MIT Technology Review

VOL. 119 NO. 5 SEPTEMBER/OCTOBER 2016

35 INNOVATORS UNDER 35
p50

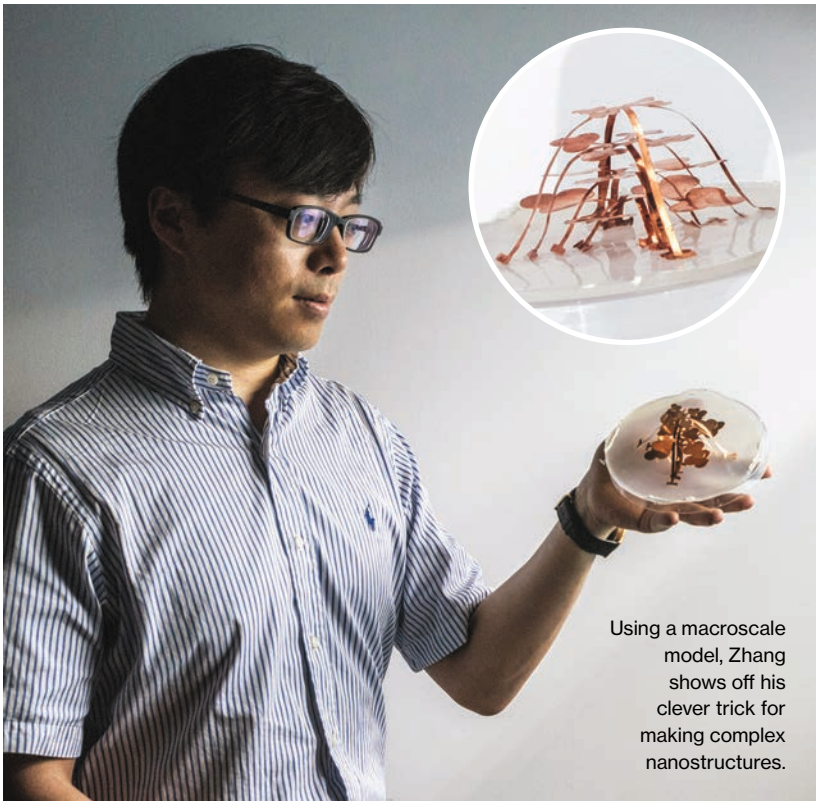
Insanely fast computer chips—and 34 other ideas that will shape the future.

Meet Qing Cao and the rest of the 2016 Innovators Under 35 inside.

Feature p. 28
Getting AI to Speak

Feature p. 44
An End to the Opioid Crisis?

MIT News p. 12
Building a Nanotech Center



Using a macroscale model, Zhang shows off his clever trick for making complex nanostructures.

Yihui Zhang

Tsinghua University

Pop-up nanostructures make it far easier to fabricate very tiny shapes.

Yihui Zhang likes to invite visitors to his office to stretch a piece of highly elastic silicone that has a soccer-ball-like structure attached to it. Once the silicone is pulled taut from four corners, the three-dimensional structure becomes a two-dimensional pattern that looks like a wheel with many adjacent hexagons and pentagons in the center. When the silicone is relaxed again, the flattened pattern pops back into its three-dimensional shape.

With this trick, Zhang has solved the challenge facing many researchers: how to fabricate complex three-dimensional nanoscale structures. Although the demonstration is done at the macro level, the idea works with nanostructures, too: easily created two-dimensional patterns can be attached to a substrate stretched taut and then buckled into three-dimensional structures as the substrate is relaxed. This process works with a wide range of materials such as metals and polymers.

Easily created two-dimensional patterns buckle into three-dimensional structures as the substrate relaxes.

The technique could be used to create nanostructures for a variety of uses. Ultimately, Zhang hopes to develop a database or algorithm that allows researchers to easily map the three-dimensional structures they want onto two-dimensional precursors. "It's a tool," he says. "People from different disciplines can build their own innovations." *—Yiting Sun*

Qing Cao

IBM Research

His inventions are helping IBM in its decade-plus quest to replace silicon transistors with more efficient carbon nanotubes.

2001 IBM researchers devise a way to produce arrays of carbon-nanotube transistors.

2002 IBM researchers show that nanotube transistors can carry more than twice the electric current of top-performing silicon transistor prototypes. This is interpreted as the first evidence that nanotubes can outperform silicon transistors.

2006 The first integrated circuit using a single carbon nanotube is built at IBM.

2008 During his doctoral studies at the University of Illinois, Qing Cao invents a way to print circuits of nanotubes on flexible plastic substrates.

2013 At IBM, Cao develops a technique that applies mechanical force to push purified nanotubes in water together into high-density, neatly ordered arrays.

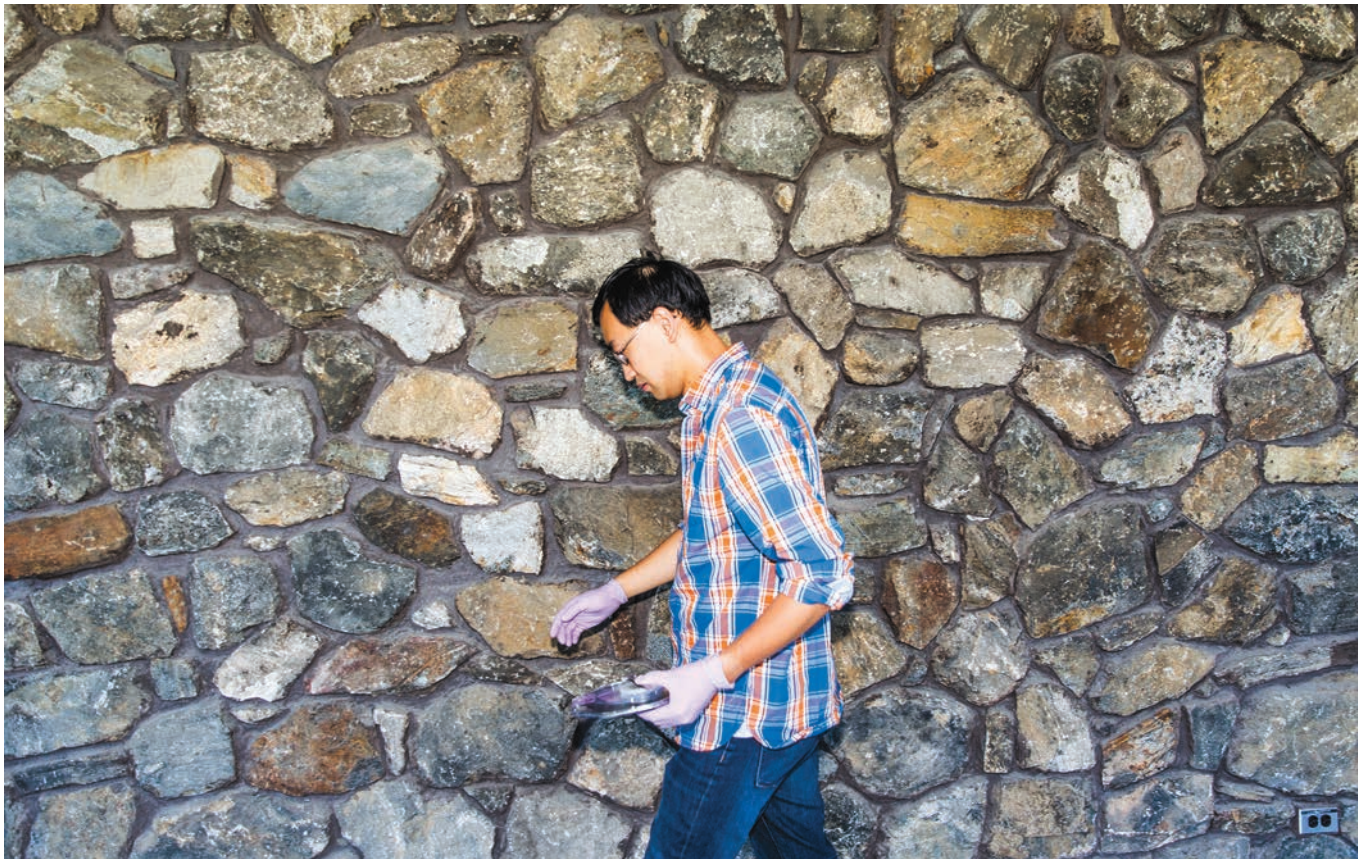
2015 Cao overcomes a fundamental roadblock to commercially viable nanotube transistors. He devises a way to connect metal wires to carbon nanotubes by welding metal atoms to the nanotubes' ends.

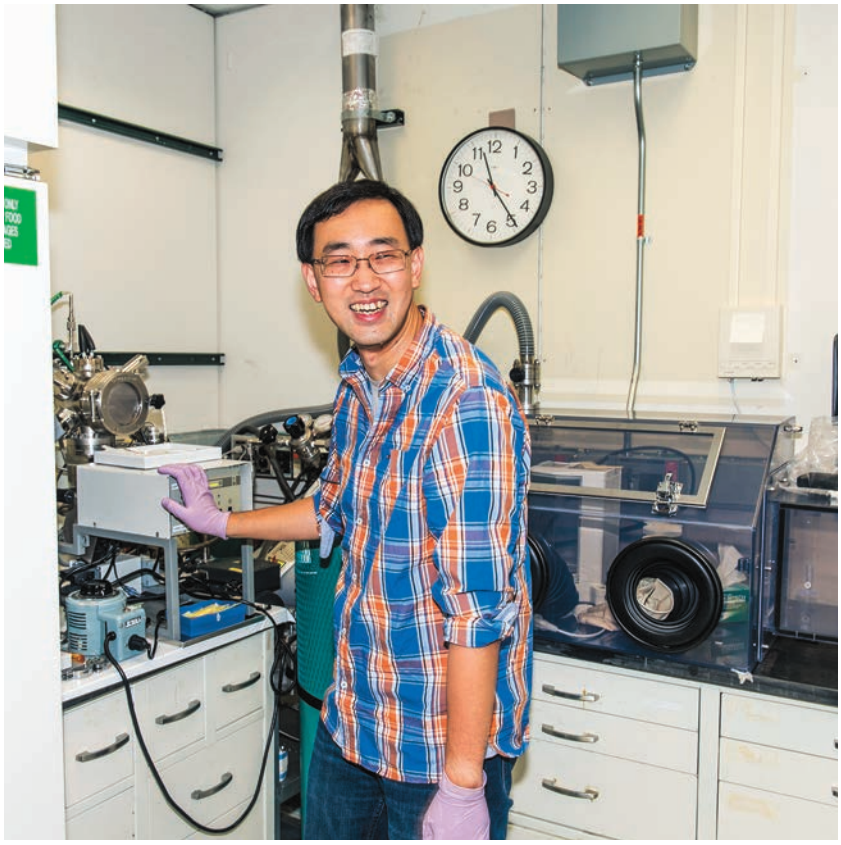
2016 IBM incorporates carbon nanotubes into its in-house semiconductor research line to figure out how to refine and scale up the technology.

2020–2025 IBM aims to have its nanotube transistors ready to replace silicon transistors. The company estimates that nanotube transistors will perform two to three times better than silicon and require half as much power.

—Elizabeth Woyke

GILLES SABRIE





Cao at IBM's Watson Research Center. At bottom right he holds a silicon-based wafer with carbon-nanotube devices.

JACKSON KRULE