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Researchers Write Nanoscale Protein Arrays Using a Nanofountain Pen and Electric Fields

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Earlier demonstrations of the NFP by the Northwestern team included directly writing organic and inorganic materials on a number of different substrates. These included suspensions of gold nanoparticles, thiols and DNA patterned on metallic- and silicon-based substrates.

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 dot and line arrays with a combination of speed and resolution not possible using other techniques."

Positively charged proteins can be maintained inside the fountain probe by applying a negative potential to the NFP reservoirs with respect to a substrate. Reversing the applied potential then allows protein molecules to be deposited at a desired site.

To maximize the patterning resolution and efficiency, the team relied on computational models of the 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 probes 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."

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