SMART MATERIALS

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1. General introduction on Smart Materials

1.1 Brief history of "Smart Materials"

1.2 Types of Smart Materials

1.3 Contents of the present course

1.1 Brief history of Smart Materials

1) The beginning

"Smart Materials"~1989
Prof. R. E. Newnham

Smart materials have the ability to perform both sensing and actuating functions.
-----adapt to changes in the environment.

- **Passive /active/very smart**

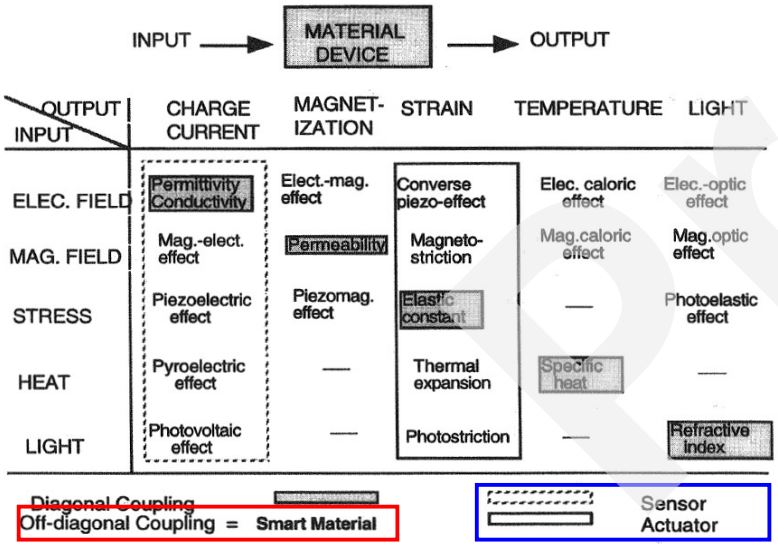
passive: response to external change without assistance ;
active: an appropriate response through an actuator circuit;
very smart: responds by altering one or more of its property coefficients.

2) Textbook definition

Smart Materials: A material which can sense a change in its environment, produce a change in response to an external stimulus or both, i.e. it can **sense and actuate**

In other words, a material which changes one of its property coefficients in response to an external stimulus, and where this change in coefficient can be used to control the stimulus

- **Sensor & Actuator**



3) Booklet of IOM^3

Dr. Diane Talbot, 2003

"Smart": something which is astute or 'operating as if by human intelligence'.

Smart materials is:
One which reacts to its environment all by itself

- **Reversible / irreversible reaction**

Environment change → **Smart Materials** → **The reaction**

temperature, stress, electrical current, magnetic field, …

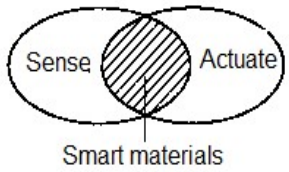
a change in volume, colour, viscosity, etc.

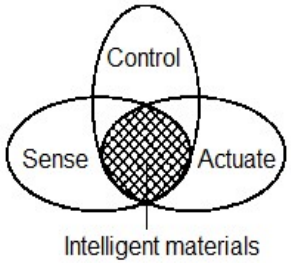
In many cases the reaction is reversible.

Illustration：

Smart materials, smart structure /system

Intelligent materials/structures, adaptive structures, etc.





Intelligent materials is the high order of the smart materials

Intelligent:

a “drive/control” or “processing” function

Smart or adaptive structures:

an electronic control circuit to provide the necessary feedback

1.2 Types of Smart Materials

Environment: external stimuli

- **Temp., Mechanical stress**
  Shape memory alloys (SMAs)
- **Stress field, Electric field**
  Piezoelectric materials
- **Magnetic field**
  Magnetostrictive materials
- **Electric or Magnetic field**
  Magneto (electro) rheological materials
- **Light, Temp. Electric field, …**
  Chromic materials

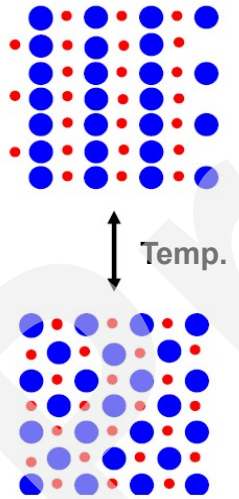
…

Shape memory alloys

A material memorizes a particular shape at a specific *temperature*

Typical materials:

1962, Nitinol



Applications:

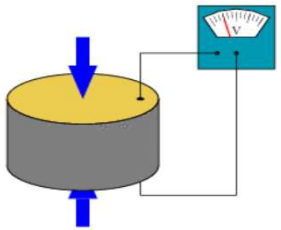
Medical
Domestic actuators
Aerospace
Manufacturing
Intelligent fabrics
…

Piezoelectric Materials

Generate electric signals when applied force, or a shape change with *voltage* (electrostriction)

Typical materials:

~1950 PZT ceramic



Piezoelectric motor

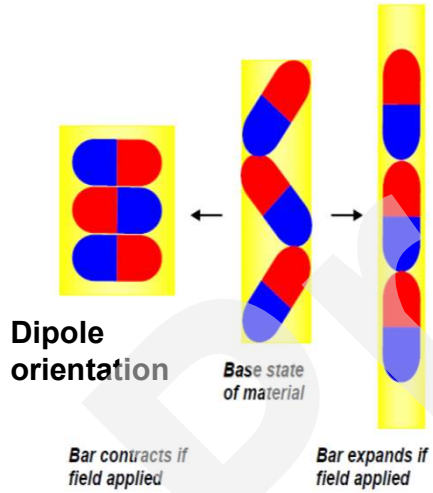
Applications:
Actuator, Sensor
Microphone and speaker, camera focus…

Magnetostrictive materials

The change in shape related to a *magnetic* field

Typical Materials:

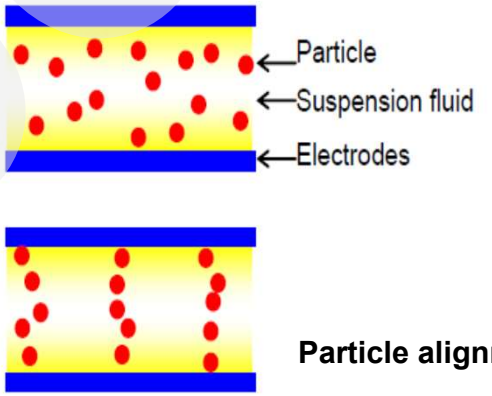
~1960 Terfenol-D



Applications:
Actuator and Sensor, Sonar

Rheological Materials

These materials can change from liquid to solid when an electrical current or magnetic field is applied.



Particle alignment

1940s

Applications: dampers, prosthetic limbs

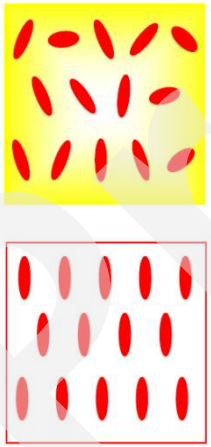
- **Chromic materials**

Which change color in response to electrical, optical, thermal, …changes.

Thermochromic materials,
Photochromic mateirals,
Electrochromic materials…

1980s

Applications:
cold beer, sunglasses



Particle alignment

1.3 Contents of our course

- Brief introduction on smart materials
- Strain and martensitic transformation
- Mechanism of shape memory effect
- Typical shape memory materials
- Fabrication & application of shape memory alloys
- Shape memory ceramics
- Polarization and ferroelectric transition
- Origin of electric field induced strain
- Typical piezoelectric materials
- Typical electrostrictive materials
- Fabrication & application of piezoelectric devices
- Future of ferroelectric devices
- Other smart materials: Magnetostrictive, Pyroelectric, Thermistor, etc.