

DR. B.C. ROY ENGINEERING COLLEGE



DURGAPUR

PIEZOELECTRIC SENSORS & ITS APPLICATIONS

PRESENTED BY: -

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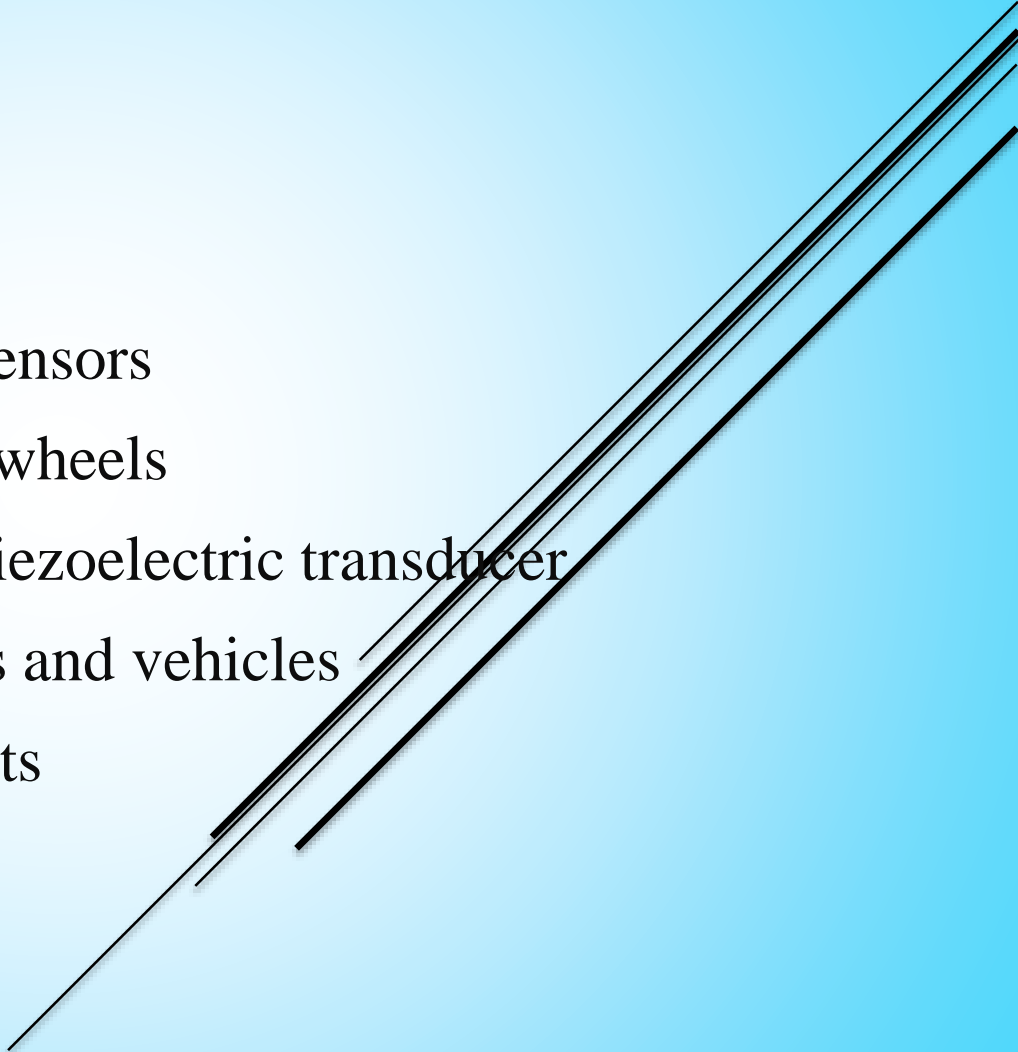
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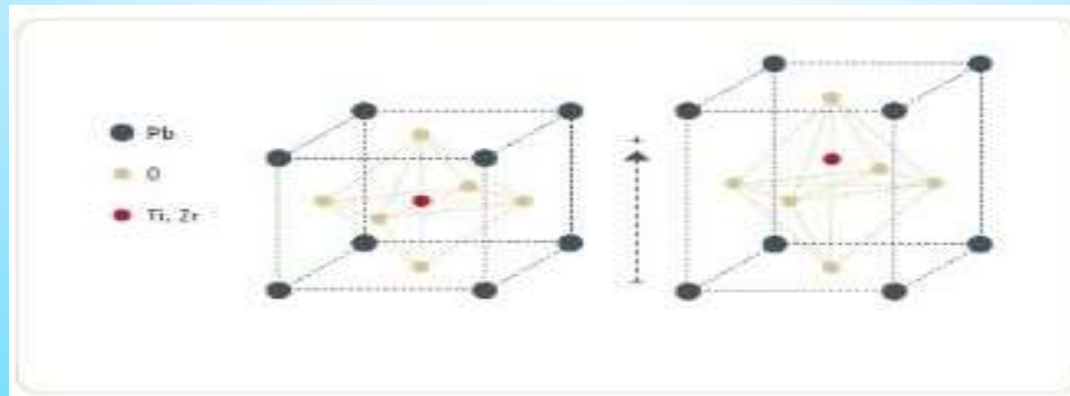
APRIL, 2015

Presentation overview

1. Introduction
 2. History
 3. How it works?
 4. How are they made?
 5. Piezoelectric pressure sensors
 6. Wear detection of train wheels
 7. Shoe-mounted PDVF piezoelectric transducer
 8. Applications in aircrafts and vehicles
 9. Applications and markets
 10. Future reviews
 11. Conclusion
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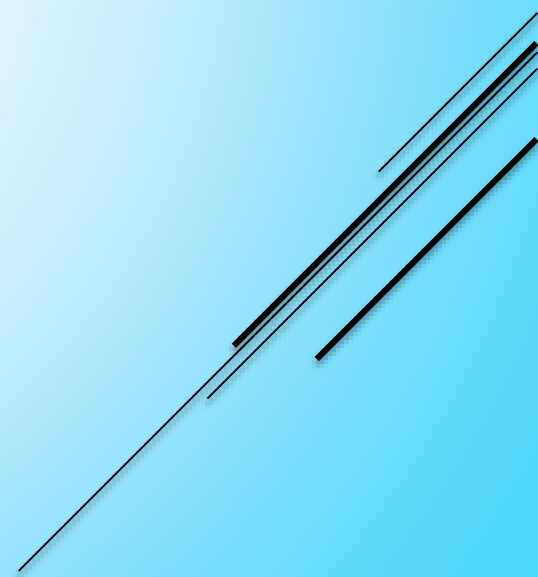
Introduction

- Generation of electrical potential in response to applied mechanical stress.
- Derived from Greek word piezo meaning squeeze
- Transducer converts one form of energy into another.
- Transduction is from mechanical energy to electrical energy.
- Many piezoelectric materials are known to exist.
- Quartz, tourmaline, ceramic (PZT), GAPO4 and many others.



History

- The word 'piezo' is derived from the Greek word for pressure.
- The piezoelectric effect was discovered by Jacques and Pierre Curie in 1880.
- Found that electricity is produced when mechanical stress is applied.



How it works?

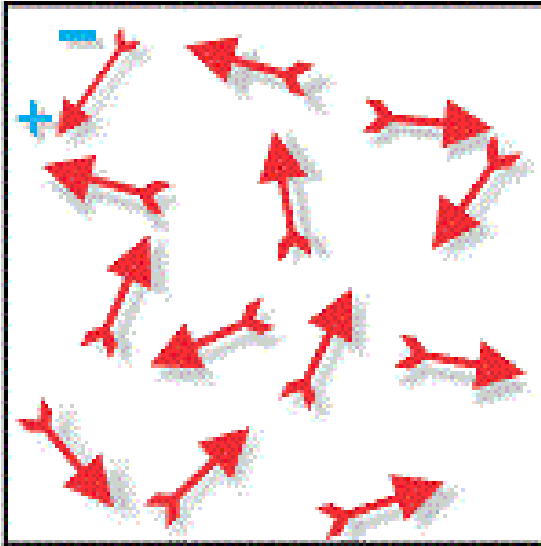
- Mechanical compression changes the dipole moment creating voltage.
- Directions of compression or tension generates voltage of the same polarity as the poling voltage.



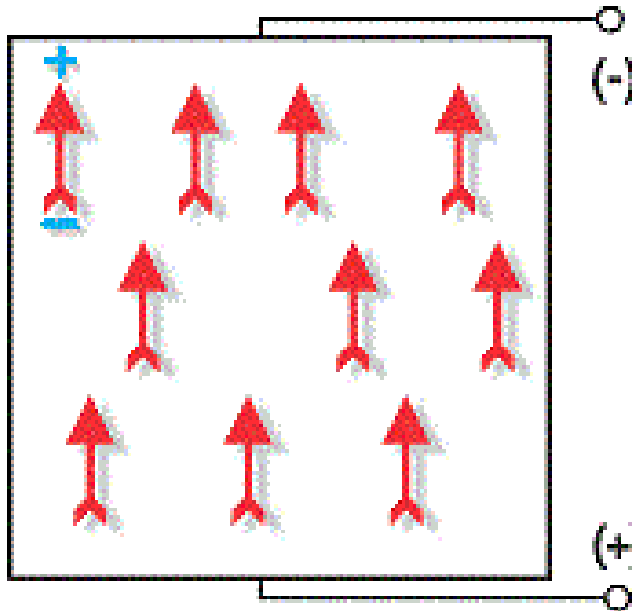
How are they made?

Polarizing (poling) a piezoelectric ceramic*

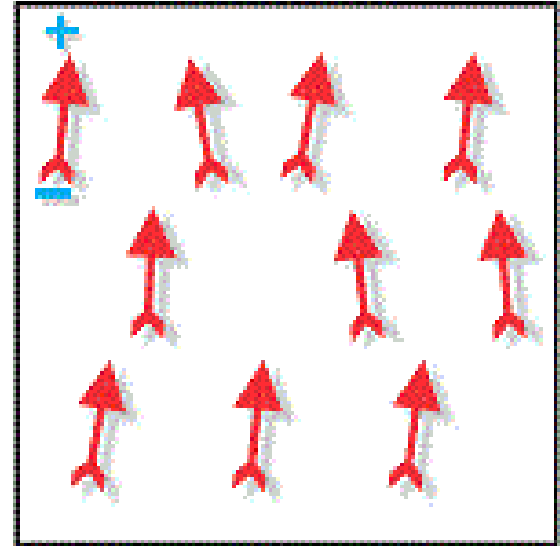
(a) random orientation of polar domains prior to polarization



(b) polarization in DC electric field

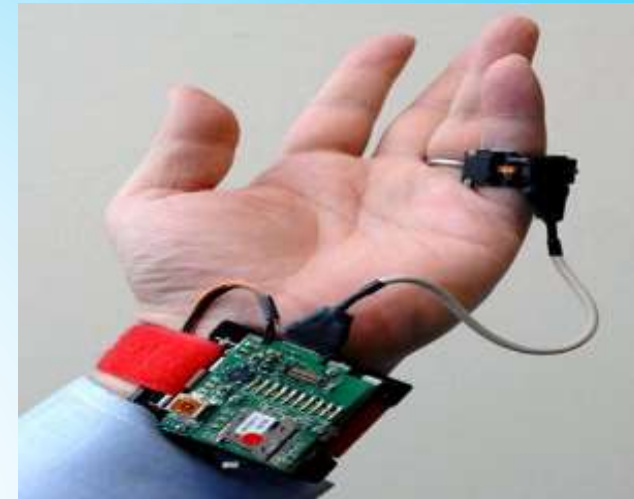


(c) remanent polarization after electric field removed



- ▶ Both natural and man made.
- ▶ When DC electric field applied, all molecules aligned in one direction.
- ▶ Exhibit electric behaviour at a particular temperature or Curie temperature.

Piezoelectric pressure sensors

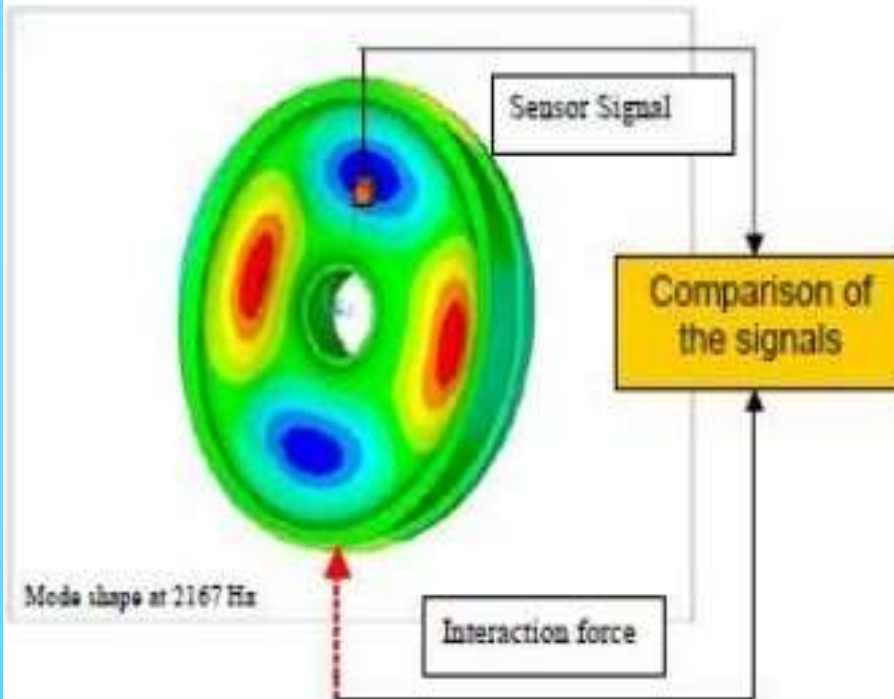


- ▶ Senses events when pressure is applied
- ▶ Includes microchip which sends signal collected by voltmeter
- ▶ Measure dynamic or changing events
- ▶ Consists of sensor housing, piezoelectric crystals and electrode
- ▶ Relay on external force to strain crystals
- ▶ Utilize a diaphragm to collect pressure
- ▶ Uses compensation element to reduce sensitivity



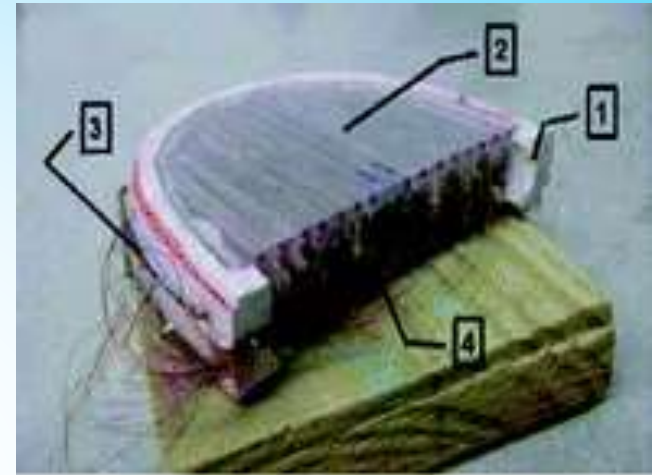
Wear detection of train wheels

This is a wear detection system for train wheels. The idea is to detect the changes in the vibration behavior of the entire wheel caused by the surface changes on the rolling contact area.

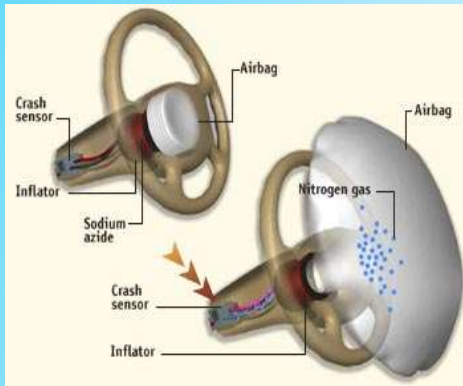


Shoe-mounted PDVF piezoelectric transducer

- ▶ Structure consists of rubber cut-outs, polycarbonate plates, copper terminals & unimorph strips.
- ▶ When stress applied around the heel, electricity is generated.
- ▶ Power generated in the order of few microwatts.
- ▶ Power generated is sufficient for MEMS, microelectronic devices & very low power application.



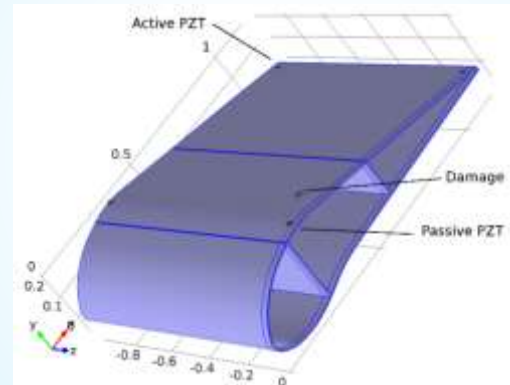
Applications in aircrafts and vehicles



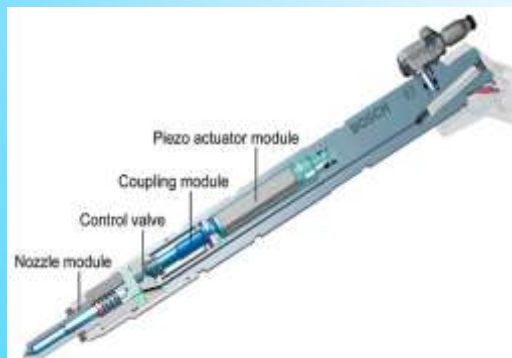
1. Crash sensor



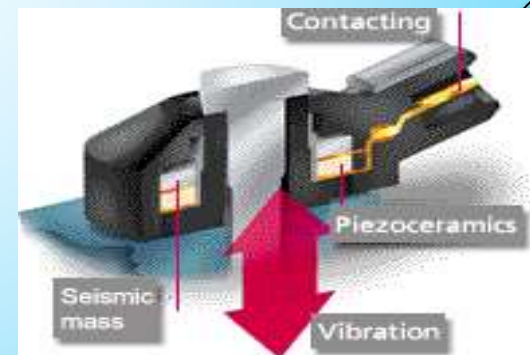
4. PZT in tyres



5. PZT in plane wings



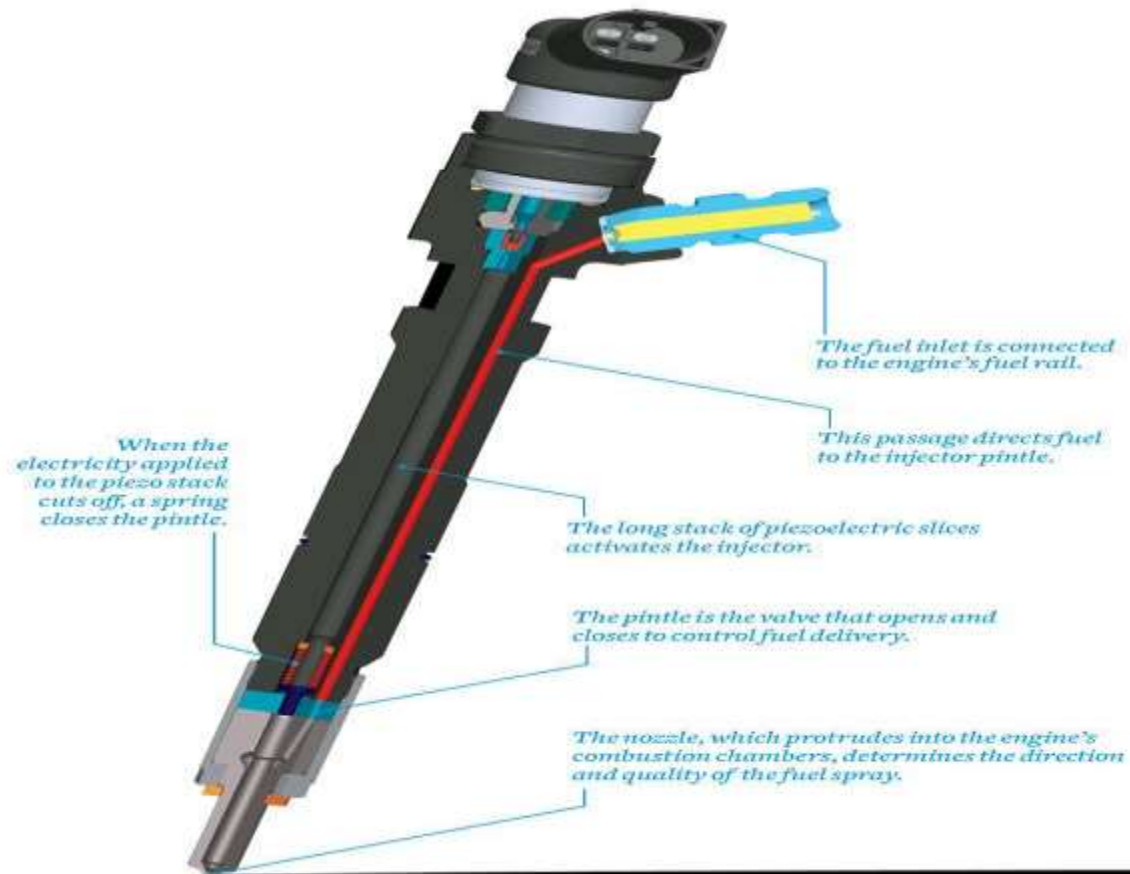
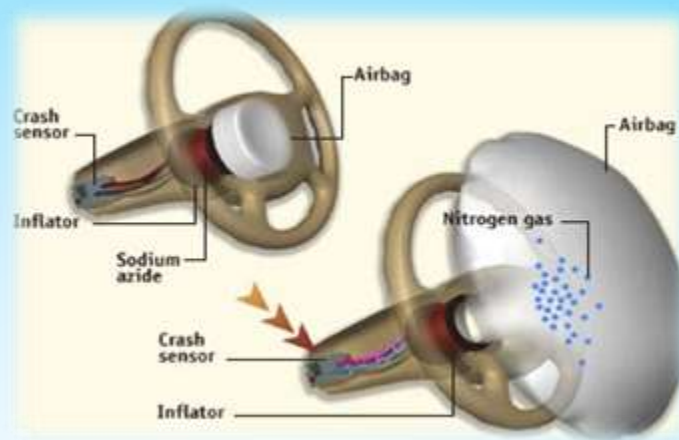
2. Fuel injection sensor



3. Knock sensor

In vehicles:-

- **Crash Sensors:-**
- Generates voltage due to force from collision.
- This completes the circuit and the inflator fills the airbag with nitrogen gas with a burst.
- **Fuel injection sensors:-**
- ▶ Works faster than conventional injectors.
- ▶ Consumes less amount of electricity.
- ▶ Gives precise control over fuel flow.



► Engine knock sensor:-

- ❑ Knock control for internal combustion engines.
- ❑ Machine tool protection.
- ❑ Capitation detection.

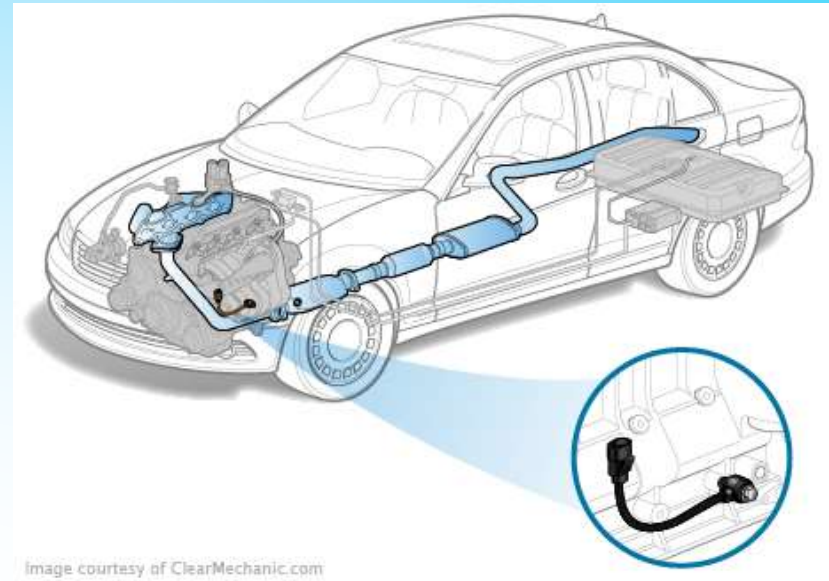
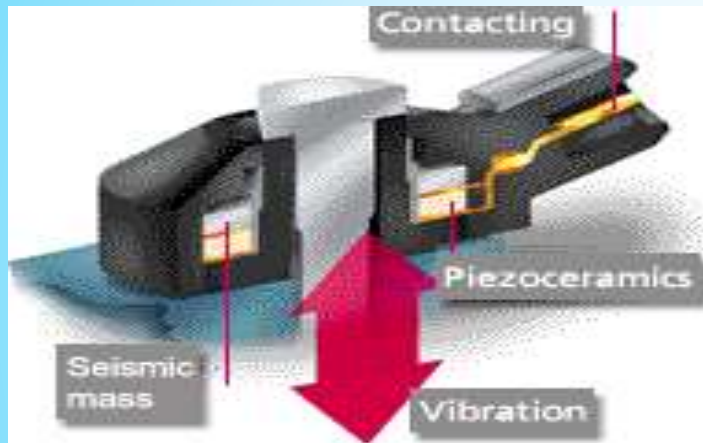


Image courtesy of ClearMechanic.com

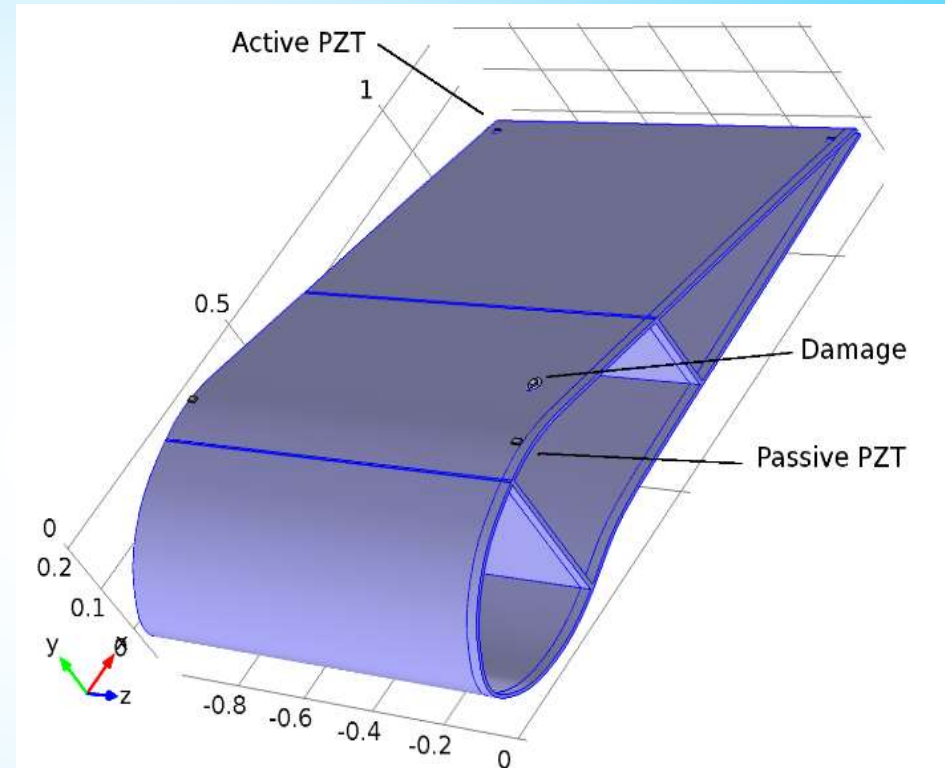
► Energy harvesting sensors:-

- ❑ PZT can be used as energy harvesters in car tyres.
- ❑ Increases battery range of cars.
- ❑ But still in experimental stage.

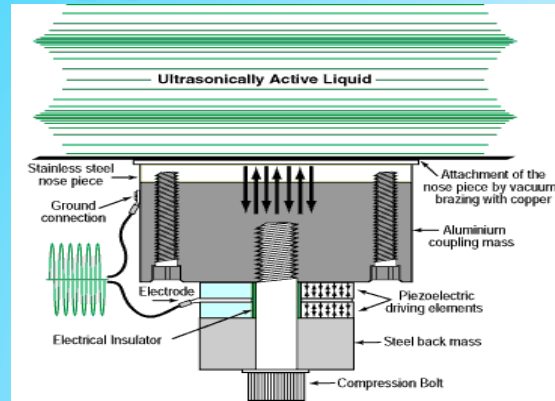


In aircrafts:-

- ❑ Piezoelectric sensors are used for damage diagnosis in wings of aeroplanes.
- ❑ Can detect at a very early stage.
- ❑ Uses the concept of noise pattern to detect damages.
- ❑ Still at an experimental stage and limited applications in real life.



Applications and markets

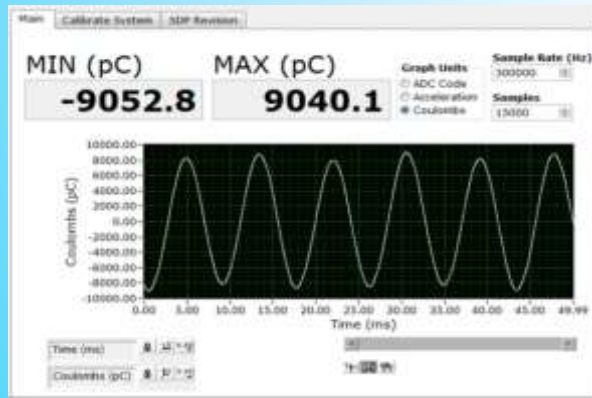


1. Ultrasonic

BOLT™ Energy Harvesting Products



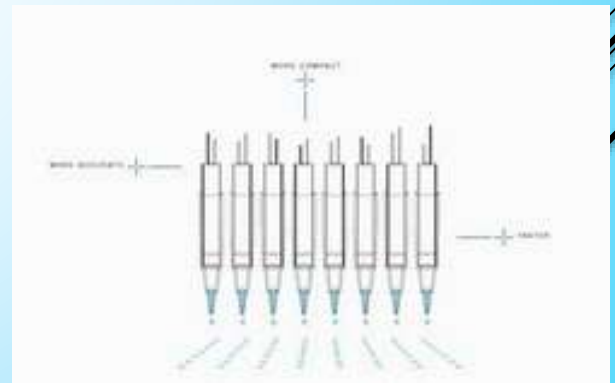
5. Energy harvesting



2. Scientific

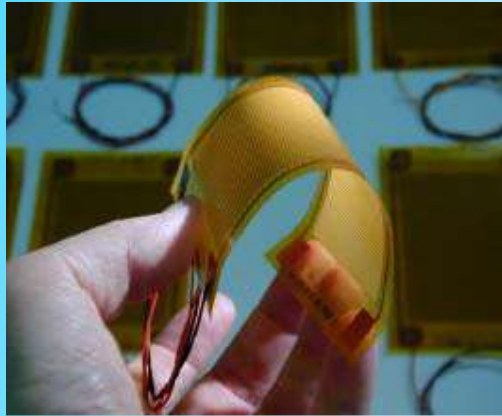


4. Medical



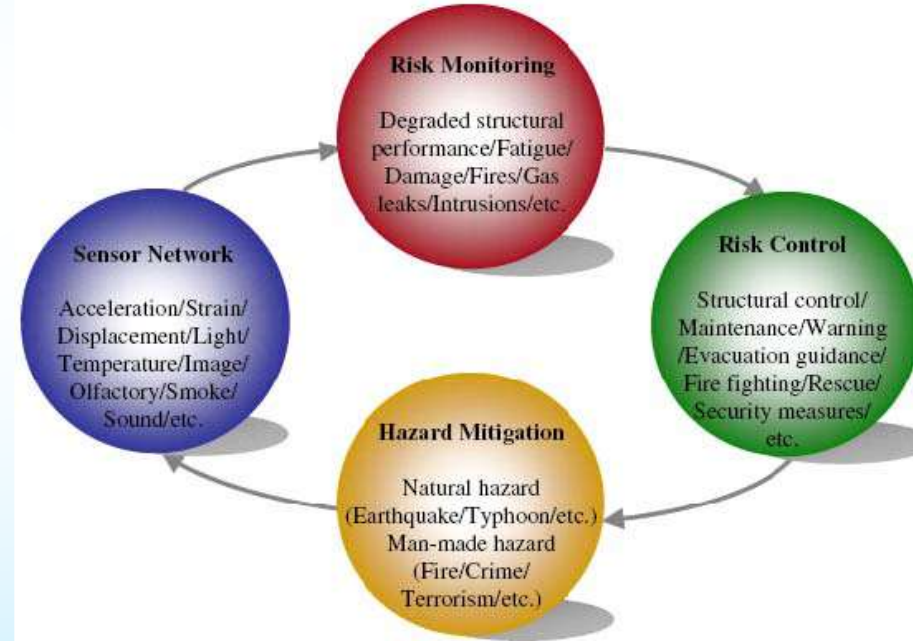
3. Pumping

Future reviews



1. New structures likely to be used

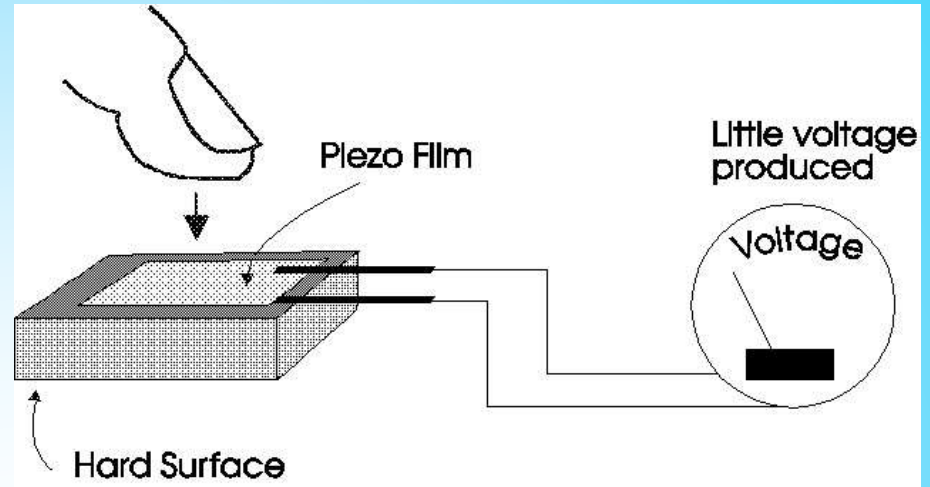
- ▶ New materials to be used
- ▶ New structures likely to be made
- ▶ Smart sensors- multi dimensional & wireless



2. Smart Sensors

Conclusion

- ▶ Piezoelectric sensors offer unique capability.
- ▶ Piezo sensors provides safety measures in vehicles and aircrafts.
- ▶ Some are used for generation of electricity.
- ▶ It is also used to save electricity.
- ▶ It has its application in every field.
- ▶ When choosing a sensor attention should be paid on performance specification.



Thank
you...