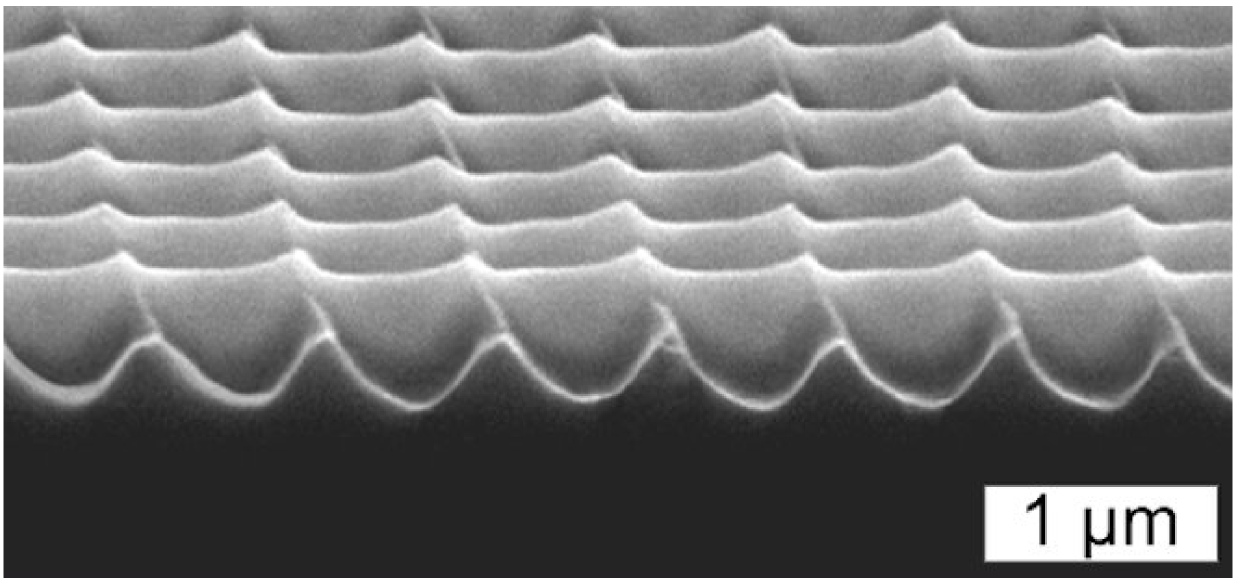
Egg-carton-style patterning keeps charged nanoparticles in place and suitable for a wide range of applications

December 3 2021, by Catharine June



2D-DNI nanovoid pattern. Credit: University of Michigan

Researchers at the University of Michigan and Seoul National University of Science and Technology have devised a new method for manufacturing devices that require precisely sized and positioned micro- and nanoscale particles. The technique is suitable for a wide array of assembly of micro- and nanoscale objects, and useful for electronic devices, and biological applications.

"It's very hard to regulate things in the microscopic and nano-scale. You want the particles to sit there, and they won't," said Jay Guo, project leader and professor of electrical engineering and computer science. "We found a way to sort and localize large quantities of particles, and we can do it in a very scalable fashion."

With this ability, engineers would be able to more efficiently manufacture and assemble photonic crystals, filtration devices and biological assays, create more sensitive sensing devices, and much more.

Guo has been working in the area of nanomanufacturing for decades, beginning with his work on roll-to-roll nanoimprint lithography. He switched to the current methodology of nanopatterning relying only on a sliced silicon wafer because of its relative simplicity and speed.

The new method adds an electric charge, which seems to make all the difference.

Creating the microfluidic device

The goal of this research was to end up with a layer of orderly and like-sized micro- or nanoparticles that could be integrated into a device with high-density arrays. Current methods for doing this tend to be tedious while requiring complicated structures. Or, they are best suited for particles that are 10s to 100s of micrometers, leaving the separation and sorting of sub-micrometer particles a persistent challenge.

Guo and his international team of researchers, including former student Prof. Jong G. Ok, put together a microfluidic device that achieved their desired goals using a method that is also scalable, and relatively low cost. Ok's team has been continuing to push the inscribing technology at his institute in Korea.

The heart of the device is a specially designed substrate that captures the particles of a specific size in an orderly arrangement. To do this, the researchers first created indentations, in the shape of nanovoids, into a polycarbonate substrate through a patterning technique known as dynamic nanoinscribing (DNI). The resulting nanovoids were all the same size.

The substrate is then coated with Al2O3 and given a positive charge after being immersed in a salt solution.

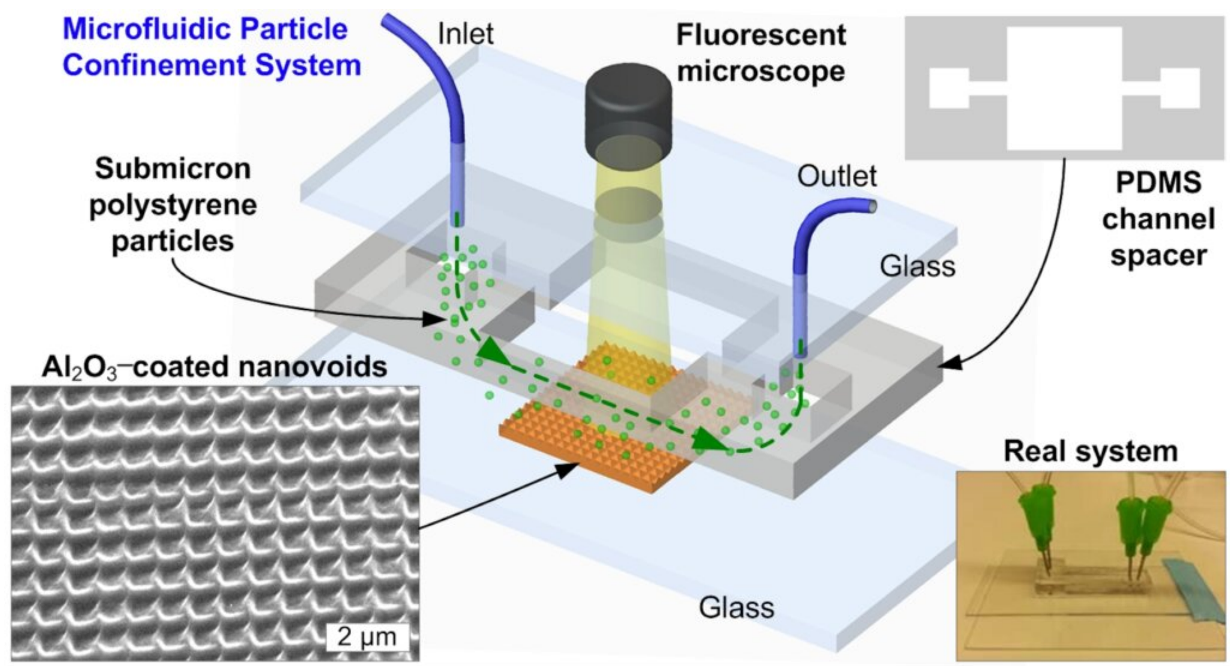


Figure 1. The microfluidic device contains a fluidic cell chamber consisting of two transparent slide glasses spaced by a poly(dimethylsiloxane) block having a slit channel. The oxide-coated nanovoid pattern is mounted on the bottom in the fluidic cell chamber, and the fluorescent-labeled particles are injected under the fluorescent microscope. Credit: University of Michigan

Figure 1 shows the test setup, which allows for submicron-sized fluidic particles to enter the system and flow over the substrate before exiting. These particles are negatively charged in order to increase their attraction to the positively-charged nanovoids in the substrate. They were also given fluorescent labels for easy detection.

It might be expected that most of the particles would simply fall to the bottom of the fluid and rest on the substrate, but that's not what happened.

Instead, only those of a specific size rested in the nanovoids. Three distinct sizes of particles were injected into the system: 200nm, 500nm, and 1,000nm (or 1

More information: Long Chen et al, Size-Selective Sub-micrometer-Particle Confinement Utilizing Ionic Entropy-Directed Trapping in Inscribed Nanovoid Patterns, *ACS Nano* (2021). DOI: 10.1021/acsnano.1c00014

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