New Jersey Nanotechnology Consortium

Pharmaceuticals and Biotechnology

Harnessing Nanotechnology for the Pharmaceutical and Biotechnology Industries

Nanotechnology is triggering a new era in the pharmaceutical and biotechnology industries which will affect our lives in the same way as microelectronics did at the beginning of the information age.

Whether the approach is "bottom- up" (such as molecular self-assembly) or "top- down" (scaling down microfabrication to nanofabrication in the sub-100 nanometer regime), nanotechnology has created new excitement in the scientific community. The micro- and nano-fabrication techniques that revolutionized the electronics industry can now be applied to life sciences. We are able to manipulate a wide range of structures in life science, from DNA in the nanometer scale to red blood cells in the micrometer scale, to create new pharmaceutical and biomedical products that are likely to have a profound effect on the human condition.

Focusing the NJNC's Core Competencies on Pharmaceutical and Biotechnology Applications

The New Jersey Nanotechnology Consortium (NJNC) is at the forefront of nanofabrication, applying manufacturing and scientific expertise to help pharmaceutical and biotechnology companies speed research and shorten time to market for new products. The NJNC's nanotechnology expertise has applications in drug discovery and delivery, biochemical and biomedical devices, and biomaterials and genomic engineering.

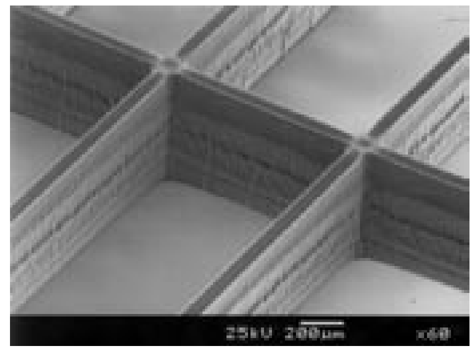
The NJNC staff has decades of electronics and microsystems experience and is well qualified to assist pharmaceutical and biotechnology companies in creating innovative new products. Customers can bring exclusive new products to market sooner, protected by a broader patent portfolio.

Pharmaceutical Applications

Drug Discovery

The NJNC can assist customers in developing new methods for drug discovery. When designing a new drug, pharmaceutical companies must test it against thousands of possible biological agents, some as small and difficult to detect as a molecule, an enzyme, or a single gene or protein. Today's "high throughput" cell assay runs can typically analyze hundreds of genes with limited sensitivity. This procedure is long, complicated, and could benefit from nanotechnology techniques that improve test sensitivity. The NJNC proposes to increase the array numbers by several orders of magnitude to encompass the entire genome in a single test run. This will dramatically accelerate the drug discovery process.

Figure 1: Fluidic cavities on membranes with >400um deep wells



Drug Delivery

Novel drug delivery methods such as targeted delivery and metered dosage can be done with bio-compatible nanodevices using patterned porous membranes, micro-reservoirs, fluidic channels, micro-scale needles, and pumps and valves that can be implanted and remotely controlled by integrated RF technology.

Figure 2: The NJNC's wafer with fluidic channels and reactors suitable for "lab-on-a-chip"

Surface Biochemical Sensors

Smaller and more sensitive biochemical sensors are needed for diagnostics to protect against bioterrorism. The NJNC can make biochemical sensors many times more sensitive by increasing the surface area with deep silicon etching technology and compact integration of circuit components. "Dense Forest", sub-500nm diameter detector tips that are tens of microns tall, can be mass-produced with near perfect uniformity. The surface area and density can be tailored to meet the level of sensitivity required for specific applications.

Figure 3: "Dense Forest" and tall detector tips for biochemical sensing. Each tip is 10um tall and 320nm in diameter

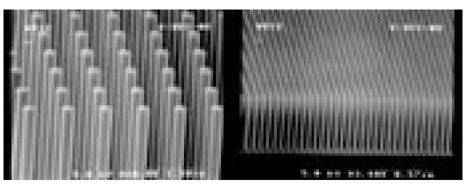
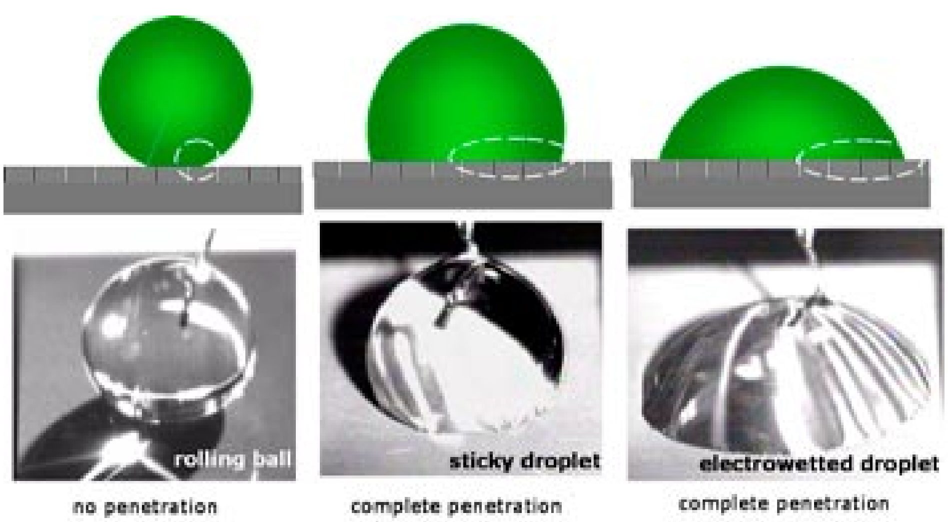


Figure 4: Photographs and schematics of making fluid roll, stick, or wet simply by changing the nanostructure at the interface.



Micro- & Nano-fluidics

Whether it is hermetically sealed reservoirs or friction-free micro and nano channels, delicate membranes or intricate micro valves, the NJNC's expertise in MEMS and nano device design, coupled with our unique processing, makes it all possible. We can make fluid flow along a surface without sticking. By modifying nano- features on a silicon substrate, the fluid in contact can be made to either wet the surface or roll along the surface without sticking. There are several ways to make it wet or roll: electrically, thermally, or by controlling the material property. These techniques enable fluid flow with and without slip at the wall boundary, making customized fluid flow and mixing possible. This expertise is part of the NJNC's inventory of enabling technology that may be used to create new "lab-on-a-chip" devices.

Biomedical Applications

Adaptive Optics for Ophthalmology

The NJNC has made adaptive optics chips that benefit ophthalmology. Such chips can monitor and compensate for defects in the cornea and lenses of the human eye. Our superb MEMS technology allows us to improve membrane mirrors in both functional complexity and device performance. We get better resolution by increasing the number of mirrors to the thousands and give a 3x improvement in stroke distance. Dry etch enables the desirable geometry to match the human eye and significantly enhances process yield. Adaptive optics can improve vision correction, preview results of LASIK surgery, diagnose retinal disease, and study human vision.

Figure 5: Adaptive optics chip suitable for human vision science

Pressure Sensor for Cardiology

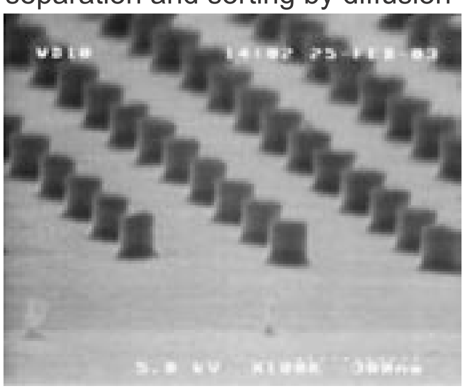
The NJNC capitalizes on its optical and silicon expertise for biomedical applications. Fiber optics are applied today in catheters for percutaneous transmyocardial revascularization (PTMR) in cardiology. There is a strong demand to be able to attach to these within-catheter fiber tips nano-devices that can monitor pressure, flow, temperature, or electrical signal, or to manipulate blood cells or plaque obstacles. This is a perfect match for our traditional strength in optical switches and modulators, which use transducer technology for sensors and micro-manipulators and transmit the signals by optical fibers. It opens up a broad range of on site monitoring and corrective possibilities for cardiology and other biomedical disciplines.

Biotechnology Applications

Genomics

The NJNC is making nano-structures that can significantly reduce the cost of DNA sequencing and make it a more common diagnostic tool. Molecular separation for DNA can be achieved with sorting by diffusion through an obstacle course of repetitive structures, currently in the tens of microns sizes. Researchers in the field desire finer structures that can help refine the sorting and reduce cost by orders of magnitude. In response, we are making sub-100nm structures that are one hundred times smaller.

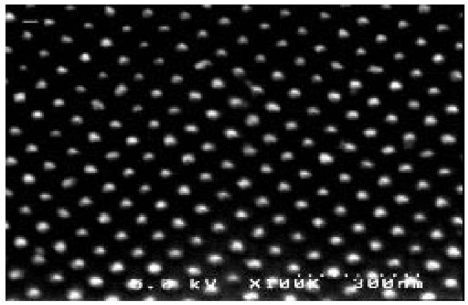
Figure 6: Sub-100nm structures for DNA sequencing: Molecular separation and sorting by diffusion



Biomaterial Engineering

Biotechnology researchers use patterned substrates to make carbon nanotubes or grow other 3-D nano-structures. This molecular templating is used for protein recognition and antibody capture. But the ability to recognize events, control reaction, and inhibit interaction is compromised without good and reproducible templates. The NJNC is making sub-50nm nano-dots templates with IC level of quality in mind. Our strength in microelectronics and nanotechnology serves to alleviate such surface engineering concerns and accelerate the progress in biomaterial engineering.

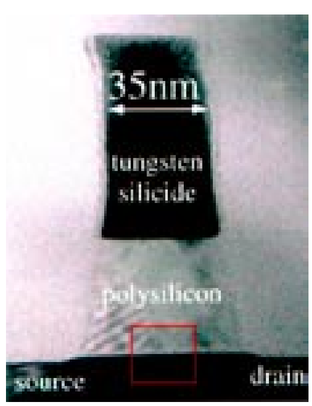
Figure 7: Sub-50nm nano-dots templates to engineer new biomaterials such as carbon nanotubes



Nano-Circuits in Cells

The NJNC is working on placing nano-circuits in the cell, to control and monitor the cell's environment and create artificial channels with nanocircuitry integrated with size-controlled nanopores. The cell sizes are typically several to tens of microns, making our expertise in micro- and nano-scale integrated systems ideal for such missions inside the cell. The NJNC's pioneering effort with 35nm ballistic transistors in the late 1990's is ideally suited for the 20-50nm CMOS transistor circuits desired for such cell applications.

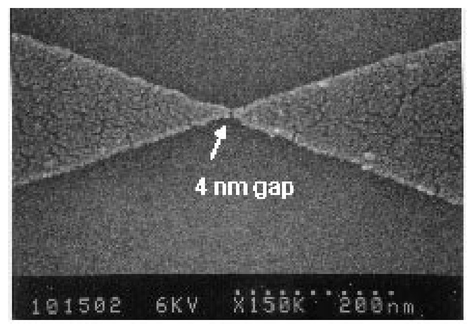
Figure 8: The NJNC's 35nm nano-transistor that can fit inside and control the cell



Molecular Biochemical Sensors

The ultimate biochemical sensors can pick up the signal of a single organism or molecule. The NJNC is working on nano-devices that can be used for organic and molecular transistor applications (with channel lengths as small as < 5 nm). These devices are extremely sensitive for electrical biochemical sensors. Any slight change in the electrical property of the target material deposited between the electrodes will be recognized in the current-voltage characteristics.

Figure 9: The NJNC's 4nm electrical probe that can detect a single organism or molecule



Harness Nanotechnology Now

The time for nanotechnology is NOW because today's micro- and nano-fabrication technologies work at scales useful for biology and chemistry. The impact of NJNC's core competence spans:

- correcting human vision
- sequencing DNA
- speeding up drug discovery
- improving drug delivery
- targeted monitoring
- molecular sensing
- advancing current techniques for engineering new biomaterial.

The NJNC can help you harness the potential of nanotechnology in pharmaceutical and biotechnology applications. We have the background, tools and expertise to turn innovative ideas into commercial applications. We can work with you at any stage of your nanotechnology project by providing you with customized support tailored to your specific needs.

Please visit our website, www.njnano.org, or call us at 1-(877) NJNC-ORG (656-2674) for information on how we can take you from concept to commercialization fast. Our technical experts will work with you to prepare a comprehensive statement of work, and put together a proposal incorporating pricing information for your specific project.

Figure 10: NJNC's micro- and nano-fluidics channels for "lab-on-a-chip" application

Figure 11: 300um deep silicon etch enabling straight wall wells

Figure 12: NJNC's optical switch mirror technology can make intricate valves with sub-um size springs

Figure 13: NJNC's optical lens array technology on a 200mm wafer is useful to imaging in biotechnology

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For more information about the New Jersey Nanotechnology Consortium please visit www.njnano.org or contact us at: +1 (877) NJNC-ORG (656-2674)

Figure 10

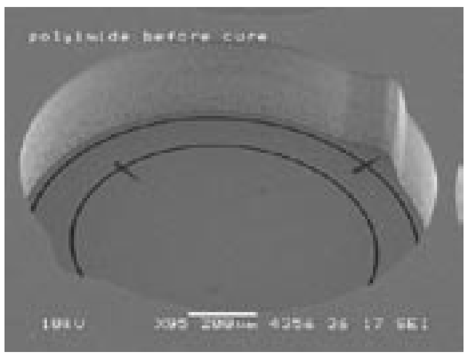

Figure 11

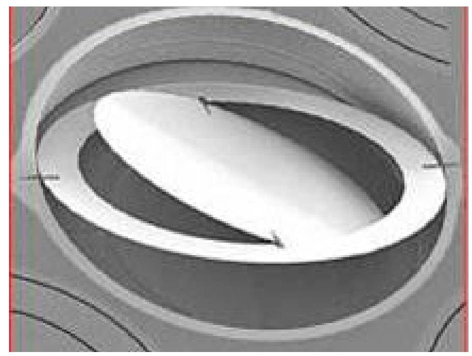

Figure 12

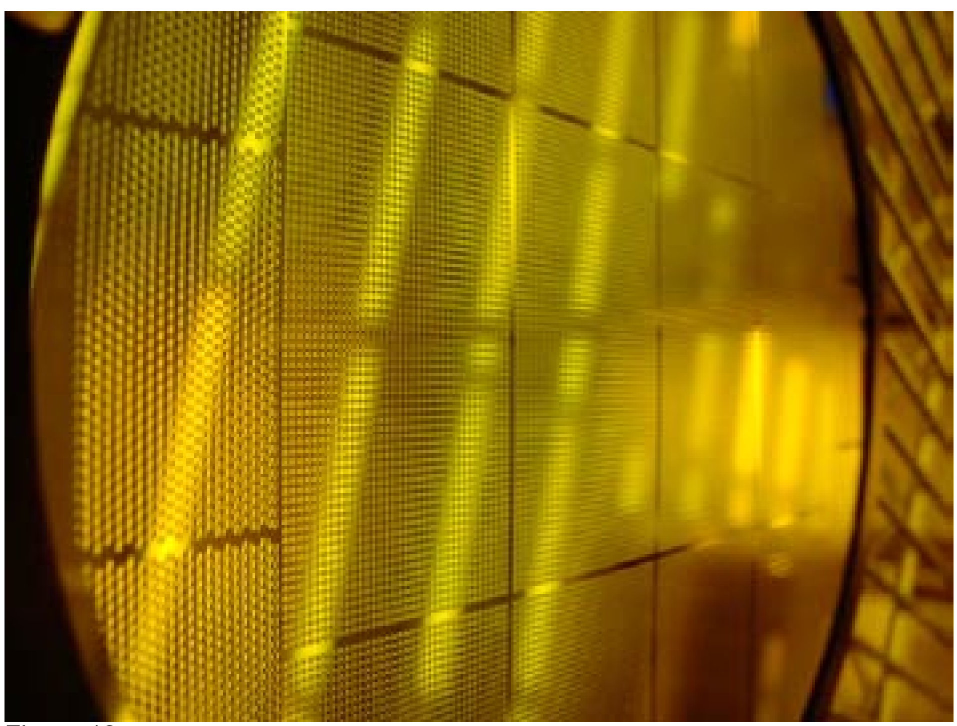

Figure 13