# More than one nanostring to their bow: Scientists moving closer to 'artificial noses'

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These days, chemical analysts are expected to track down even single molecules. To do this highly sensitive detective work, nano researchers have developed minute strings that resonate in characteristic fashion. If a molecule docks onto one of the strings, then it becomes heavier, and its oscillations become measurably slower.

Until recently, however, such “nano-electromechanical systems”, or NEMS, have been short of practical applications. Physicists at LMU Munich, Germany, have now made a breakthrough in this field: They have constructed a system of nanostrings made of non-conducting material, where each string can be electrically excited separately. Thousands of these strings can be produced on a small chip. One of the devices that could be created with this system is a highly sensitive “artificial nose” that detects various molecules - pollutants for example - individually. These new NEMS could also be used in a multitude of other applications - acting as tiny pulse generators in mobile phone clocks, for example.

Quick, certain and cheap detection of single molecules is a task that chemical analysts are now expected to perform. Luckily, there is a method they can employ for this, which uses nanotechnology: Specifically, they use “nano-electromechanical systems”, or NEMS. These systems involve strings with diameters of the order of 100 nanometers - a ten-thousandth of a millimeter or a 1/500 of a human hair - which can be excited to resonate in a characteristic fashion. If these strings are coated with the right kind of chemicals, then molecules will

dock onto them. More specifically: only one kind of molecule can dock onto each string.

When a molecule docks onto a string, the string becomes heavier and its oscillation slows down a tiny bit. “By measuring the period of oscillation, we could therefore detect chemical substances with molecular precision,” explains Quirin Unterreithmeier, first author of the study. “Ideally, you would have several thousand strings sitting on a chip the size of a fingernail, each one for highly specifically recognizing a single molecule - so you could build an extremely sensitive ‘artificial nose’, for example.”

Until recently, however, getting such systems to work has proven technically difficult; one problem being to produce and measure the oscillations. While the nanostrings can be made to oscillate by magnetomechanical, piezoelectric or electrothermal excitement, this only works if the nanostrings are made of metal, or are at least metal-coated, which in turn greatly dampens the oscillations, preventing sensitive measurement. That hardly allows the detection of a single molecule. It also makes it harder to distinguish the different signals from differently oscillating strings.

The newly developed method now avoids these difficulties. Quirin Unterreithmeier, Dr. Eva Weig and Professor Jörg Kotthaus of the Center for NanoScience (CeNS), the Faculty of Physics of LMU Munich and the cluster of excellence “Nanosystems Initiative Munich (NIM)” have constructed an NEMS in which the nanostrings are excited individually by dielectric interaction - the same phenomenon that makes hair stand on end in winter. Following this physical principle, the nanostrings, which are made of electrically non-conducting silicon nitride, are excited to resonate when exposed to an oscillating inhomogeneous electric field, and their vibration then measured.

The alternating electric field required for this stimulation was produced between two gold electrodes right up close to the string. The oscillations were measured by two other electrodes. “We created this setup using etching techniques,” reports Weig. “But this was easily done - even repeated ten thousand times on a chip. The only thing to do now is to make sure the strings can be individually addressed by a suitable circuit.” All in all, this ought to be a technically easy exercise - but one that will allow a breakthrough in chemical analysis. Yet there are even more applications that can be seen beyond this “artificial nose”. Among other things, the nanostrings could be employed as the pulse generators in mobile phone clocks, for example. These novel resonators could even be used as ultra-sharp electrical signal filters in metrological systems.

More information: "Universal transduction scheme for nanomechanical systems based on dielectric forces", Quirin P. Unterreithmeier, Eva M. Weig, Jörg P. Kotthaus, *Nature*, 23 April 2009, doi:10.1038/nature07932, www.nature.com/nature/journal/ … ull/nature07932.html

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