Semiconductor membrane mimics biological behavior of ion channels

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A semiconductor membrane designed by researchers at the University of Illinois could offer more flexibility and better electrical performance than biological membranes. Built from thin silicon layers doped with different impurities, the solid-state membrane also could be used in applications such as single-molecule detection, protein filtering and DNA sequencing.

"By creating nanopores in the membrane, we can use the membrane to separate charged species or regulate the flow of charged molecules and ions, thereby mimicking the operation of biological ion channels," said lead researcher.

Jean-Pierre Leburton, the Stillman Professor of Electrical and Computer Engineering at Illinois.

Leburton, with postdoctoral research associate Maria Gracheva and graduate student Julien Vidal, simulated the operation of the semiconductor membrane at a number of electrostatic potentials. They report their findings in a paper accepted for publication in the journal *Nano Letters*, and posted on the journal's Web site.

In the researchers' model, the nanopore-membrane structure is made of two layers of silicon, each 12 nanometers thick, with opposite (n- and p-) doping. The electrostatic potential is positive on the n-side and negative on the p-side of the membrane.

The nanopore has an hourglass shape, with a neck 1 nanometer in diameter and openings on each side of the membrane 6 nanometers in diameter. The “size” of the nanopore can be changed by changing the electrostatic potential around it.

By controlling the flow of ions, the artificial nanopore offers a degree of tunability not found in biological ion channels, said Leburton, who also is a researcher at the university’s Beckman Institute, the Coordinated Research Laboratory, and the Micro and Nanotechnology Laboratory.

In addition to serving as a substitute for biological ion channels, the solid-state nanopore and membrane could be used in other applications, including sequencing DNA.

“Using semiconductor technology to sequence the DNA molecule would save time and money,” Leburton said. “By biasing the voltage across the membrane, we could pull DNA through the nanopore. Since each base pair carries a different electrical charge, we could use the membrane as a p-n junction to detect the changing electrical signal.”

Source: University of Illinois at Urbana-Champaign

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