“Making Stuff Smarter”

- Shape-Memory Material: Metals & Polymers

Agenda

- Smart Material
- Shape Memory Material
- Applications
- Hands on Activity-Explore Two Shape-Memory Metal
- Conclusion

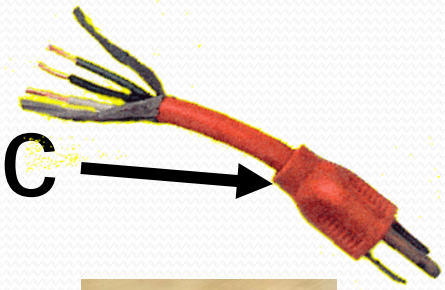
“Smart” Material

- “Respond” to changes in their environments
- Designed by Material Scientists and Engineers
- Why do we have to design new material?
- Goals for new design: Cheaper, Stronger, Greener/ Cleaner (bioplastics), Lighter, Smaller, Smarter
- Nature provides us inspiration to design smart materials
- Are there any examples of “Smart” material in nature?
- Lets think of materials around us
- Are all material smart?

Insulator –

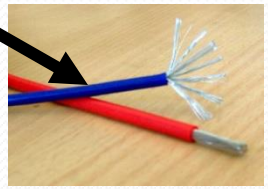
Any material that does not allow electric current to pass through it

- plastic



- cloth

- rubber

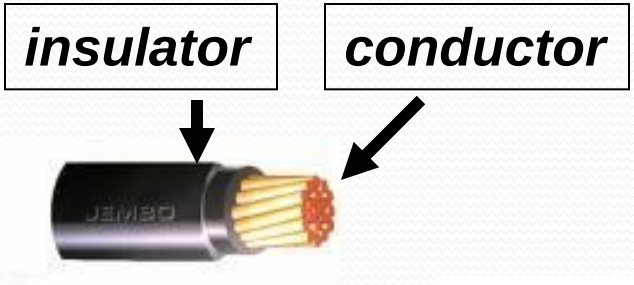


- wood

- glass

Conductor –

Any material that allows electric current to pass through it



- copper
- aluminum
- steel

- any metal

Shape Memory Material: Nitinol

- Revolutionary shape-memory materials: Nitinol
- An alloy of nickel and titanium, and see its amazing shape-memory properties.
- Can you think of an example of a such a material that we can use?

Applications of Smart Material

http://www.pbs.org

Solve problems in engineering, medicine, and everyday life

Hands-on Activity

- Two shape-memory materials : Shaper Memory alloys and Polymers
- These smart material can be programmed to return to a previously set shape when exposed to heat

Objectives:

- **You will learn :**
- **“smart” materials that can sense and respond to their environments**
- **shape-memory materials, which are smart materials that can be programmed to remember specific shapes**
- **two shape-memory materials, an alloy and a polymer**

What is an NiTiNOL?

The smart alloy in the first part of this demonstration is a nickel (Ni) and titanium (Ti) alloy named Nitinol (pronounced “night-in-all”) whose shape-memory properties were discovered at the Naval Ordnance Laboratory (NOL) in White Oak, Maryland, in 1961 (hence the name NiTiNOL).

Other shape-memory alloys are copper-aluminum-nickel, copper-zinc-aluminum, and iron-manganese-silicon

How does Nitinol work?

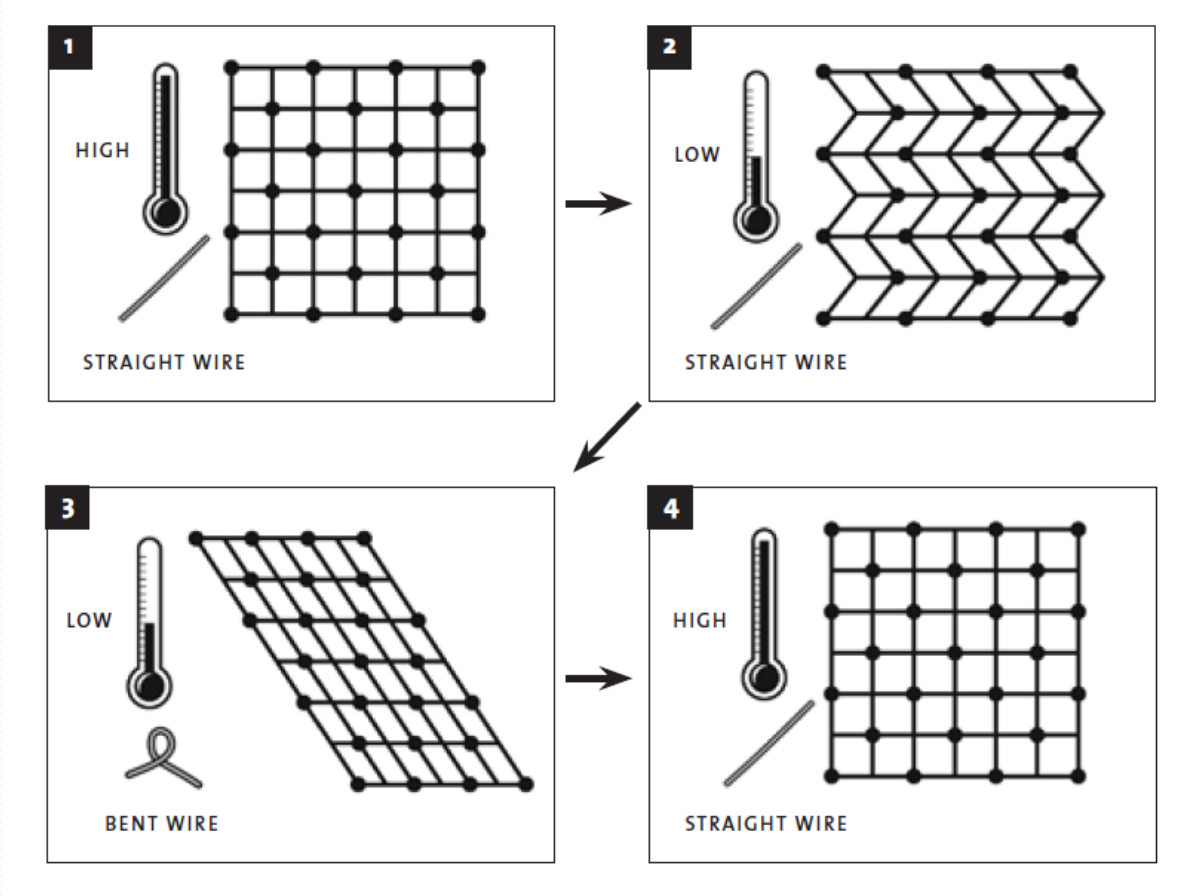
Most common materials undergo a phase change at specific transition temperatures.

For example, they change from solid to liquid at their melting points, like ice to water, or from liquid to gas at their boiling points, like water to steam.

Nitinol, however, when heated, undergoes a phase change while remaining solid. This causes its atoms to shift to a new arrangement, changing its outward shape, while remaining solid.

Heat source- will be warm water or a hair dryer-provides thermal energy for atoms to rearrange

NiTi: How It Works



NiTi: How It Works

- A shape-memory alloy has two structures or phases, which it can transition between while remaining solid. In the high temperature phase, called austenite, the atoms arrange themselves in their “memorized” or permanent shape.
- In this case, the wire is set straight (1)
- As the alloy cools and enters the low temperature phase, called martensite, the cubic structure becomes folded or twinned (2)

NiTi: How It Works

- In this state, the wire can be deformed, skewing the cubic structure(3)
- The alloy will hold that deformed shape until it is

heated back above the transition temperature, at which point the atoms revert to their austenite

state and the wire "remembers" its previous shape and straightens (4)

- Training the wire to a new memorized shape requires a blast of thermal energy on the order of 500°C (about 900°F) for the new shape to be temporarily maintained with applied force (such as pliers) until the wire sets and relaxes. Cooling the material ensures that the new shape becomes fixed.

Conclusion

Answer the following Questions:

1. What are Smart Material?
2. Give an example of an Smart Memory Material.
3. Name 3 uses for Smart Memory Material.
4. What is an alloy and What is a Polymer?
5. What happened when NiTi spring was stretched/ bend and then heated?
6. Can you think of designing any new material?

Thank you