# Humidity sensor: hybrid nanoelectronics made from living bacteria and gold nanoparticles

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Living organisms as an integral part of electronic components? What may look like science fiction at first glance is actually a serious approach to the nanoelectronics of tomorrow. Living organisms could provide the required nanostructures. Researchers at the University of Nebraska (Lincoln, USA) have now shown that bacteria coated with gold nanoparticles can function as a humidity sensor.

The properties of metallic nanoparticles differ radically from those of larger particles and are of great interest for nanoelectronics. In order to use nanoparticles, they must be placed on a suitable support, a "nanoscaffold". "Biological structures have proven to be promising supports," explains Ravi Saraf, "especially when their responses to stimuli can be integrated."

Saraf and his co-worker Vikas Berry produced a chip covered with extremely fine gold electrodes and applied a suspension of Bacillus cereus. On such surfaces, these long bacteria basically lie down to form bridges between the pairs of electrodes. Then the nanoparticles come in: the researchers dipped their chip into a solution of gold nanoparticles coated with polylysine, a synthetic protein. The tiny gold particles are strongly attracted to the bacterial surface, which contains long, brushlike, highly mobile chain molecules that are negatively charged. Like tentacles, these surround the gold particles—positively charged by the polylysine—and hold them tight. At the end of this process, the bacteria are coated with a thin layer of gold nanoparticles—and are still alive.

The researchers apply a voltage of 10 V across the electrode pairs and measure the current across the bacterial bridges to complete the bioelectronic humidity sensor. If the humidity is increased from about 0 to 20%, the current decerases by a factor of 40. Why does this chip react so sensitively to changes in humidity? Moisture causes the bacterial membrane to swell, which increases the distance between the individual gold particles attached to it by about 0.2 nm. This is not much, but it is enough to hinder electron transport between the particles. Unlike a "normal" macroscopic gold layer, in which the electrons can "flow" unhindered, here they must "jump" from one particle to the next.

"Our humidity sensor demonstrates the vast potential that lies in hybrid structures containing microorganisms and nanoparticles," says Saraf.

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