezoelectric and Piezoresistive Instrumentation

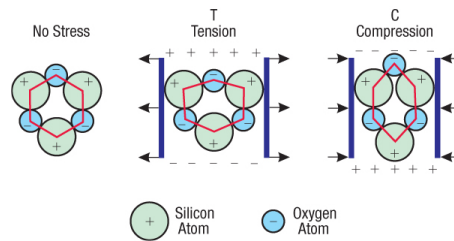
By: Kris Hyblova, Abby Covrig, Kyron Heinrich



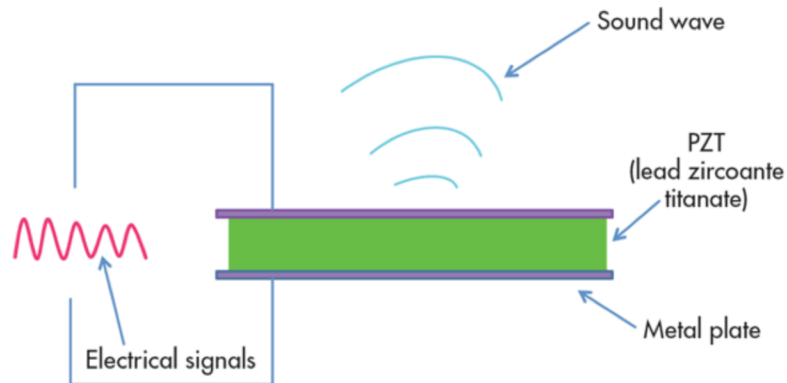
## Direct Piezoelectric Effect



Piezoelectric Effect in Quartz



## Inverse Piezoelectric Effect



## Piezoelectric Materials

### Materials

- Single Crystal:
  - Quartz, Lithium Niobate ( $\text{LiNbO}_3$ ), and Lithium Tantalate ( $\text{LiTaO}_3$ )
    - Surface Acoustic Wave devices (SAWs), dynamic pressure sensors
- PolyCrystal:
  - Barium titanate ( $\text{BaTiO}_3$ ), Piezoelectric  $\text{Pb}(\text{Ti,Zr})\text{O}_3$  solid solutions (PZT) ceramics
- Polymers:
  - Polyvinylidene difluoride (PVDF)
  - Drawn and stretched to polar phase

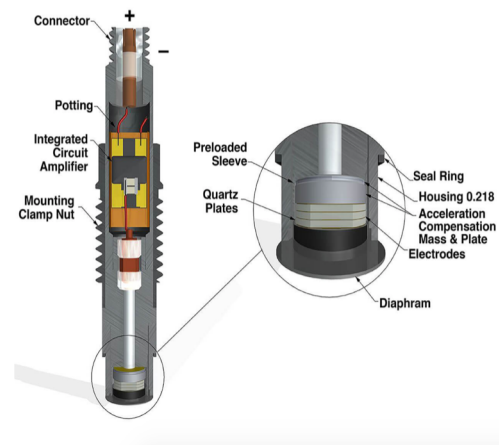
## Piezoelectric properties

TABLE 1.2 Piezoelectric Properties of Representative Piezoelectric Materials<sup>49,50</sup>

Parameter	Quartz	BaTiO <sub>3</sub>	PZT 4	PZT 5H	(Pb,Sm) TiO <sub>3</sub>	PVDF-TrFE
$d_{33}$ (pC/N)	2.3	190	289	593	65	33
$g_{33}$ ( $10^{-3}$ Vm/N)	57.8	12.6	26.1	19.7	42	380
$k_t$	0.09	0.38	0.51	0.50	0.50	0.30
$k_p$		0.33	0.58	0.65	0.03	
$\epsilon_3^X/\epsilon_0$	5	1700	1300	3400	175	6
$Q_M$	$>10^5$		500	65	900	3-10
$T_C$ (°C)		120	328	193	355	

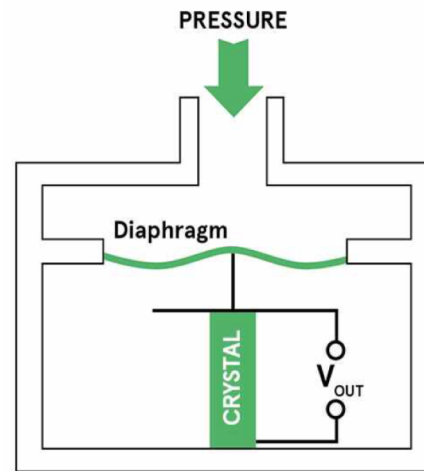
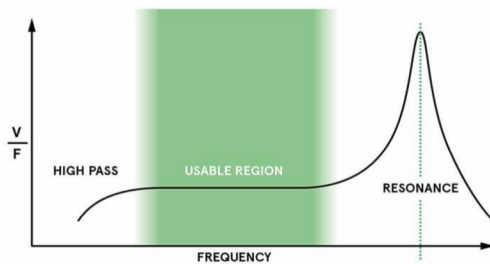
## General Purpose Pressure Sensor

- Measurement Range: 200 psi (1379 kPa)
- Sensitivity: ( $\pm 15\%$ ) 25 mV/psi (3.6 mV/kPa)
- Low Frequency Response: (-5%) 0.5 Hz
- Resonant Frequency:  $\geq 500$  kHz ( $\geq 500$  kHz)
- Electrical Connector: 10-32 Coaxial Jack
- Weight: 0.21 oz (6.0 gm)



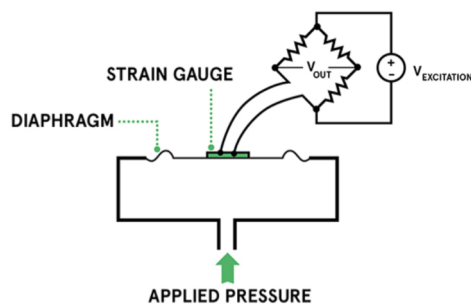
## Sensors

- Piezoelectric sensors are required for specific applications
  - turbulence, blast, ballistics, and engine combustion
  - (Not good for static pressure applications)



## What is Piezoresistive Effect?

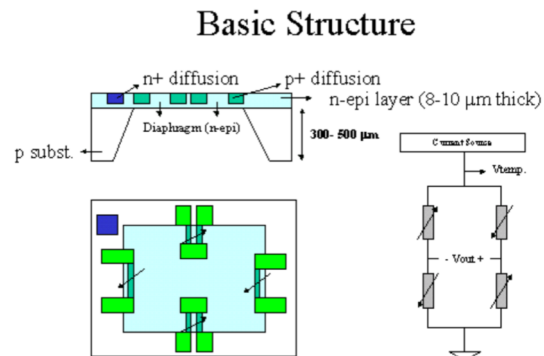
- Material: semi-conductors (mainly silicon)
- A stress changes the resistivity of the material



The Piezoresistive Effect: Change in the electrical resistivity of a semiconductor or metal when mechanical strain is applied.

## Example

- Strain Gauge
  - Silicon
    - adding various elements -> Regions with more or less electrons
    - Changes resistivity in certain areas
  - N and P sections create sensing 'wires'



## DMP333 High Range Precision Pressure Transmitter

(incorporates a silicon piezoresistive sensing element)

- pressure sensor designed for high pressure applications
- Temperature range: -40 to 125 degC
- Pressure range: 60 to 600 bar (870 psi to 8700 psi)



<https://www.sensorsone.com/wp-content/uploads/2013/10/DMP333.pdf>

## Advantages

- Robust
- Calibration and performance doesn't change over time
- Simple construction
- Large output signal
- Integrated circuits for signal processing
- Stable over time

## Disadvantages

- Consume more power
- Requires constant temperature
- Junction leakage

## References

- <https://www.sensorsone.com/wp-content/uploads/2013/10/DMP333.pdf>
- <https://www.autodesk.com/products/eagle/blog/piezoelectricity/>
- <https://www.avnet.com/wps/portal/abacus/solutions/technologies/sensors/pressure-sensors/core-technologies/piezoelectric/>
- <https://www.pcb.com/resources/technical-information/introduction-to-pressure-sensors>
- <http://www.microsystems.metu.edu.tr/piezops/piezops.html>
- <https://www.avnet.com/wps/portal/abacus/solutions/technologies/sensors/pressure-sensors/core-technologies/capacitive-vs-piezoresistive-vs-piezoelectric/>

Questions

