Coiled nanowires may hold key to stretchable electronics

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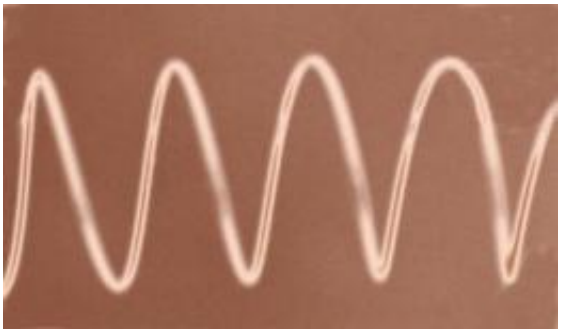


Zhu's research team has created the first coils of silicon nanowire on a substrate that can be stretched to more than double their original length, moving us closer to developing stretchable electronic devices. Credit: Yong Zhu, North Carolina State University

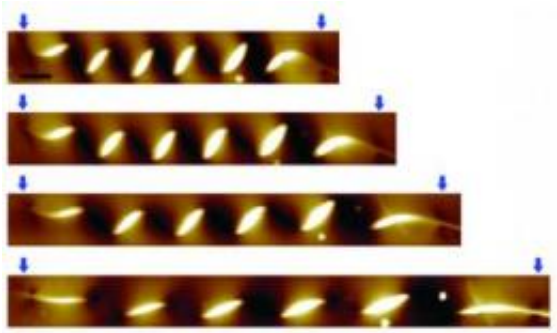
Researchers at North Carolina State University have created the first coils of silicon nanowire on a substrate that can be stretched to more than double their original length, moving us closer to incorporating stretchable electronic devices into clothing, implantable health-monitoring devices, and a host of other applications.

"In order to create stretchable electronics, you need to put electronics on a stretchable substrate, but electronic materials themselves tend to be rigid and fragile," says Dr. Yong Zhu, one of the researchers who created the new nanowire coils and an assistant professor of mechanical and aerospace engineering at NC State. "Our idea was to create

electronic materials that can be tailored into coils to improve their stretchability without harming the electric functionality of the materials."

Other researchers have experimented with "buckling" electronic materials into wavy shapes, which can stretch much like the bellows of an accordion. However, Zhu says, the maximum strains for wavy structures occur at localized positions – the peaks and valleys – on the waves. As soon as the failure strain is reached at one of the localized positions, the entire structure fails.

"An ideal shape to accommodate large deformation would lead to a uniform strain distribution along the entire length of the structure – a coil spring is one such ideal shape," Zhu says. "As a result, the wavy materials cannot come close to the coils' degree of stretchability." Zhu notes that the coil shape is energetically favorable only for one-dimensional structures, such as wires.



Here you can see multiple images of the silicon nanocoil as it is being stretched. Credit: Yong Zhu, North Carolina State University

Zhu's team put a rubber substrate under strain and used very specific levels of ultraviolet radiation and ozone to change its mechanical

properties, and then placed silicon nanowires on top of the substrate. The nanowires formed coils upon release of the strain. Other researchers have been able to create coils using freestanding nanowires, but have so far been unable to directly integrate those coils on a stretchable substrate.

While the new coils' mechanical properties allow them to be stretched an additional 104 percent beyond their original length, their electric performance cannot hold reliably to such a large range, possibly due to factors like contact resistance change or electrode failure, Zhu says. "We are working to improve the reliability of the electrical performance when the coils are stretched to the limit of their mechanical stretchability, which is likely well beyond 100 percent, according to our analysis."

More information: A paper describing the research, "Controlled 3D Buckling of Silicon Nanowires for Stretchable Electronics," was published online Dec. 28 by *ACS Nano*.

Provided by North Carolina State University