One- and Two-Dimensional Nanowire Arrays Generated by DNA-Templated Fabrication

A major challenge in the assembly of functional nanodevices is the preparation of ordered arrays of nanowires. Nanowire alignment has been previously achieved with electric fields or by directing the flow of precursor solutions containing the nanoparticles. In addition, oriented single-walled carbon nanotube arrays can be obtained by controlling the gas flow in chemical vapor deposition. Recently, researchers in the Department of Chemistry at Purdue University have fabricated one- and two-dimensional metallic nanowire arrays by modifying existing techniques whereby DNA molecules are manipulated and assembled.

As reported in the November issue of *Nano Letters*, Purdue University researcher Chengde Mao and co-workers used a combination of molecular combing and DNA-templated metallization to generate ordered metallic nanowire arrays. Using λ–DNA (48,500 base pairs, ~16.5 μm in length), the researchers employed a three-step strategy. First, fluid-flow-assisted molecular combing was used to prepare parallel or crossed DNA. Palladium ions (Pd^{2+}) were then quickly adsorbed onto the negatively charged DNA backbone. Chemical reduction produced palladium nanowires, which followed the patterns defined in the first step. The researchers said that branches formed from nonspecific metal deposition are greatly reduced with their method.

The researchers modified previously published molecular combing methods to obtain one- and two-dimensional arrays. After placing a DNA solution with 0.45 mM $Mg(Ac)_2$ (Ac stands for an acetyl group) onto a glass slide or a freshly cleaved mica surface, the solution was driven along one or two directions with compressed air. Stretched and parallel DNA chains were thereby produced over several centimeters, as shown by fluorescence microscopy (in the case of the glass slides) or tapping-mode atomic force microscopy (mica). The researchers identified divalent cation concentration and flow velocity of the droplet as the two factors that have critical impact of the resulting DNA networks.

After a 10 s incubation of the DNA networks with a $Pd(Ac)_2$ solution, reductive metallization occurred within a 15 s exposure to a reduction bath. The researchers showed that prompt removal of the $Pd(Ac)_2$ solution after DNA activation avoided uncontrolled nucleation, random nanoparticle aggregation, and undesirable short branches, which were reported in previous studies by other researchers. Atomic force micrographs showed that the nanowires are uniform with an average diameter of <30 nm. Cross-section analysis showed that the height of the nanowires varies from 4 nm to 10 nm.

While the researchers acknowledge that further method refinement is necessary to eliminate defects from their networks, they expect that their method will become sufficient for fabricating connecting wires in nanoscale electric circuits and could be adapted for making ordered nanowire networks of other materials.

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