Bacteria put to work as weavers of nanoscale biomaterials

For several decades, bacteria have been used to create soft materials such as rubber and fabrics. These materials have been used in a variety of applications, from clothing to medical devices. However, the ability to precisely control the composition and structure of these materials has been limited.

Unfortunately, most tools capable of patterning with such tiny resolution were developed for the silicon microelectronics industry and cannot be used for soft and relatively sensitive biomaterials such as DNA and proteins.

Now a team of researchers at Northwestern University has demonstrated the ability to rapidly write nanoscale protein arrays using a tool they call the nanofountain probe (NFP).

The results, which will be published online the week of Oct. 13 in the Proceedings of the National Academy of Sciences (PNAS), include demonstrations of sub-100-nanometer protein dots and sub-200-nanometer line arrays written using the NFP at rates as high as 80 microns/second.

Each nanofountain probe chip has a set of ink reservoirs that hold the solution to be patterned. Like a fountain pen, the ink is transported to sharp writing probes through a series of microchannels and deposited on the substrate in liquid form.

"This is important for a number of reasons," said Owen Loh, a graduate student at Northwestern who co-authored the paper with fellow student Andrea Ho. "By maintaining the sensitive proteins in a liquid buffer, their biological function is less likely to be affected. This also means we can write for extended periods over large areas without replenishing the ink."

"We are very excited by these results," said Espinosa. "This technique is very broadly applicable, and we agree by Russia and China to continue cooperation in the field of nanotechnology.

In the case of protein deposition, the team found that by applying an electrical field between the nanofountain probe and substrate, they could control the transport of protein to the substrate. Without the use of electric fields, protein deposition was relatively slow and sporadic. However, with proper electrical bias, protein dot and line arrays could be deposited at extremely high rates.

"The use of electric fields allows an additional degree of control," Espinosa said. "We were able to create deposition process. "By modeling the ink flow within the probe tip, we were able to get a sense of what conditions would yield optimal patterns," says Jee Rim, a postdoctoral researcher at Northwestern.

Espinosa collaborated closely with Neelesh Patankar, associate professor of mechanical engineering at Northwestern, and Punit Kohli, assistant professor of chemistry and biochemistry at Southern Illinois University, Carbondale.

"We are very excited by these results," said Espinosa. "This technique is very broadly applicable, and we are pursuing it on a number of fronts." These include single-cell biological studies and direct-write fabrication of large-scale arrays of nanoelectrical and nanoelectromechanical devices.

"The fact that we can batch fabricate large arrays of these fountain probe means we can directly write large numbers of features in parallel," added Espinosa. "The demonstration of rapid protein deposition rates further supports our efforts in producing a large-scale nanomanufacturing tool."

Source: Northwestern University

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