Glass electrodes used in nanoscale pump

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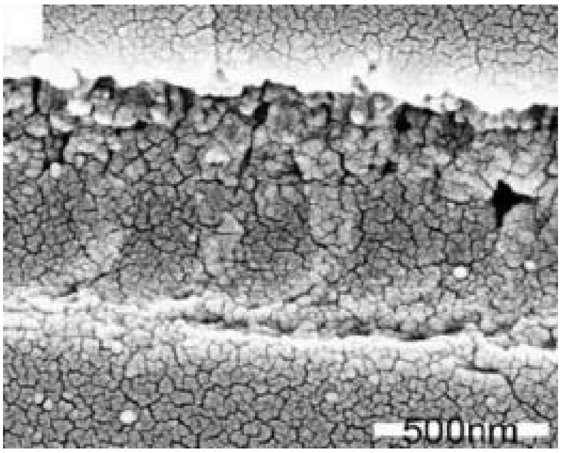

SEM showing surface roughness of the fs-laser machined nanochannel. Image credit: *Nature Nanotechnology*, doi:10.1038/nnano.2010.81.

(PhysOrg.com) -- A team of engineers from the U.S. and South Korea has developed what is believed to be the smallest man-made pump ever built, powered by a glass electrode. The pump is about the same size as a red blood corpuscle.

While glass does not normally conduct electricity, the team discovered a few years ago that at the nanoscale glass can conduct electricity without breaking. They have now used the property to solve a problem inherent in nanodevices, which is the difficulty of integrating wires into them to provide the required electrical current.

The engineers involved in the research were Sanghyun Lee from South Korea's Pohang University of Science and Technology, and Alan Hunt and Ran An from the University of Michigan in Ann Arbor in the U.S. They machined nanochannels inside a glass substrate (a microscope cover slip) using a new laser technique (called "femtosecond-laser nanomachining"), leaving a thin glass wall at the tip of each channel that can change properties reversibly from an insulator to a conductor in the presence of high electric fields. This phenomenon is called "dialectric breakdown," and usually results in overheating and damage, but at the nanoscale there is no damage to the glass.

When the channel is filled with an electrically conducting solution it effectively becomes a tiny liquid wire, with the glass wall at the end acting as an electrode. Hunt described the thickness of the glass wall by saying that "if Alice ate a mushroom in Wonderland and shrank to the size of a gnat, the thread in her dress would be about as thick as the conductive glass wall in the electrode."

The team demonstrated the glass electrodes by using them to power a microscopic pump consisting of an assembly of three 0.6-micrometer-wide glass electrodes. Each electrode consists of two channels positioned end to end with the glass wall between them. The wall would normally prevent the electrolyte and electric current from passing through, but at the nanoscale applying an electric potential of only 10 volts was enough to transform the insulating glass into a conducting electrode. The heat generated by dielectric breakdown was dissipated so quickly at this scale that there was no damage to the glass.

The pump works by electroosmosis, in which electricity pushes the fluids from one end of the pump to the other. The heart of the pump measures only four micrometers across, and the pump is capable of controlling a flow rate of one femtoliter (10^{-15} liters) per second. It could be used for applications such as delivering drugs to an individual cell or for taking fluid samples from single cells. The glass electrodes could also be integrated into other nanoscale devices.

The results of the research are published online in *Nature Nanotechnology*.

More information: Sanghyun Lee et al., Liquid glass electrodes for nanofluidics, *Nature Nanotechnology*, Published online: 16 May 2010 | doi:10.1038/nnano.2010.81