16.982 Bio-Inspired Structures
Spring 2009

Nanomanufacturing and Smart Materials

- Nanomanufacturing.
  - Theory.
  - Applications.
- Smart Materials.
  - Theory.
  - Applications.

Nanotechnology

Nanotechnology
Nanomanufacturing
- The Complete Process
- Applications

Nanomanufacturing vs. Traditional

What are Smart materials?
- Advantages
- Types of Smart materials
- Applications
- Economical Outlook

Merging Smart Materials and Nanotechnology

References

Questions

- The term was first proposed by K. Eric Drexler in the 1970's.
- A nanometer is one billionth of a meter.
- It involves the manipulation of the structure of matter atom-by-atom.
- It is currently undergoing extensive development.
- It has not yet yielded significantly useful commercial products.

Nanomanufacturing

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- It is now quite accepted as was the idea of flying to the Moon in the pre–space age year of 1950.
- It will use nanomachines to build structures, features, devices, systems, as well as other nanomachines.
- Most research predicts that within 20 to 30 years nanomanufacturing will become a reality.

The Complete Process

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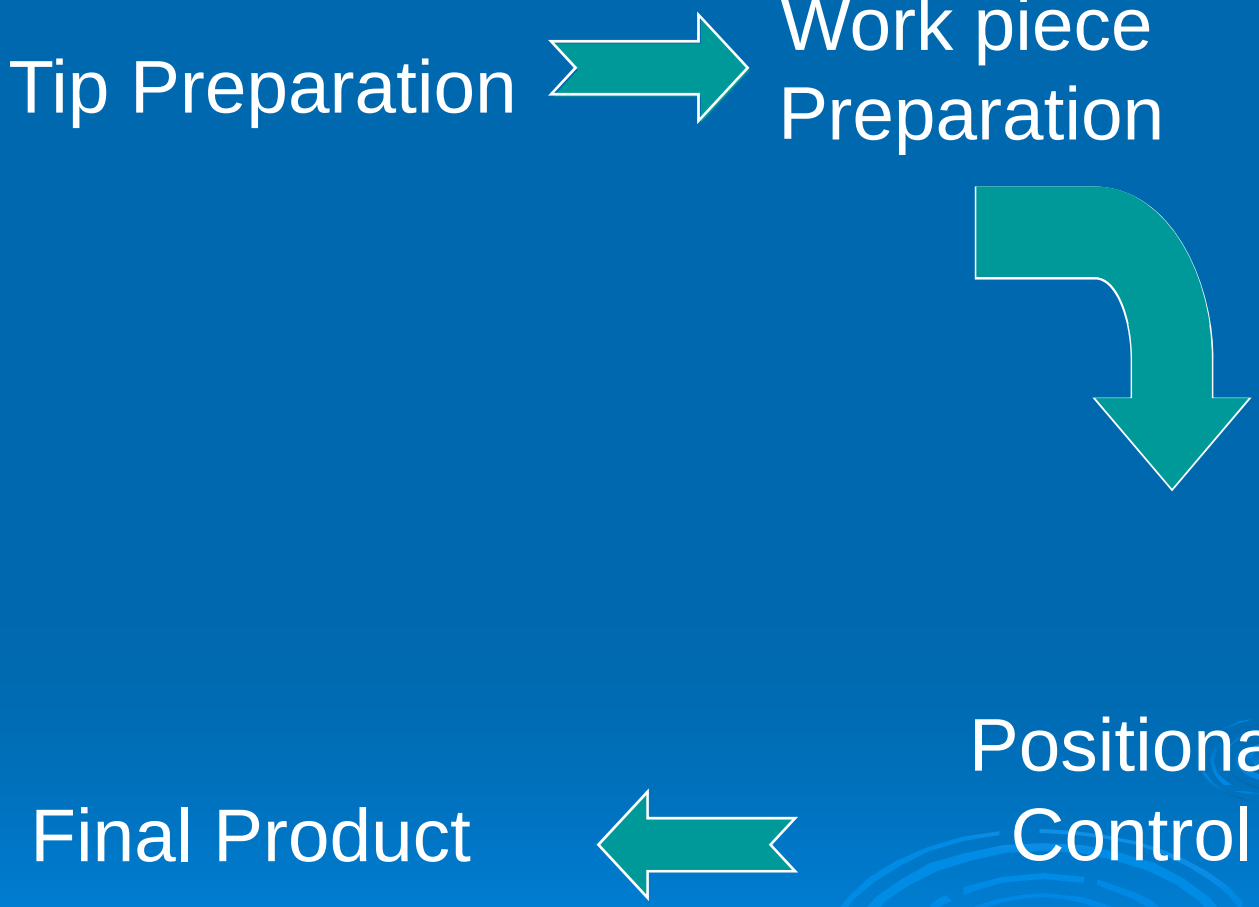

Applications

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Questions

1. Chronometry Devices.
2. Sensor units.
3. Optical devices.
4. Biomedical products.
5. Computing and information storage devices.
6. Smart materials using nanoscale devices.

Applications

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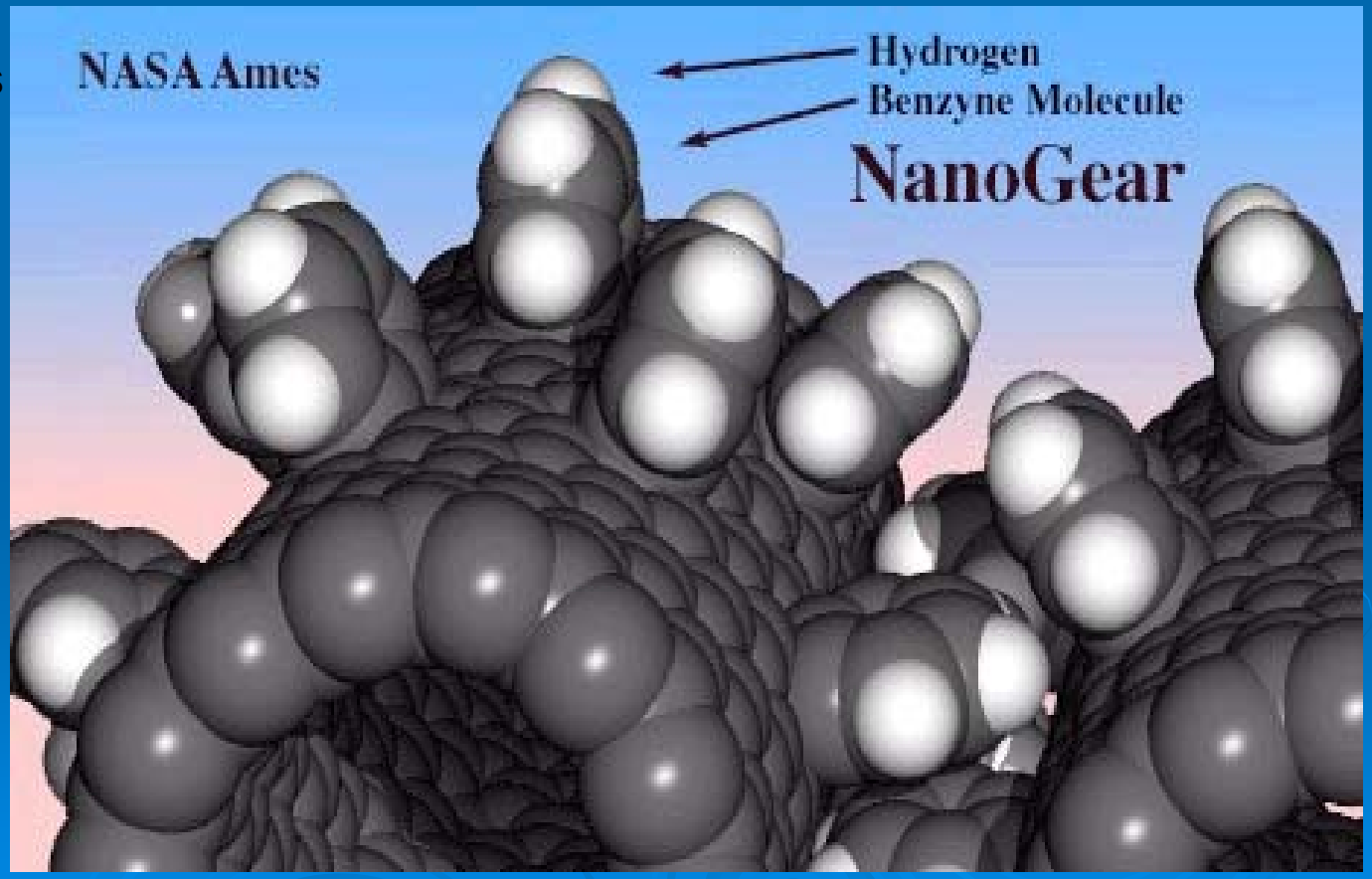

Applications

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Universal Joint

Planetary Gear

Bearing

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Bottom-up:

- Products are manufactured one atomic particle at a time.

Top-down:

- Every product begins with a bulk material process and is subsequently refined down.

What are Smart Materials?

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- Senses a stimulus (eyes).
- Takes an intelligent decision (brain).
- Through electronic feedback it takes corrective/preventive measures to avoid catastrophic situations (arm).

Advantages

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- No moving parts.
- High reliability.
- Low power requirements.
- Provide new capabilities that are presently not possible.

Types of Smart Materials

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1. Piezoelectric Materials
2. Shape Memory Alloys
3. Magnetostrictive Materials
4. Active Fluids
5. Optical Fiber Bragg Grating Sensors.

1. Piezoelectric Materials

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- Expand and contract with the application of voltage.
- Piezoceramics are the most widely used smart material.
- Applications
  - Ink Jet Printers.
  - Sonar.
  - Medical Diagnostics.
  - High frequency stereo-speakers.
  - Computer Keyboards.
  - Microphones.

2. Shape Memory Alloys

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- Are metals that can be deformed and then returned to their original shape by heating.
- Applications
  - Aeronautical applications.
  - Surgical tools.
  - Muscle wires.

3. Magnetostrictive Materials

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- Expand and contract with the application of magnetic fields.
- Applications
  - High-power sonar transducers.
  - Motors.
  - Hydraulic actuators.

4. Active Fluids

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- Respond to an electric (electrorhelogical) or a magnetic (magnetorheological) field with a change in viscosity.
- Applications
  - Tunable dampers.
  - Vibration-isolation systems.
  - Clutches.
  - Brakes.
  - Resistance Controls.

5. Optical Fiber Bragg Grating Sensors

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- Respond to strain and temperature by a shift in their optical wavelength.

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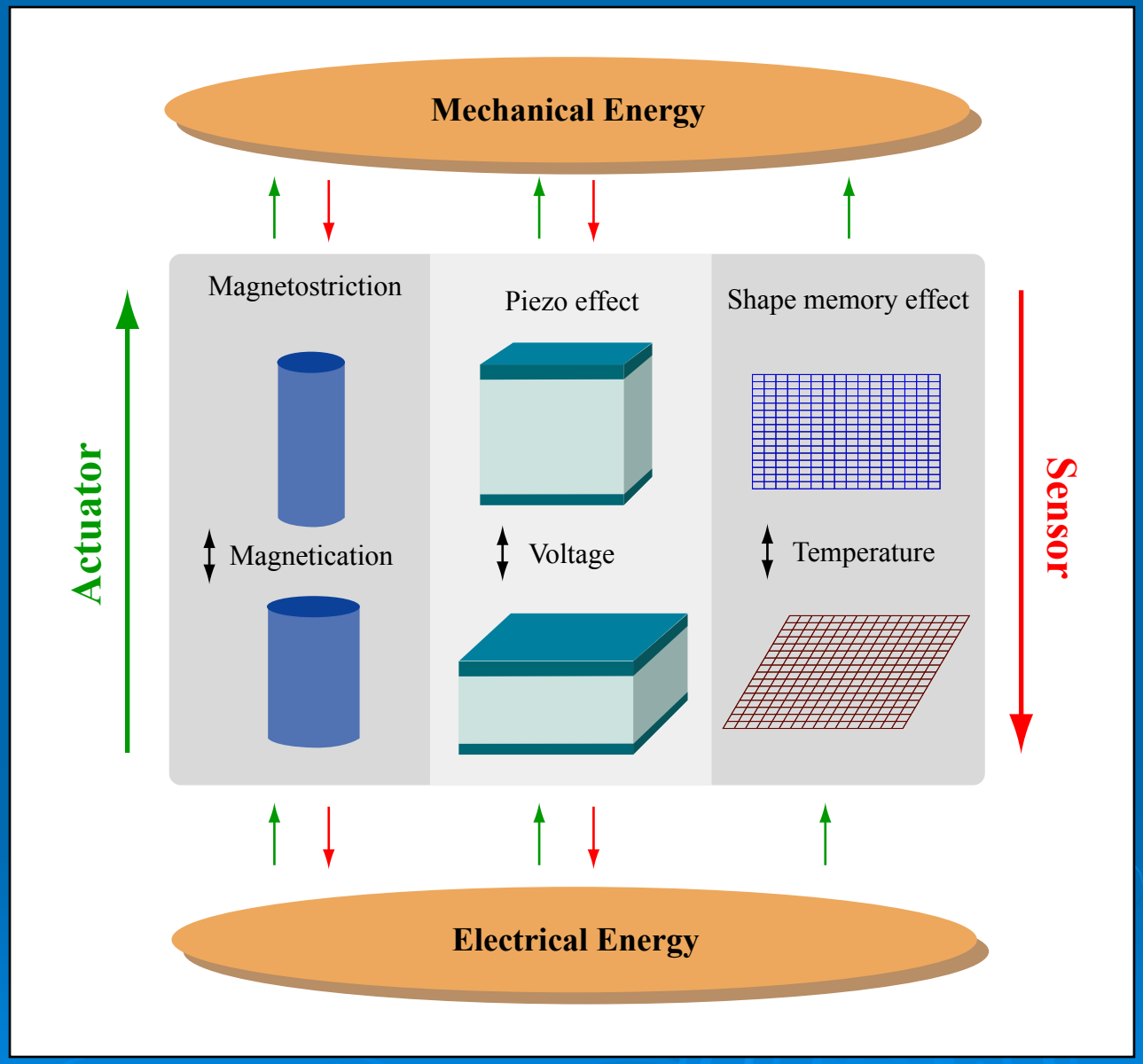

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Economical Outlook

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- $1 Billion dollar market
  - 75% - Electro-ceramics
  - 10% -Shape Memory Materials
  - 10% - Magnetostrictive materials
  - 5% - Active Fluids

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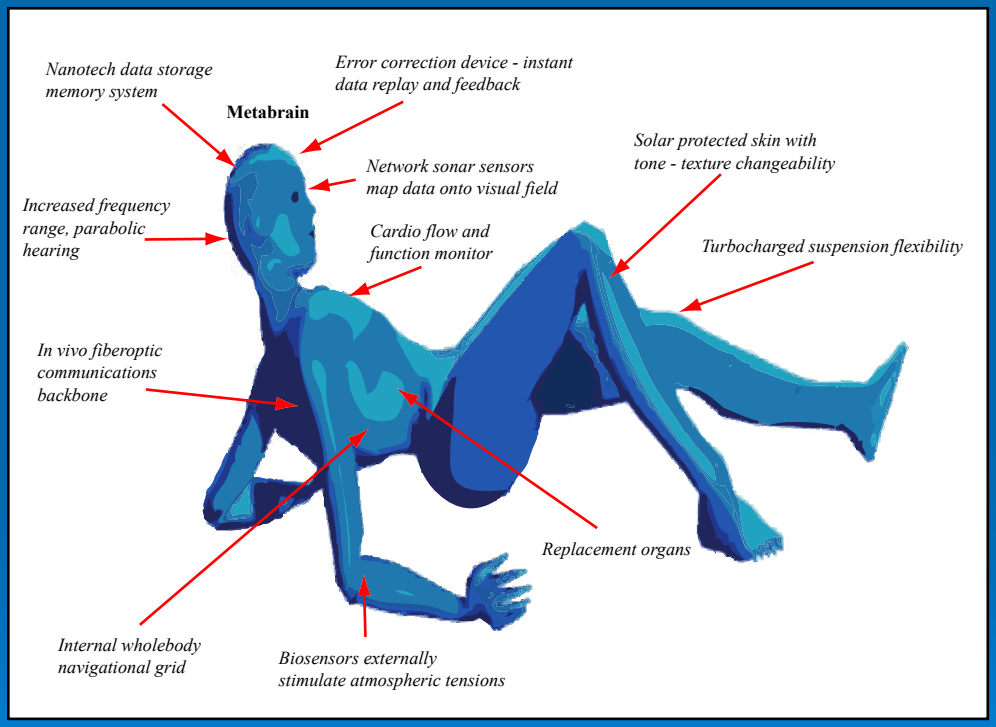

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