TRANSDUCERS

An Introduction

TRANSDUCERS

- A transducer is a device that converts energy from one form to another
- Energy forms can be mechanical, visual, aural, electrical, thermal, chemical, etc. (examples to follow)
- Used to change information into a form that can be easily transferred, stored, processed, interpreted, etc.

Types of Energy Transformations

- Electromagnetic - EM fields ⟺ current

Examples:

Receiving Antennas

Transmitting Antennas

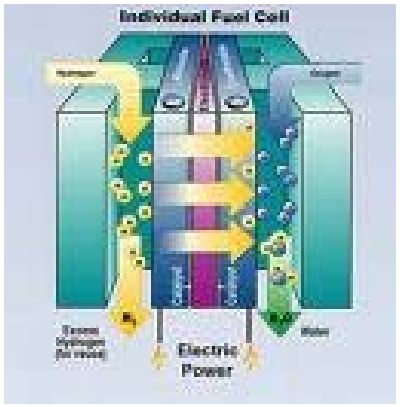
Types of Energy Transformations

- Electrochemical - substance → voltage

Examples:

pH Probe

Fuel Cell

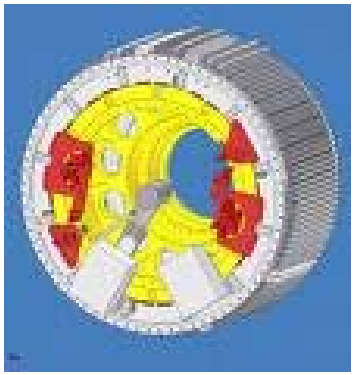


Types of Energy Transformations

- Electromechanical - movement ⟺ voltage

Examples:

Motor/Generator



Phonograph Cartridge

Types of Energy Transformations

- Electroacoustic - vibration ⟺ voltage

Examples:

Loudspeaker

Microphone

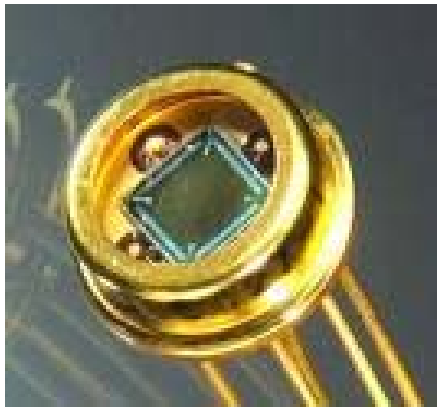
Types of Energy Transformations

- Photoelectric - light ⟺ voltage

Examples:

Light Bulb

Photodiode



Types of Energy Transformations

- Thermoelectric - temperature ⟺ voltage

Examples:

Hotplate

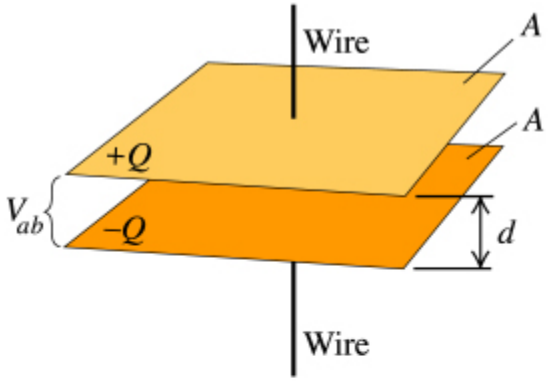
Thermistor

Principles of Energy Transformation

Capacitive Transducers

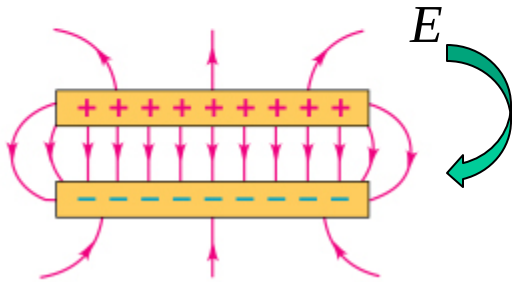
Voltage between plates: $Vab = Ed$

$$C = \frac{Q}{V} = \frac{Q}{Ed} = \frac{\varepsilon A}{d}$$



(a)

Electric Field



(b)

where:

Q = plate charge

ε = permittivity of dielectric

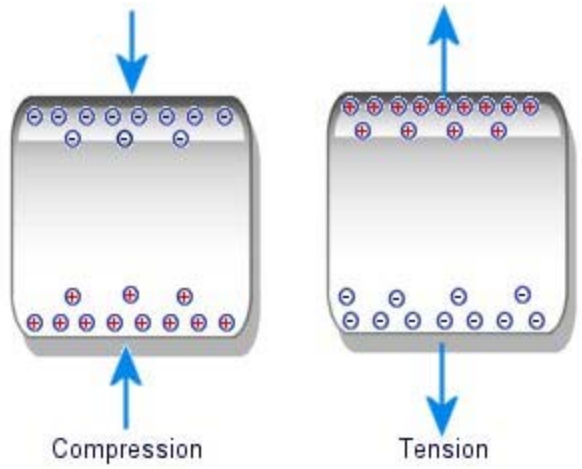
A = area of plates

d = distance between plates

Principles of Energy Transformation

Piezoelectric Transducers

Voltage on opposite sides of piezoelectric crystal is dependent on magnitude and direction of force applied to the crystal.

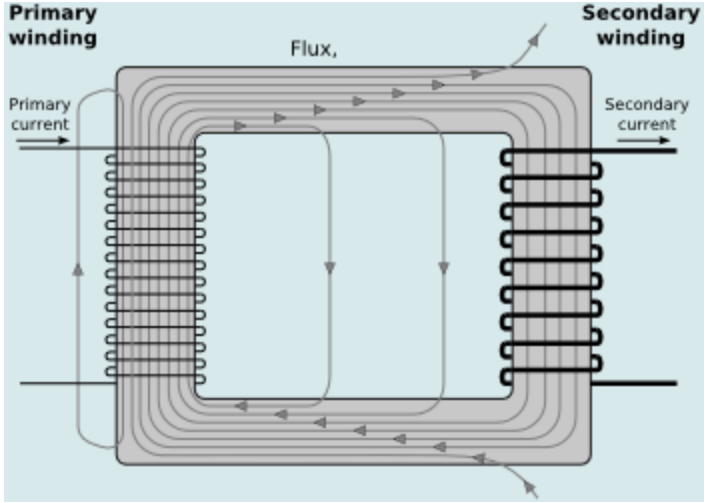


Type of Piezoelectric Materials:

- Natural crystals (quartz, rochelle salts)
- Synthetic crystals (lithium phosphate)
- Ferroelectric ceramics (barium titanate)

Principles of Energy Transformation

Electromagnetic Transducers



$$E = -\frac{d(N\phi)}{dt}$$

$N\phi =$ number of electric flux linkages

$\frac{d(N\phi)}{dt} =$ time rate of change of electric flux linkages

Principles of Energy Transformation

Electromechanical Transducers

•Some type of mechanical contact

•Convert physical change (movement, distance, etc.) to electrical signal (or *vice-versa*)

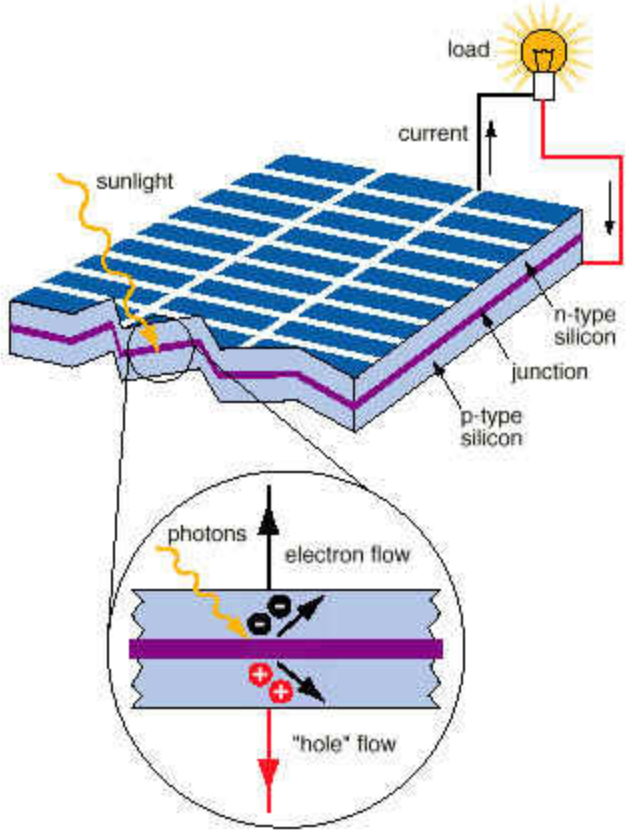
•Mouse - Movement of track ball causes electric signal

Principles of Energy Transformation

Photovoltaic Transducers

•Light of proper wavelength ionizes atoms in silicon base.

•Charges are recombined by flowing through load, creating electrical current.



Terminology

- Measurand - that property being quantified or transformed.
- Passive Transducer (Sensor) - one which draws its operating power from the measurand.
- Active Transducer - one which requires external power.
- Accuracy - how close is the measurement to the actual value?
- Resolution - how fine of a measurement can we make?
- Range - what input (and output) values are possible?

Terminology

- Sensitivity - how much does a change in input affect the output? (also called the scale factor.)

- Linearity - does the output change uniformly with the input?

- Repeatability - output signal should be the same whenever the measurand value is the same.

- Response Time - how quickly does the transducer respond to changes in the measurand value?

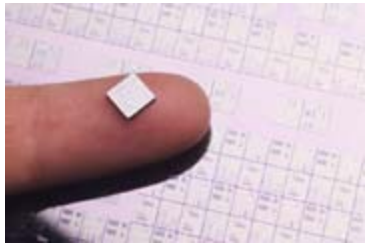
Packaging and Integration

Considerations:

- Technology
- Environment
- End User
- Cost

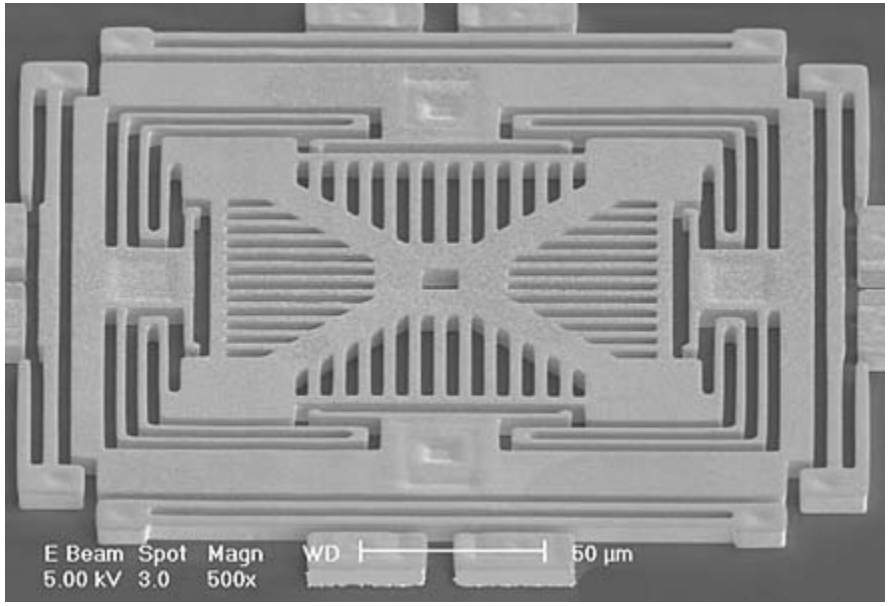
Packaging and Integration

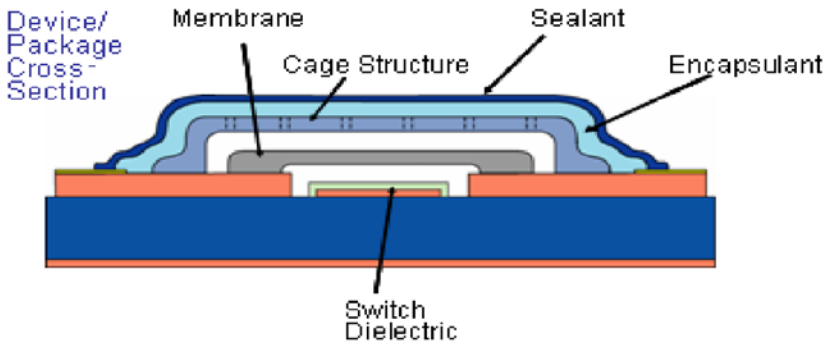
Generally, size matters - *SMALLER IS BETTER!*



Packaging and Integration

MEMS = Micro Electro Mechanical Systems





Summary

- A *transducer converts energy* from one form to another
- A *passive transducer* is called a *sensor*
- Transducer *form* is often influenced by *function* (and *vice-versa*)
- Trend is to have sensor *package as small as possible*
- *MEMS* construction holds promise for *sensor design* and *packaging*

References

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•Norton, H.N. “Handbook of Transducers” Prentice-Hall, 1989.

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•Ulaby, F.T. “Fundamentals of Applied Electromagnetics” Pearson Prentice Hall, 2004.