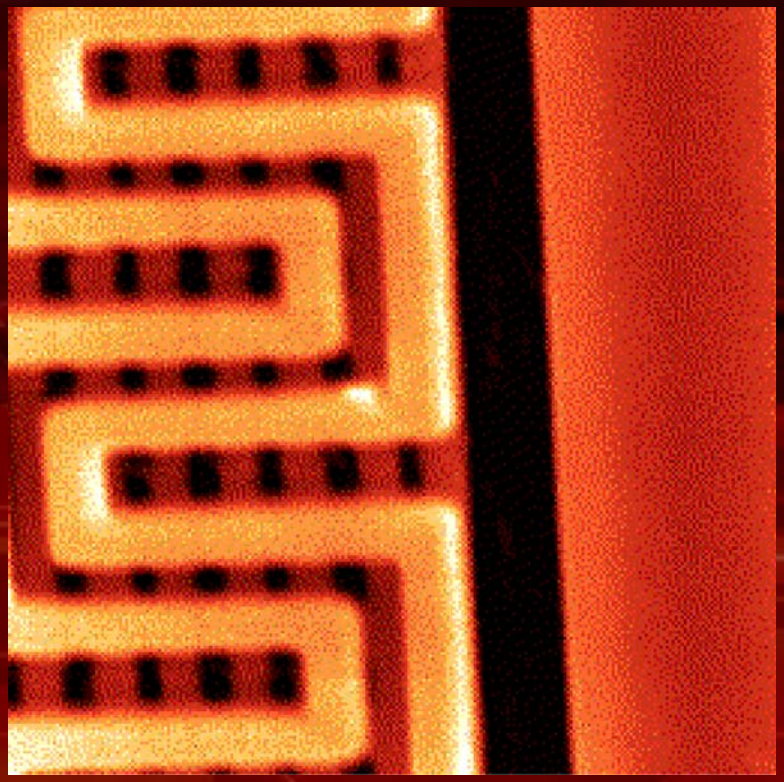
Nanosensors



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Overview

- What is a Nanosensor?
- Why Nanosensors?
- How are they made?
- Blue Crab Nanosensors
- Applications
- The Future of Nanosensors
- Challenges of mass production

What is a Nanosensor?

- Biological, chemical, or physical sensory points used to convey information about nanoparticles to the macroscopic world

Why Nanosensors?

- Smaller
- Require less power to run
- Greater sensitivity
- Better specificity

Methods of Production

- Top-down lithography
  - Starting out with larger blocks and carving out the desired form
- Bottom – up assembly
  - Starting with components such as molecules and atoms and placing them one-by-one into position to create the desired form
- Molecular Self-Assembly (2 Methods)
  - Method 1:
    - Using a piece of previously created or naturally formed nanostructure and immersing it in free atoms of its own kind, making it more prone to attract more molecules and captures free atoms and continue creating more of itself, thus larger components of nanosensors
  - Method 2:
    - Starts with a complete set of components that would automatically assemble themselves into a finished product

Blue Crab Nanosensors

- A substance found in the shell, called chitosan, is a key component used in a nanosensor, a “system on a chip” at the nanoscale
  - developed at the University of Maryland
- Detects minute quantities of explosives, bioagents, chemicals, and other dangerous materials in air and water
- This could lead to security and safety developments for airports, hospitals, etc.

What is Chitosan?

•A biological compound that readily binds to negatively charged surfaces

•It can interact with a wide variety of substances and works well in complex, sensitive devices, such as nanosensors

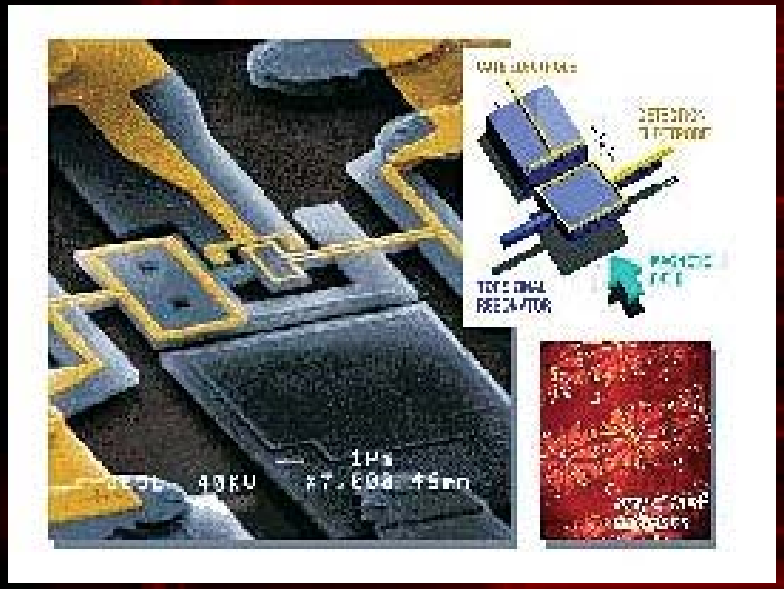
•Commonly used in weight loss supplements

How the Blue Crab Sensor Works

- Multiple mini vibrating cantilevers, which resemble diving boards, are coated with the chitosan
- Optical sensing technology is used to see when the cantilevers vibrations change
  - Different cantilevers detect different substances and concentrations

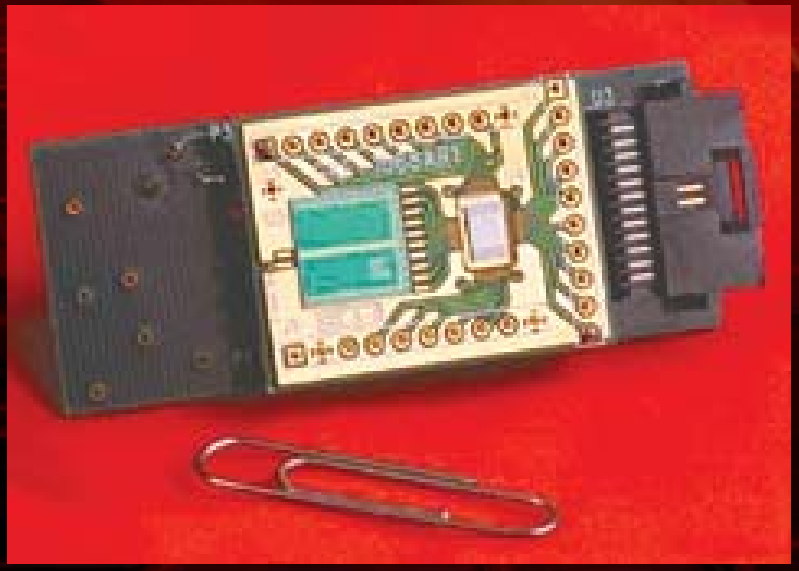
- When the targeted substance enters the device from the air/water, the chitosan on a specific cantilever interacts with the substance and causes that cantilever's vibration to change
  - The optical sensing system sees the vibration change and indicates that the substance has been detected

Types of Sensors



Electrometer:

•Consists of a torsional mechanical resonator, a detection electrode, and a gate electrode used to couple charge to the mechanical element



Chemical Sensor:

•Incorporates capacitive readout cantilevers and electronics for signal analysis

•sensitive enough to detect single chemical and biological molecules

Applications

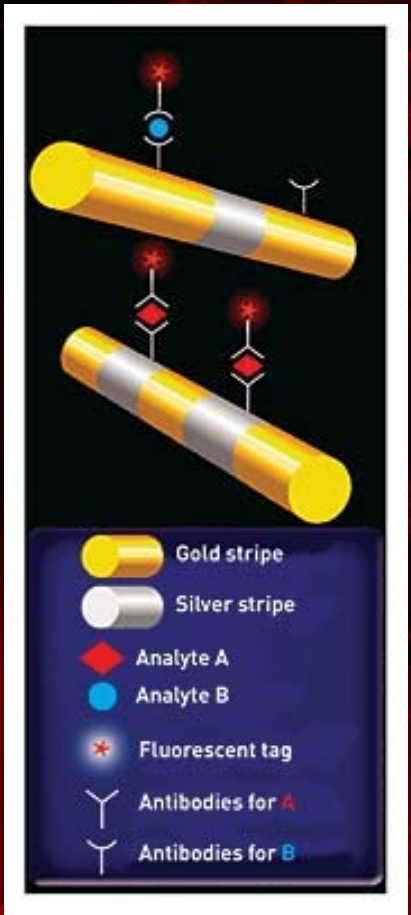
- Transportation
- Communications
- Integrated Circuits
- Building and Facilities
- Medicine
- Safety
- National Security
- Aerospace

Biosensors

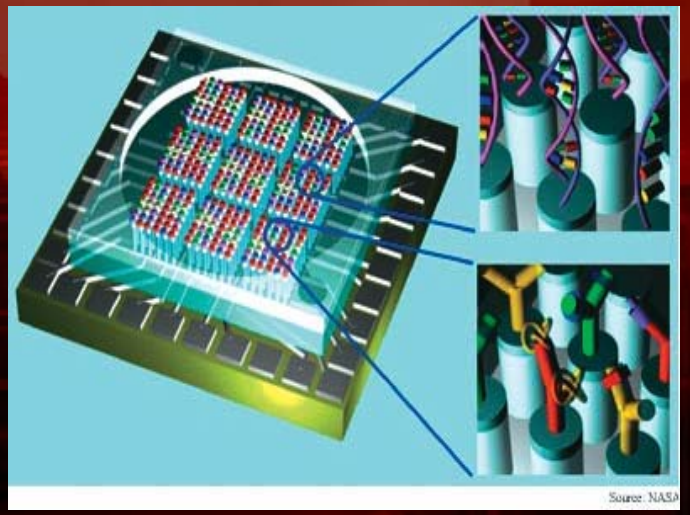
- Nanowire sensors can detect chemicals and biologics
  - Biologics are defined as any therapeutic serum, toxin, antitoxin, vaccine, virus, blood, blood component or derivative, allergenic product, or analogous product, or derivatives applicable to the prevention, treatment, or cure of injuries or diseases of man.

    (FDA Definition)
- University of Michigan researchers are developing intra-cellular devices to sense pre-malignant cancerous changes in living cells
  - The devices are created from synthetic polymers, called dendrimers, that are made layer-by-layer into spheres with diameters of less than 5nm
- Nanosensor to detect asthma attacks up to 3 weeks in advance

Biosensors



•DNA and other biomaterials can be sensed using encoded antibodies on Nanobarcode particles



•DNA molecules attach to the ends of vertical carbon nanotubes that are grown on a silicon chip

•These detect specific types of DNA in an analyte

Military / National Security

The SnifferSTAR is a nano-enabled chemical sensor that is integrated into a micro unmanned aerial vehicle

- A lightweight, portable chemical detection system combines a nanomaterial for sample collection and concentration with a MEM based “chemical lab-on-a-chip” detector.
- Most likely to be used in defense and homeland security

Aerospace

- Nanosensors can pass through membranes and into white blood cells, called lymphocytes, to detect early radiation damage or infection in astronauts

- May be able to eventually be administered through the skin every few weeks, avoiding injections or IVs during space missions

- This eliminates the need to draw and test blood

The Future

- Could lead to tiny, low power, smart sensors manufactured cheaply in large quantities
- Service areas could include:
  - Situ sensing of structural materials
  - Sensor redundancy in systems
  - Size and weight constrained structures
    - Satellites and space platforms

Challenges

- Reducing the cost of materials and devices
- Improving reliability
- Packaging the devices into useful products
- Mass-producing
  - Methods are typically incompatible with those used in making electronics that amplify and process the signals the nanowires generate

Resources

- General Information:
  - http://www.sensorsmag.com/sensors/article/articleDetail.jsp?id=361237
  - http://www.technologyreview.com/Nanotech/18127/
  - http://en.wikipedia.org/wiki/Nanosensor
- Biosensors:
  - http://blogs.zdnet.com/emergingtech/?p=672
  - http://www.lymphomation.org/biologics.htm
- Blue Crab Nanosensors:
  - http://www.technologynewsdaily.com/node/3907
  - http://en.wikipedia.org/wiki/Chitosan
- Aeronautics
  - http://www.sciencedaily.com/releases/2002/07/020711080818.htm

QUESTIONS ???