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Press information
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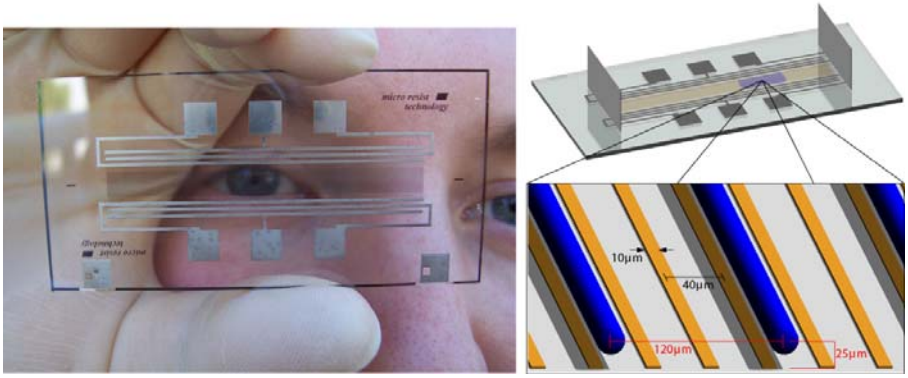
A molecular laboratory – on a chip

In the age where nanoscale electronics have become the norm, it may not come as a surprise that large fundamental physics experiments are starting to follow suit – being scaled down from a lab to a chip. Trendsetters Meek and co-workers at the Fritz Haber Institute in Berlin have developed a new micro-chip structure that is capable of performing the same experiments traditionally done with much larger machines. With this chip, they are able to fully control and confine gas-phase CO molecules in an array of electric field traps just above the chip's surface. Their results have been published in the journal Science. (Published: June 26, 2009 | *Science*)

Making precise observations of gas-phase molecules is notoriously difficult in part due to the obvious reason that the molecules are free to roam around. Most contemporary experiments investigating molecules and reaction processes between colliding molecules have been performed using (supersonically expanded) molecular beams. These beams provide a fairly pure sample of molecules. However, the molecules are moving at some several hundred meters per second in the laboratory – or chip – frame. The new microstructure can slice a portion of these fast molecules out of the beam and decelerate them down to a standstill over a distance of only a few centimeters. Moreover, the structure can also accelerate the molecules back off the chip to assure that all molecules arrive simultaneously in the detection region; such a mature detection scheme is one of the biggest benefits of the chip.



Left: PhD student Sam Meek holds up the microchip decelerator. Right: A schematic of the chip with a detailed zoom-in showing the micro-dimensions of the electrodes.

The 5-cm long microchip, made by the Berlin-based company micro resist technology, is fashioned with over 1200 gold electrodes – each no bigger than a single human hair – set 40-µm apart. Applying specific voltages to the electrodes creates an array of electric field minima positioned about 25 µm above the chip's surface. Each minimum runs parallel along the electrodes, thus creating a tubular well centered around a zero-electric field region. By varying the voltages the researchers can move these minima to an arbitrary position along the chip.

For molecules that are in states which “seek out” low electric fields – often referred to as ‘low-field-seekers’ – the minima in the potential serve as microscopic nets in which the molecules are trapped. Hence moving the traps is tantamount to moving the molecules along the chip. The forces used here are the same as those used in the so-called Stark decelerator, which has also been developed and refined in the group of Gerard Meijer. However, the chip has a continuously present well in which the molecules are trapped, as opposed to an effective well created by the switching on and off of electric fields in the Stark decelerator.

This demonstration of loading and detecting molecules on a chip opens up a whole new class of experimental molecular physics studies. Future plans include direct lifetime measurements of particular molecular states, and interfering or colliding trapped molecules with other cold molecules. The latter experiment promises to reveal interesting quantum effects that have, to date, remained experimentally elusive. Of the many experiments that can be devised, one particularly seductive idea proposes using trapped polar molecules above a chip as qubits for a quantum computer. These up and coming chip experiments assures that in the near future the word ‘downsizing’ will be applied to more and more fundamental physics experiments.

[CH]

Original Publication:

Samuel A. Meek, Horst Conrad, Gerard Meijer
Trapping Molecules on a Chip
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Abstract, *pdf*

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