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Patent for arrays of nanoscale electrical probes awarded to NJIT today

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Reginald C. Farrow and Zafer Iqbal, research professors at NJIT, were awarded a patent today for an improved method of fabricating arrays of nanoscale electrical probes. Their discovery may lead to improved diagnostic tools for measuring the spatial variation of electrical activity inside biological cells.

US Patent 7,964,143 discloses a nanoprobe array technique that allows for an array of individual, vertically-oriented nanotubes to be assembled at precise locations on electrical contacts using electrophoresis. The location of each nanotube in the array is controlled by a nanoscale electrostatic lens fabricated by a process commonly used in the manufacture of integrated circuits.

The research appeared in 2008 in the the *Journal of Vacuum Science and Technology*, entitled "Directed self-assembly of individual vertically aligned carbon nanotubes." Support for the research was provided by the Department of Defense.

The number of nanotubes deposited at each location is controlled by the geometry of the lens, which makes it possible to deposit a single nanotube in a window much larger than its diameter. After deposition, each individual nanotube can be modified to insulate the shaft and to sensitize it to a specific ion in the cell. The task is accomplished by attaching an appropriate functional molecule or enzyme to the tip of the nanotube.

The completed nanoprobe array may be configured for multiple diverse electrochemical events to be mapped on timescales limited only by the nature of the nanotube's contact with the cell membrane and the speed of integrated circuits.

For three different types of cells (human embryonic kidney cells, mouse neurons, and yeast), the NJIT researchers have measured the electrical response to a signal. This signal is generated by a pair of carbon nanotube probes spaced only six micrometers apart. Yeast cells are too small to measure with the tools most commonly used in the industry for determining electrical response.

The researchers have also demonstrated depositing single wall carbon nanotubes on metal contacts in arrays of vias (windows in an insulator exposing the metal) spaced only 200 nanometers apart. They've also shown the ability to attach electrochemically different functional enzymes to vertically oriented single wall carbon nanotubes at different closely-spaced sites on the same chip.

Both today's patent and a companion patent awarded last year (7,736,979) teach a method for depositing a single nanotube vertically in an electronic circuit using techniques currently used in the fabrication of computer chips. This enables the bridging of electronic technology with biological sensing all the way down to the nanoscale.

Using the process called electrophoresis, the nanotubes in a liquid suspension are drawn to metal contacts at the base of precisely-located vias. Each via gets charged and acts like an electrostatic lens. Once the first nanotube is deposited the electric field is modified and can redirect other nanotubes from depositing on the metal, even though the via may have a diameter several times larger than the diameter of the nanotube element.

This discovery has led to the following patented and patent-pending technologies: a vertical transistor using a single one-nanometer carbon nanotube, a planar biofuel cell, and the nanoprobe array announced today.

Provided by New Jersey Institute of Technology