As easy as blowing bubbles

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Researchers in the US and Hawaii have developed a simple technique to align carbon nanotubes and nanowires over large areas – by suspending these materials in a polymer and blowing bubbles from the suspension. The bubbles, which grow to 25 cm in diameter and 30 cm in height, contain regularly spaced nanowires or nanotubes all pointing in the same direction. The method could prove useful for applications that require large-scale arrays of nano- or opto-electronic devices such as sensors and displays.

"Our work provides a general and efficient approach for large-scale assembly of aligned nanotubes and nanowires," said Charles Lieber of Harvard University. "Controlled assembly of these nanomaterials has been a bottleneck for many potential applications, where regular distribution of aligned components is required."

Although researchers have developed techniques to produce aligned materials, these only work on the centimetre-scale or smaller. The new method, developed by Lieber's team and Anyuan Cao at the University of Hawaii at Manoa, can produce aligned films of nanotubes and nanowires over areas as large as 25 cm across by 30 cm – a scale that is relevant to many commercial applications. "Moreover, our method can assemble aligned structures on virtually any substrate, opening up new avenues of research on highly flexible substrates," explained Lieber.


Making the nanocomposite films

The researchers began by suspending nanotubes or nanowires in an epoxy polymer. Next, they blew bubbles from the suspension. They did this by pouring the mixture onto a die surface containing a small hole so that the solution formed a membrane over the surface.

By then forcing nitrogen gas through the hole, they made the membrane expand until it formed a bubble. The team used a metal ring to stabilize and direct the bubble as it expanded so that the polymer mixture stretched to just 200–500 nm thick. The nanowires or nanotubes were found to spread out evenly across the surface of the bubble and all aligned in approximately the same direction. The Harvard–Hawaii researchers suspect that sheer forces, produced when the bubble grows, are responsible for aligning the

nanocomponents.

"The high degree of alignment, controlled density and large area coverage possible with this technique could be used in applications such as biological and chemical sensors and displays," said Lieber. One challenge that needs to be overcome, however, is automating the process – which would further increase coverage area – but the researchers are confident that they could achieve this given the blown-film extrusion technique available in the film manufacture industry.

The team now plans to fabricate nanosystems with distinct electrical or optical properties and use different polymers to facilitate device fabrication. "For example, we have developed photopolymer-based bubbles that can be directly integrated into conventional lithographic processes to pattern electrodes," Lieber told *nanotechweb.org*. "We will also try to understand why the nanostructures align during bubble blowing and explore making 3D devices based on scrolling or folding these nanowire/nanotube films," he added.

The work was reported in *Nature Nanotechnology*.

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