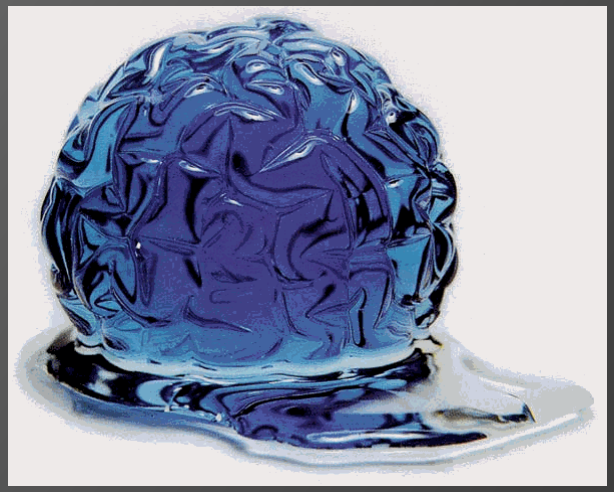

SMART MATERIAL

Metallurgical Engineering Department

What is Smart materials?

- The materials have the ability to change shape or size simply by adding a little bit of heat, or to change from a liquid to a solid almost instantly when near a magnet; these materials are called smart materials

- smart material with variable viscosity may turn from a fluid which flows easily to a solid

- A variety of smart materials already exist, and are being researched extensively. i.e.

- Piezoelectric materials
- Magneto-rheostatic material
- Electro-rheostatic materials
- Shape memory alloys.

- (coffeepots, cars, the International Space Station, eyeglasses) and the number of applications for them is growing steadily.

- **Smart materials** or designed materials are materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, temperature, moisture, pH, electric or magnetic fields.

- Piezoelectric **materials** are materials that produce a voltage when stress is applied.
- Since this effect also applies in the reverse manner, a voltage across the sample will produce stress within the sample.
- Suitably designed structures made from these materials can therefore be made that bend, expand or contract when a voltage is applied.

- used to measure fluid compositions,
  fluid density
  fluid viscosity
  force of an impact.

Magneto-rheostatic material & Electro-rheostatic materials

- Electro-rheostatic (ER) and magneto-rheostatic (MR) materials are fluids, which can experience a dramatic change in their viscosity

- These fluids can change from a thick fluid (similar to motor oil) to nearly a solid substance within the span of a millisecond when exposed to a magnetic or electric field; the effect can be completely reversed just as quickly when the field is removed.

The MR fluid is liquid as shown on the left, when no magenetic field is present, but turns solid immediately after being placed in a magnetic field on the right.

Application of MR & ER Materials

- MR fluids are being developed for use in car shocks, damping washing machine vibration, prosthetic limbs, exercise equipment, and surface polishing of machine parts.

- ER fluids have mainly been developed for use in clutches and valves, as well as engine mounts designed to reduce noise and vibration in vehicles

- **Shape-memory alloys** and shape-memory polymers are materials in which large deformation can be induced and recovered through temperature changes or stress changes (pseudo elasticity).

- The large deformation results due to martensitic phase change.

- The two main types of shape-memory alloys are the copper-aluminium-nickel,
  nickel-titanium (NiTi) alloys
- This material is a lightweight
- Solid-state alternative to conventional actuators such as hydraulic, pneumatic, and motor-based systems.
- Shape-memory alloys have applications in industries including medical and aerospace

- **Materials**
- Alloys of metals having the memory effect at different temperatures and at different percentages of its solid solution contents.
- Ag-Cd 44/49 at.% Cd
- Au-Cd 46.5/50 at.% Cd
- Cu-Al-Ni 14/14.5 wt.% Al and 3/4.5 wt.% Ni
- Cu-Sn approx. 15 at.% Sn
- Cu-Zn 38.5/41.5 wt.% Zn
- Cu-Zn-X (X = Si, Al, Sn)
- Fe-Pt approx. 25 at.% Pt
- Mn-Cu 5/35 at.% Cu
- Fe-Mn-Si
- Pt alloys
- Co-Ni-Al
- Co-Ni-Ga
- Ni-Fe-Ga

Application of Shape memory alloy

- **Aircraft**
- Boeing, General Electric Aircraft Engines, Goodrich Corporation, NASA, and All Nippon Airways developed the Variable Geometry Chevron using shape-memory alloy that reduces aircraft's engine noise.
- shape-memory coupling
- orthopaedic surgery, dental braces
- Eyeglass frames

- pH-sensitive polymers are materials that change in volume when the pH of the surrounding medium changes.

- Temperature-responsive polymers are materials which undergo changes upon temperature.

- Halochromic **materials** are commonly used materials that change their color as a result of changing acidity.

- Application is for paints that can change color to indicate corrosion in the metal underneath them.

- **Chromogenic systems** change color in response to electrical, optical or thermal changes.

- These include electro chromic materials, which change their color or opacity on the application of a voltage (e.g., liquid crystal displays), thermo chromic materials change in color depending on their temperature, and photo chromic materials, which change color in response to light—for example, light sensitive sunglasses that darken when exposed to bright sunlight.

- Photomechanical materials change shape under exposure to light.

- Self-healing materials have the intrinsic ability to repair damage due to normal usage, thus expanding the material's lifetime

- **Dielectric elastomers (DEs)** are smart material systems which produce large strains (up to 300%) under the influence of an external electric field.

- Pumps
- Valves
- Robotics
- Power Generation
- Active Vibration Control of Structures
- Optical Positioners such for auto-focus, zoom, image stabilization
- Sensing of force and pressure
- Active Braille Displays
- Speakers
- Deformable surfaces for optics and aerospace

- **Thermoelectric materials** are used to build devices that convert temperature differences into electricity and vice-versa
- two commonly employed combinations are

  1. iron and constantan

  2. Chromel – (an alloy of chromium and nickel) and alumel –an alloy of aluminum and nickel