# Researchers use nanoscale transistors to study single-molecule interactions

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An interdisciplinary team from Columbia University that includes electrical engineers from Columbia's Engineering School, together with researchers from the University's departments of Physics and Chemistry, has figured out a way to study single-molecule interactions on very short time scales using nanoscale transistors. In a paper to be published online January 23 in *Nature Nanotechnology*, they show how, for the first time, transistors can be used to detect the binding of the two halves of the DNA double helix with the DNA tethered to the transistor sensor. The transistors directly detect and amplify the charge of these single biomolecules.

Prior to this work, scientists have largely used fluorescence techniques to look at interactions at the level of single molecules. These studies have yielded fundamental understanding of folding, assembly, dynamics, and function of proteins and other cellular machinery. But these techniques require that the target molecules being studied be labeled with fluorescent reporter molecules, and the bandwidths for detection are limited by the time required to collect the very small number of photons emitted by these reporters.

The Columbia researchers, including Professor of Electrical Engineering Ken Shepard, Professor of Chemistry Colin Nuckolls, and graduate students Sebastian Sorgenfrei and Chien-Yang Chiu, realized that transistors, like those used in modern integrated circuits, have reached the same nanoscale dimensions as single molecules. "So this raised the interesting question," said Sorgenfrei, the lead author on the study, "as to whether these very small transistors could be used to study individual molecules."

They have discovered that the answer is "yes." The transistors employed in this study are fashioned from carbon nanotubes, which are cylindrical tubes made entirely of carbon atoms. While these are still emerging devices for electronics applications, they are exquisitely sensitive because the biomolecule can be directly tethered to the carbon nanotube wall creating enough sensitivity to detect a single DNA molecule.

The Columbia team expects this new technique to be a powerful tool for looking at single molecule interactions and is looking at instrumentation applications that currently rely almost exclusively on fluorescence such as protein assays and DNA sequencing. They also plan to study interactions at time scales several orders of magnitude greater than current techniques based on fluorescence.

"The area of single molecule research is an important one and pushes the envelope on our sensing systems," commented Ken Shepard, Professor of Electrical Engineering at Columbia Engineering. "There is a huge potential for modern nanoelectronics to play an important role in this field. Our work, which has been a terrific collaboration between groups from Electrical Engineering, Chemistry, and Physics, is a great example of how nanoelectronics and biotechnology can be combined to produce new, exciting results."

Shepard hopes that this research, which was funded primarily by the National Science Foundation and the National Institutes of Health, will lead to exciting new applications for nanoscale electronic circuits.

Provided by Columbia University