Nanosensors: A Quick Look

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Nanosensors

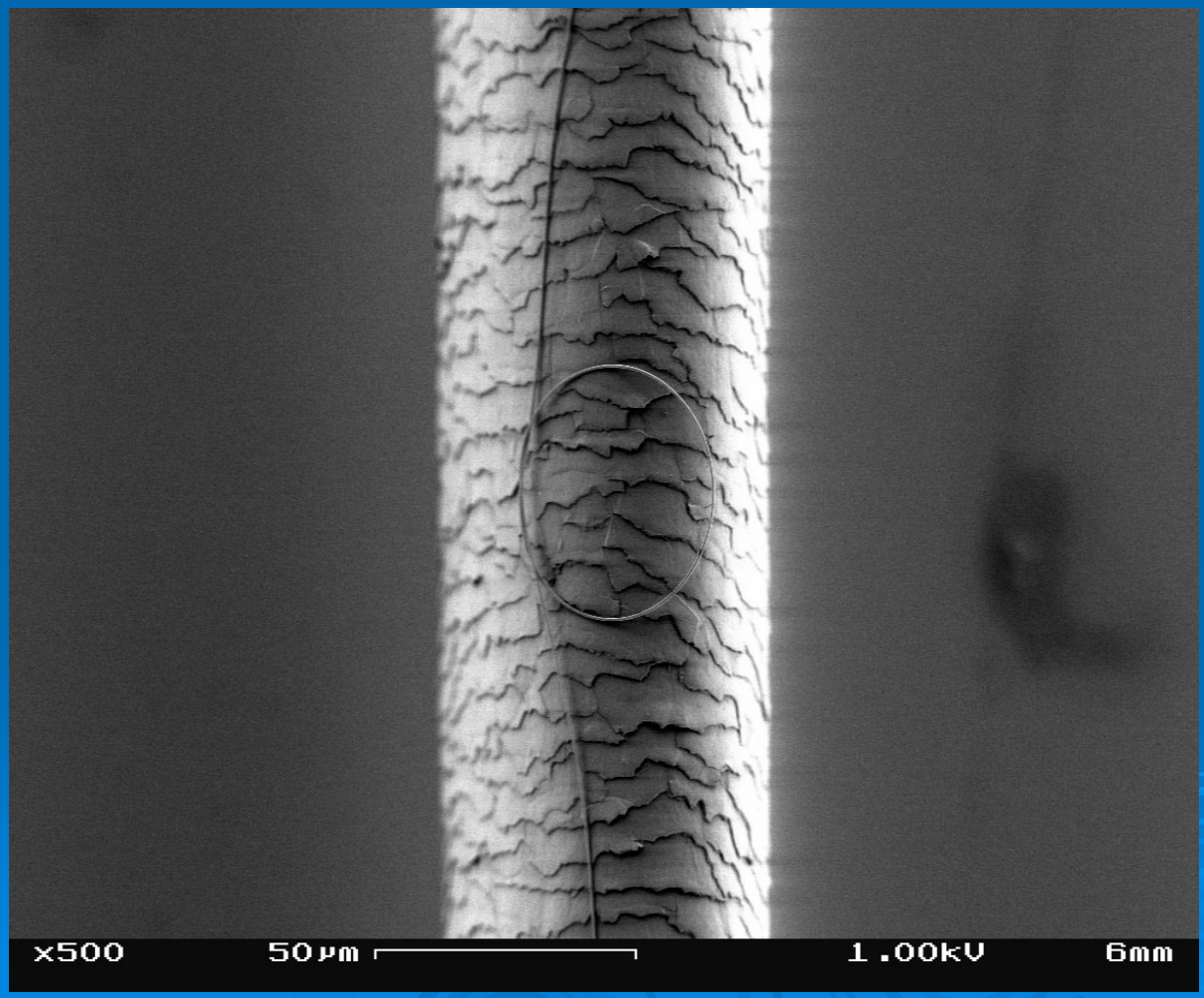
- What is a nanosensor?
- How do they differ from other sensors?
- What can or do they “sense”?
- What is an active sensor vs. a passive sensor?
- How might they be useful in the pulp and paper industry and allied industries?

What is a nanosensor?

- It can be a sensor that is itself on the nanoscale of 10 to 100 nanometers.
- It can be a sensor that will detect the presence of nanomaterials or molecules in that size range or smaller.

Nanowire curled into loop in front of a human hair (nanowire is about 50nm in width)

Credit: Limin Tong, Harvard University



How is a nanosensor different from conventional sensors?

- Conventional sensors are usually quite large from handheld devices up to mounted units the size of a small TV set.
- Nanosensors will be much smaller, the sensor could be a small test strip of paper or film type of material.
- The sensitivity or detection range of nanosensors can range down to just a few molecules of a specific inorganic, organic, or biological material.

Fluid Channel Nanosensors

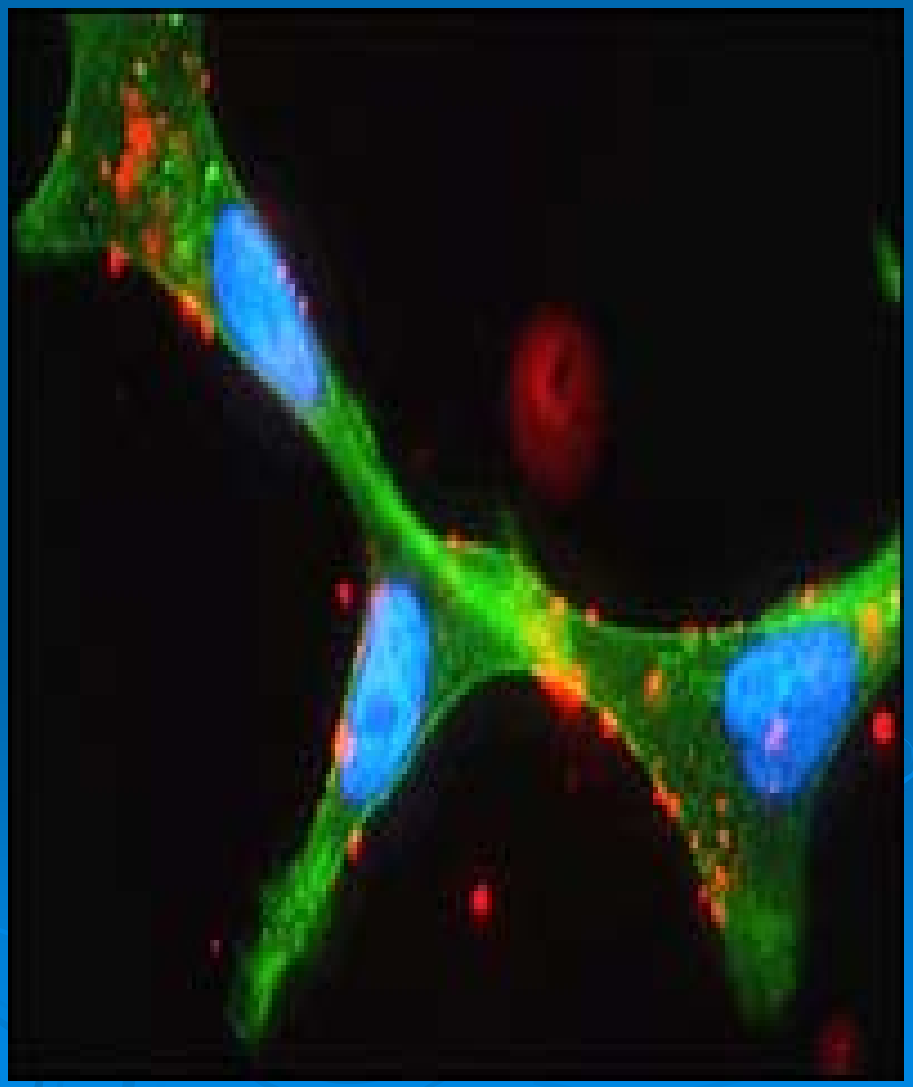
- Manufacturing of **fluidic boards** for microanalysis or for bottom up **nano engineering of delicate products** (food, medicines).
- As the manufacturing technology using the **phase separation molding in a roll-to-roll process**, high volume and low costs are within reach.
- With molding features below 1µm, the active structures can be incorporated in the fluid channel board as well, making a product even smaller. Add the possibility of **optical structures, microporous membranes and contact holes in the same device**, the micro analysis system or **nano production reactor** is working.

What can a nanosensor detect?

- A specific gas, hydrogen sulfide, ammonia, warfare gases.
- A specific organic molecule such as an alcohol, fatty acid, lipid, or amino acid.
- Biologically active materials such as ATP or pathogen.
- A change in pH, temperature, conductivity, or moisture.

Using nanoparticles to deliver drugs to surface of abnormal cancerous cells

- Researchers can put different things on inside or outside of nanoparticles.
- Nanoparticles work like a bus that can safely deliver passengers to different destinations.
- To hit cancerous cells, nanoparticles are “decorated” with aptamers (tiny chunks of genetic material).
- Aptamers act like **sensors with “homing devices”** that recognize surface molecules on cancer cells and avoid normal cells.



Recent Nanosensor Articles

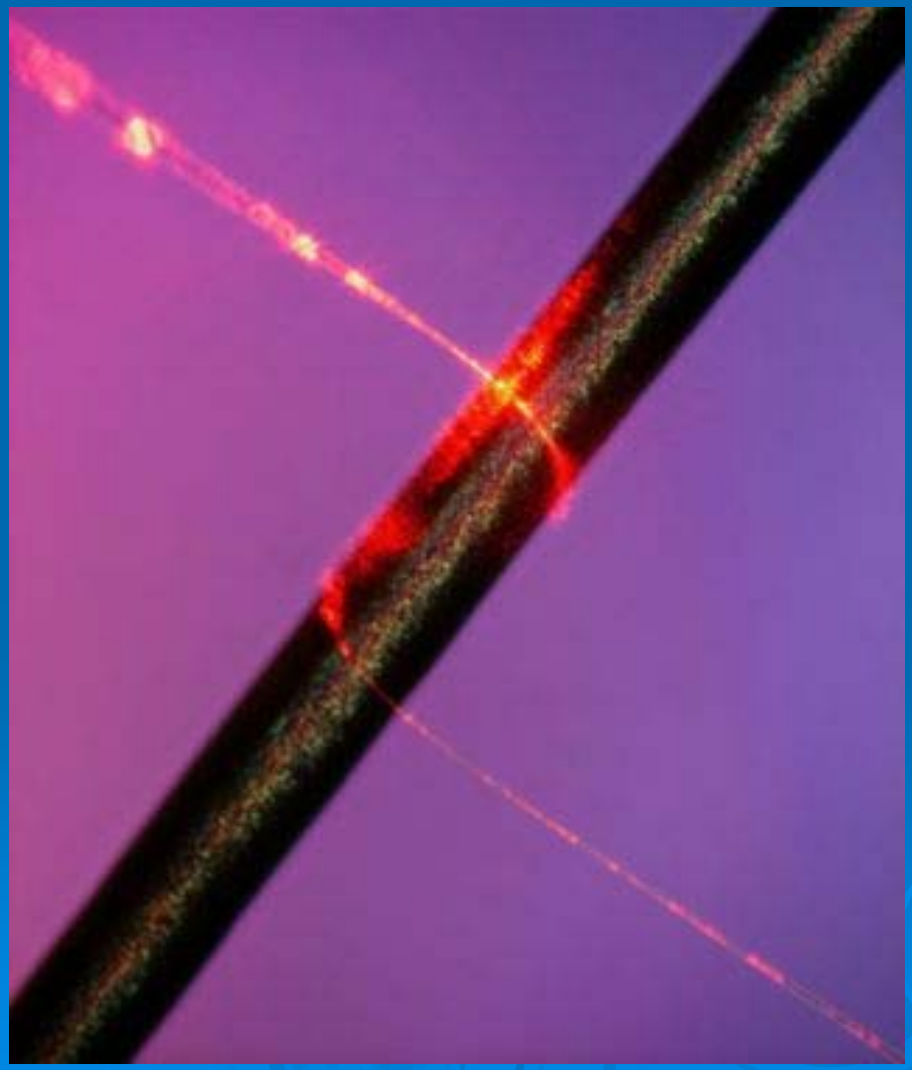
- Poly (Decyl methacrylate)-based **Fluorescent PEBBLE Swarm Nanosensors for Measuring Dissolved Oxygen in Biosamples**, Y. Cao, Y.-E. Koo and R. Kopelman, Analyst, **129**, 745-750 (2004).
- Development of a **Hydroxyl Radical Ratiometric Nanoprobe**, M. King and R. Kopelman, Sensors and Actuators B: Chemical **90,** 76-81 (2003).

What is an “active” sensor vs. a “passive” sensor?

- An active nanosensor would have the ability to send a signal that could be received remotely. For example, an embedded nanosensor in a stationary position in a water reservoir, lake, or stream could detect the presence of a dangerous pathogen and send a signal.
- A passive nanosensor would rely on observation of a change in color, opacity, or fluorescence.

Beam of light being wrapped around a silica nanowire

Credit: Limin Tong, Harvard University



How might nanosensors be useful in the pulp & paper industry??

- Production of printable sensors on specialized papers could provide a new market niche for innovative producers.
- Nanosensors could detect early changes in water quality from mill outfalls and allow them to respond faster to prevent problems with discharges.
- Nanosensors embedded in production processes could give better feedback for tighter control of quality specifications for critical production steps or final product quality (moisture, opacity, brightness, etc).

Are nanosensors here or are they “science fiction”?

- Nanosensors are already available and many more sophisticated ones are being developed.
- Sensors for detection of certain biological materials are a very hot area, particularly the presence of disease agents.
- The use of antibodies and enzymes gives true nanosensing capabilities since the detection levels are down to a few molecules for some biological markers.
- Detection of or a change in fluorescence is a widely used detection method for nanoscale materials.

Future of Nanosensors

- Nanosensor development will be rapid.
- Almost any applications that can be envisioned will more than likely be reduced to practice in the next ten years or less.
- There will likely be a shift from very specialized diagnostic (pharmaceutical) uses to more everyday uses (food display quality, air and water quality monitoring).

Thank You!