Lahore College for Women University Lahore

Lecture:14

Course: Nanotechnology & Nanostructures

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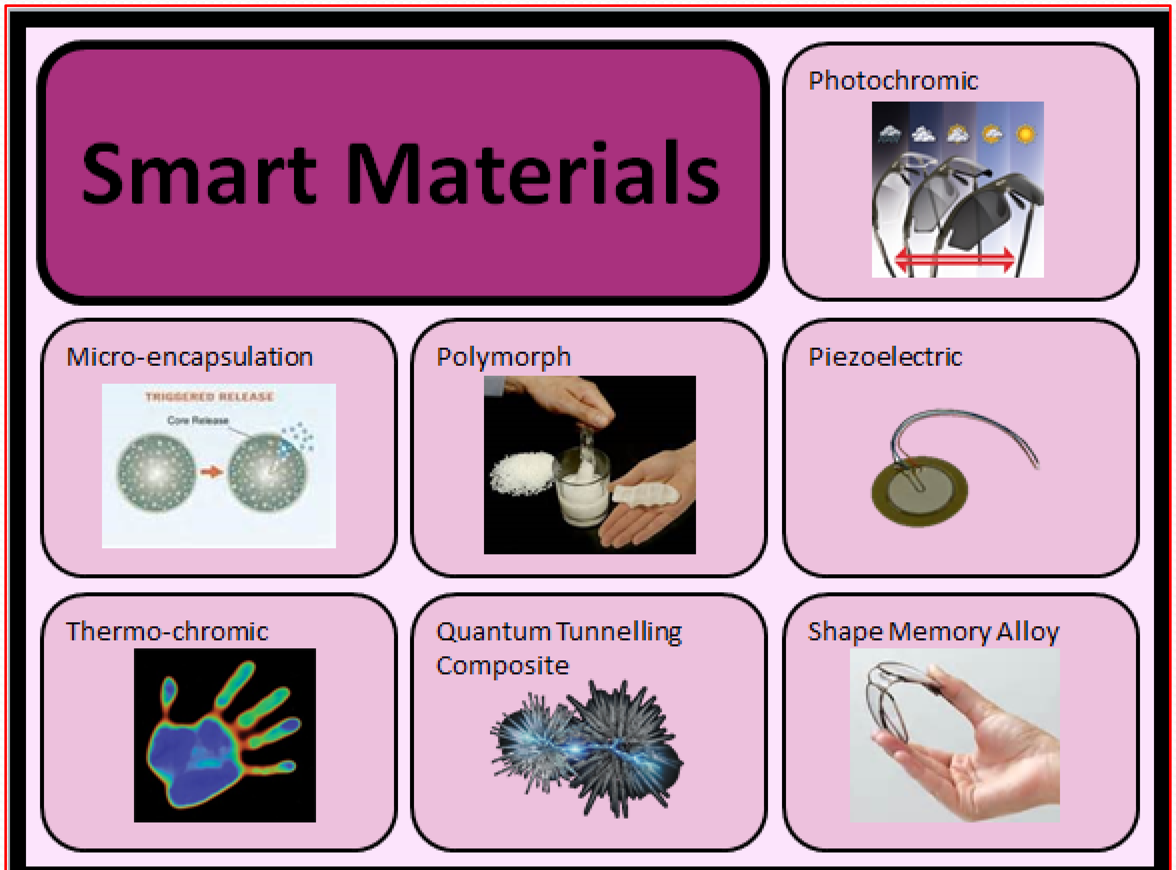
Smart Materials



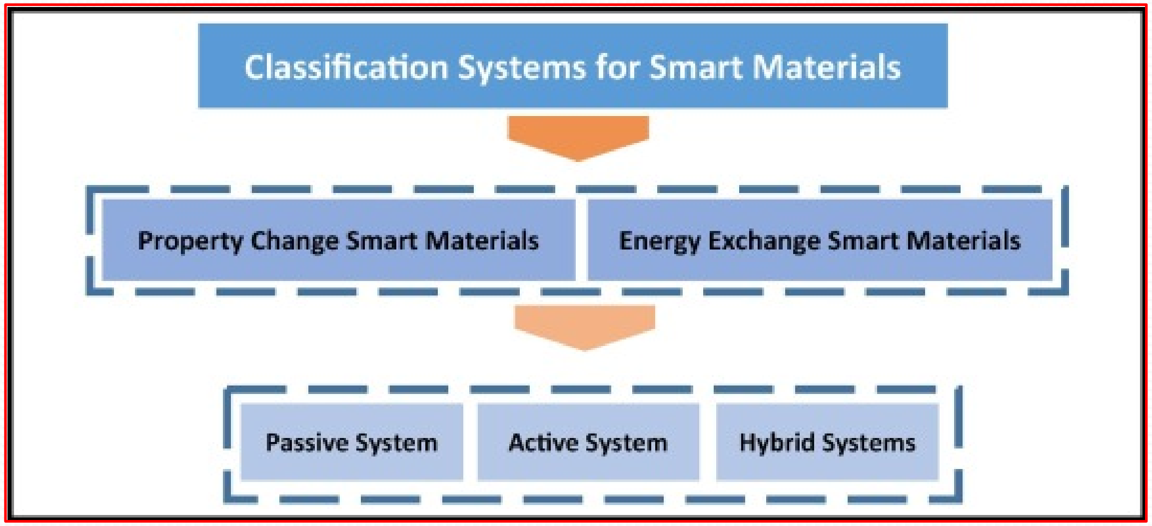
Smart Materials

- A number of materials have an apparent ability to change one or more of their properties in response to the input from an outside source.
- A variety of reactions or processes and phase changes may take place internally in a material as a consequence of the input signal from an external source that in turn alters the material's properties.

Classification of Smart Materials

- There are two different types of smart materials.

1. **Type I**
2. **Type II**

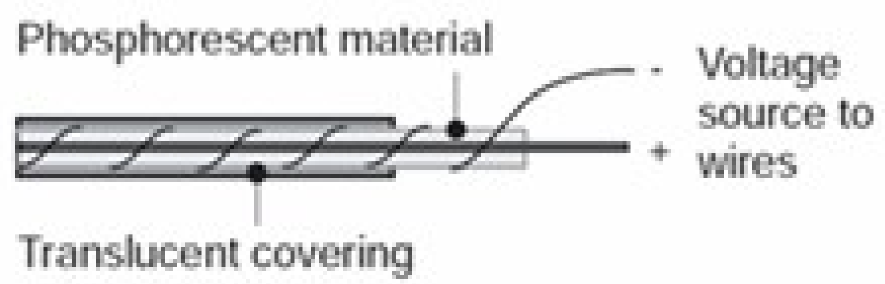


Type I-Smart Materials- Property Changing

- In these smart materials, there is an apparent change in certain properties of the material such as changes in optical properties that result in color changes.
- For example, thermochromics change their apparent color as the temperature of their surrounding environment increases and there is an input of thermal energy into the material.

Type II

- The smart material subjected to the input of one energy type changes it into another energy type as a consequence of induced internal actions and thus there is an "energy-exchanging" behavior.
- For example, in a common piezoelectric material, the input of mechanical energy causes an electrical energy output, or vice versa.

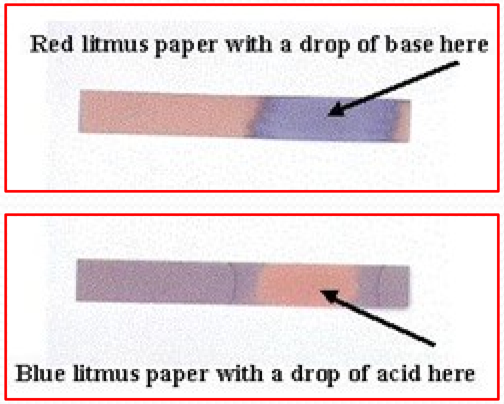


Electroluminiscent wire

TYPE OF SMART MATERIAL	INPUT		OUTPUT
Type 1 Property-changing			
Thermomochromics	Temperature difference		Color change
Photochromics	Radiation (Light)		Color change
Mechanochromics	Deformation		Color change
Chemochromics	Chemical concentration		Color change
Electrochromics	Electric potential difference		Color change
Electrorheological	Electric potential difference		Stiffness/viscosity change
Magnetorheological	Electric potential difference		Stiffness/viscosity change
Type 2 Energy-exchanging			
Electroluminescents	Electric potential difference		Light
Photoluminescents	Radiation		Light
Chemoluminescents	Chemical concentration		Light
Thermoluminescents	Temperature difference		Light
Light-emitting diodes	Electric potential difference		Light
Photovoltaics	Radiation (Light)		Electric potential difference
Type 2 Energy-exchanging (reversible)			
Piezoelectric	Deformation	⟷	Electric potential difference
Pyroelectric	Temperature difference	⟷	Electric potential difference
Thermoelectric	Temperature difference	⟷	Electric potential difference
Electrorestrictive	Electric potential difference	⟷	Deformation
Magnetorestrictive	Magnetic field	⟷	Deformation

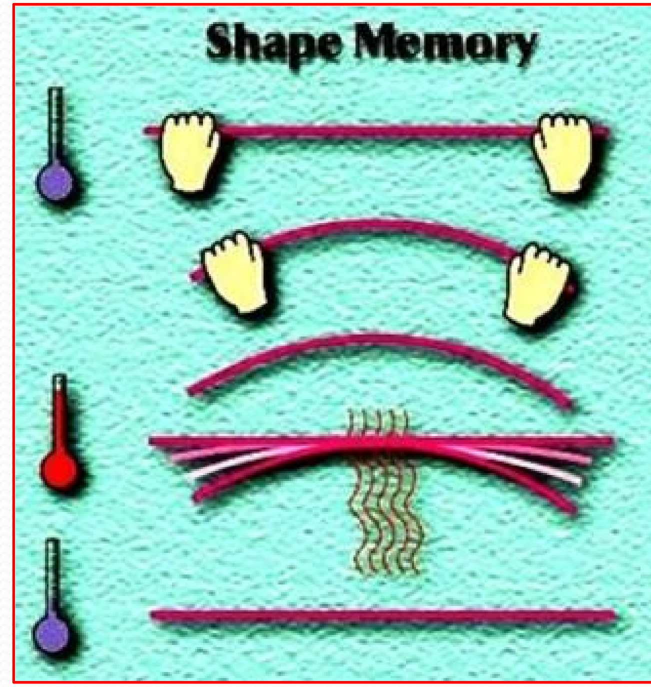
Colour Changing Property

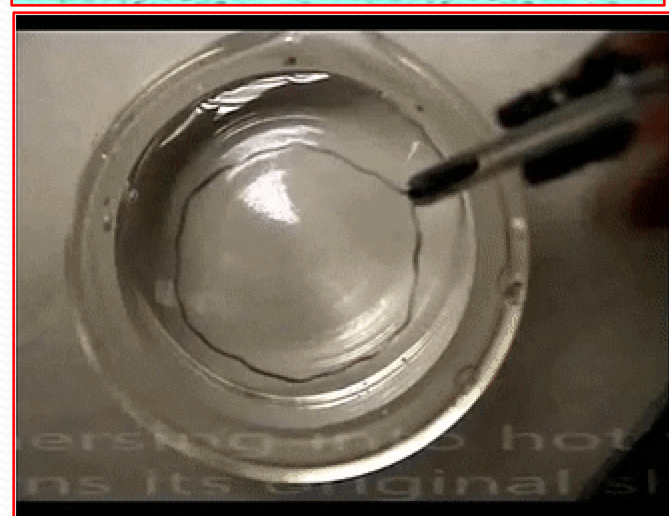
- The apparent ability of a material to change color is a light-related characteristic.
- Many existing "smart materials" have this characteristic, including thermochromics, photochromics, chemochromics, and mechanochromics. In all these materials, input of one form or another of external energy causes an apparent color change in the material.



Shape Changing Property

- There are few materials that exhibit "memory". If a piece of material with "shape-memory alloy" is deformed from an initial shape into a new shape, it will remain in the new shape. When heated to a certain critical temperature, the material will literally go back to its initial shape without mechanical aid. The material "remembers" its original shape and returns to it. The heat can be directly applied or come via an electric current.
- Materials such as TiNi have been developed for this purpose.

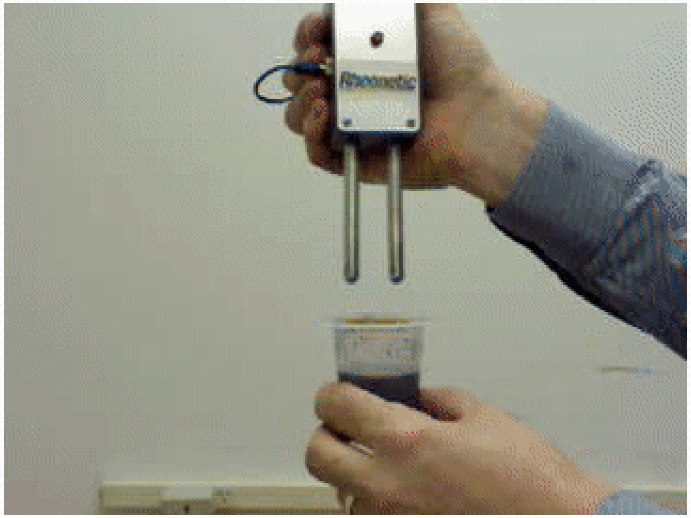




Varying Electric, Magnetic and Other Properties

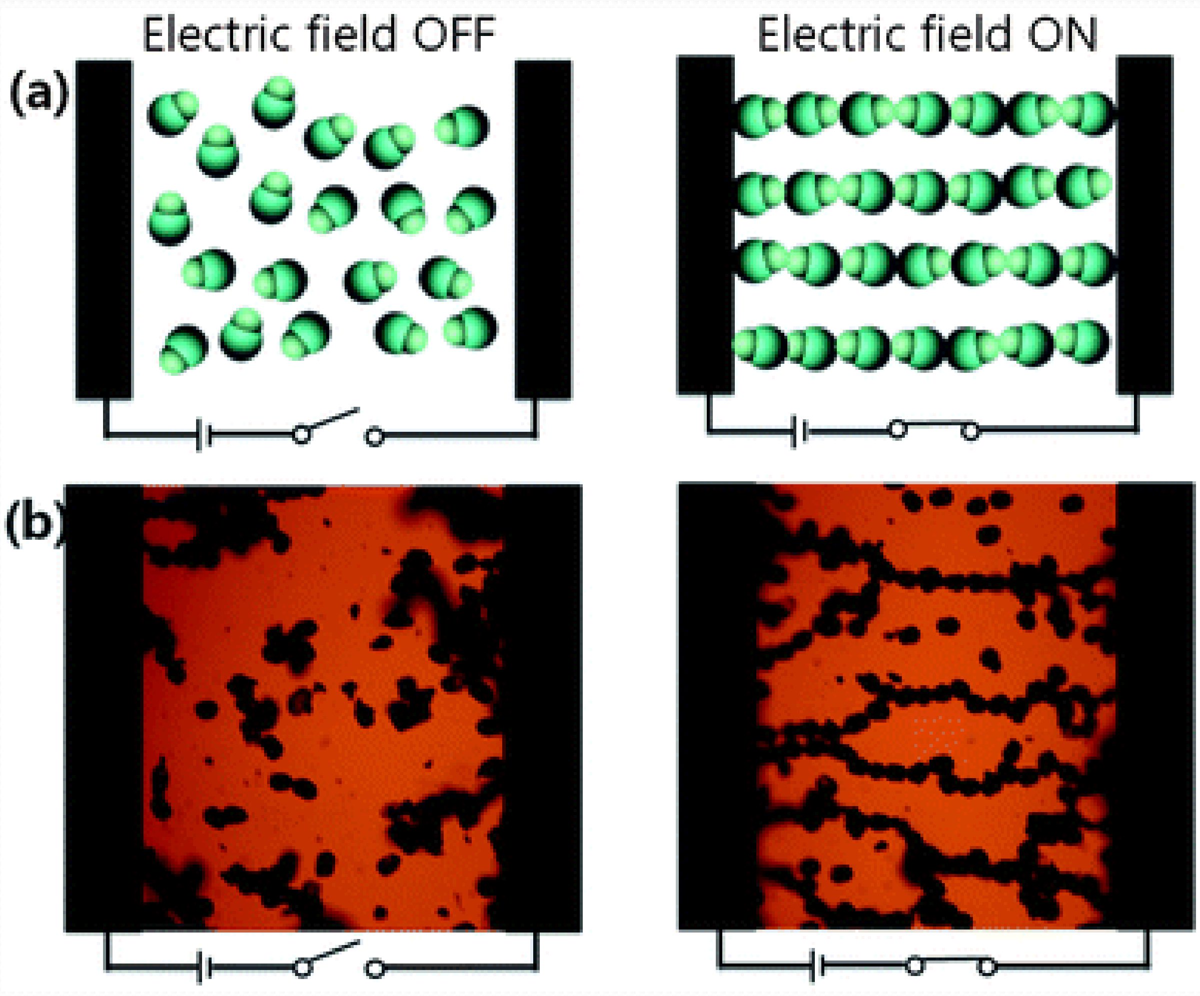
- The smart materials may have ability to change its electrical resistance, its magnetic properties, its stiffness, or even its shape via the input of some energy source. Smart materials possess one or more of these qualities. For examples:
- A magnetorheological fluid changes its rheological properties (its viscosity and stiffness) as the surrounding magnetic environment varies.
- An electrorheological fluid changes its rheological properties (its viscosity and stiffness) in response to an electric current.

- These kinds of fluids are generally "structured fluids" that contain colloidal dispersions that change phase when subjected to a magnetic or electrical field. These materials can transfroms from a very fluid state to a highly viscous state due to the changes in the electrical or magnetic environment.
- These materials have been used in automotive clutches as parts of power transfer devices.



Magnetorheological Fluid

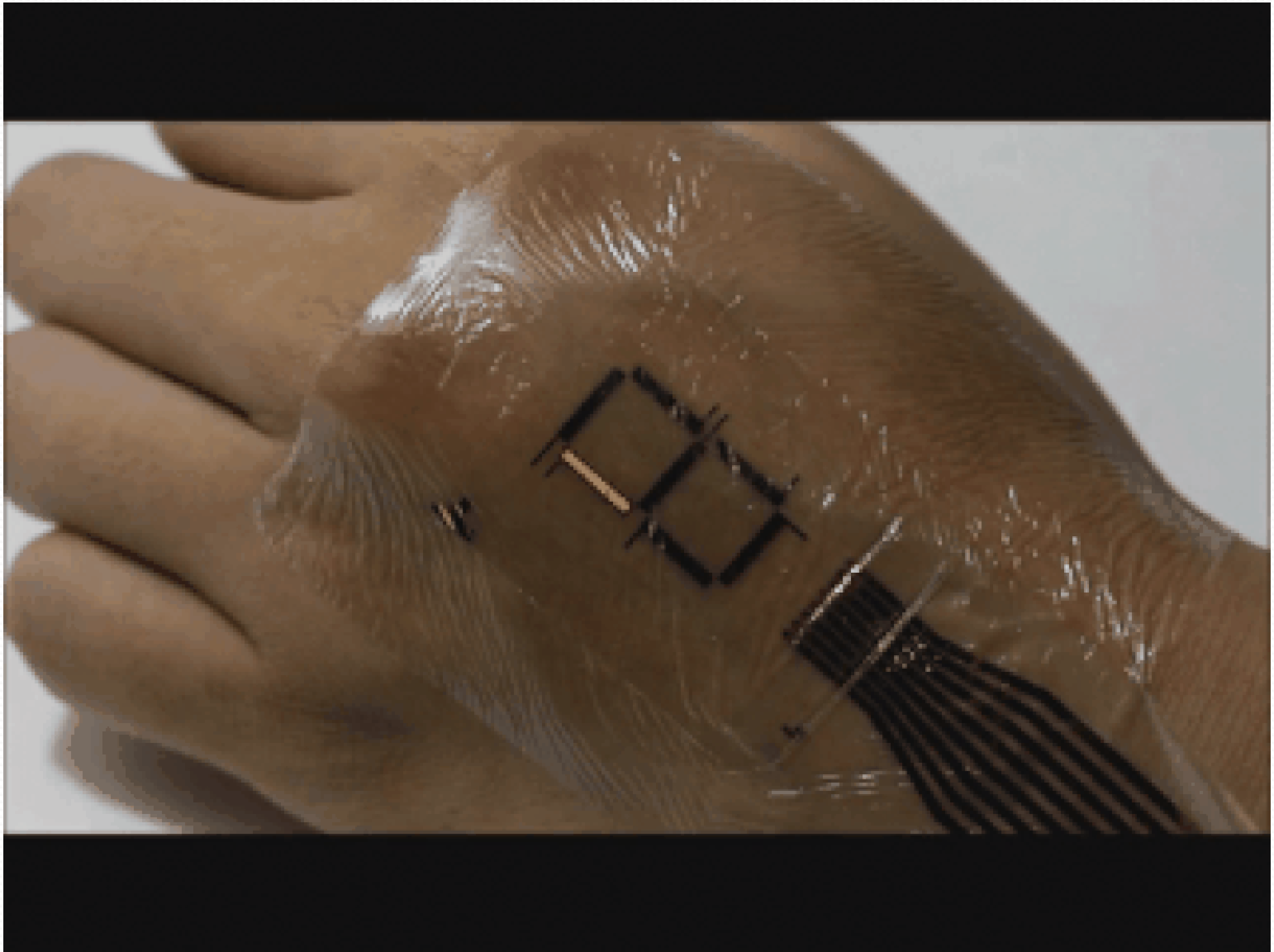
Electrorheological fluid



Smart skins and envelopes

- In developing various kinds of surface structures (skins, coverings or envelopes) that exhibit smart behavior "multifunctional" surfaces are focused.
- These surfaces might include functions varying from antibacterial to self-repairing and others.
- The smart sensor/actuator systems respond to a variety of stimuli and they are in turn linked to a comprehensive control/logic system.

Electronic Tatto turns skin into display




It has a smart sensor
that detects when your
hand is underneath it

Thank You