'Voltage Patterning' could be next step in nanostructure lithography

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(PhysOrg.com) -- "What you want these days is to have precise control of nanostructures. Using masks and optical techniques, it is possible to control how nanostructures grow for use in practical applications," David Field tells *PhysOrg.com*. "This is already done in silicon devices. However, with softer materials it is a bit more difficult. Our work could make it possible for a new method of patterning that would work with a number of materials."

Field, a scientist at the University of Aarhus in Aarhus, Denmark, calls the new possibility ‘voltage patterning’. Along with his peers at Aarhus, Balog, Cicman and Jones, Field believes that the results of a recent experiment showing spontaneous dipole alignment in N_2O in multilayers on a substrate of gold, could lead to a number of nanotechnology applications (they even have a patent application in for the principle behind voltage patterning). Their work appears in *Physical Review Letters*: “Spontaneous Dipole Alignment in Films of N_2O.”

“What we’ve done,” Field explains, “is fire electrons at solids to see what happens. We’re using very low energies - which no one else has done with layers of N_2O.” What they found when they sent electrons, generated using the Aarhus synchrotron, ASTRID, careening into films of N_2O over gold, surprised them. “We got a current even when the voltages told us we shouldn’t. This showed that the N_2O spontaneously acquired a positive charge. We think this must be due to dipole alignment.”

“Most scientists are using one thousand times the currents we were using, and that is why this wasn’t seen before,” Field says. “Such large currents would destroy the effect which we have seen in seconds or less. The very low currents we use - femtoamps - interfere negligibly with the dipole alignment.”

Varying different aspects of the set-up, like thickness and deposition temperature, created very distinct effects in the way the system behaves. “We discovered that you have to have a certain thickness for the charge to appear,” Field explains. “Once we reached a certain thickness, the voltage began increasing with the film thickness. We also found that when we increased the temperature, the voltage appeared for thinner films. However at lower temperature, once you had a thick enough film, then the voltage started to rise faster than at higher temperatures. You could get up to five volts!”

“Though this behavior is a bit complicated, the system is really well-behaved and reproducible to the millivolt level,” Field adds. “We are sure that we are seeing a real effect and not an artefact.”

Even though the Aarhus team hasn’t gone beyond this initial discovery stage, the potential applications are causing some excitement. “With current lithography techniques,” Field explains, “you have to create the patterns you want for nanostructures bit by bit. The potential for voltage patterning is that you could put down a pattern of N_2O with a mask, remove the mask and then other molecules you introduce would be attracted to the where the N_2O lies and be patterned accordingly. It could be very efficient.” He is quick to reiterate that this process hasn’t been tested yet, but it does have future potential to create patterns for a wide range of molecules, especially biomolecules.

Applications that could grow from this discovery include biosensor applications, lab on a chip applications and nanoxerography. “We need to get together with those in the industry who are ready to more fully develop techniques to implement the principle we have demonstrated."

More information: Balog, Cicman, Jones and Field, "Spontaneous Dipole Alignment in Films of N_2O." *Physical Review Letters* (2009). Available online: link.aps.org/doi/10.1103/PhysRevLett.102.073003 .