Nano-Architecture

A Caltech scientist creates tiny lattices with enormous potential.

By Katherine Bourzac

Breakthrough
Materials whose structures can be precisely tailored so they are strong yet flexible and extremely light.

Why It Matters
Lighter structural materials would be more energy-efficient and versatile.

Key Players
- Julia Greer, Caltech
- William Carter, HRL Laboratories
- Nicholas Fang, MIT
- Christopher Spadaccini, Lawrence Livermore National Laboratory

To visit the lab of Caltech materials scientist Julia Greer is to enter a realm where the ordinary rules of physical stuff don't seem to apply. Greer designs and builds nanomaterials that behave in ways surprising to those of us who spend our days in a world where strong materials like ceramic and steel tend to be heavy, while lightweight ones are weak. When Greer controls architecture at the nanoscale, the rules change.

Conventional ceramics are strong, heavy, and (as anyone who has dropped a plate knows) brittle, prone to shattering. But last year Greer created a ceramic that is one of the strongest and lightest substances ever made. It's also not brittle. In a video Greer made, a cube of the material shudders a bit as a lab apparatus presses down hard on it, then collapses. When the pressure is removed, it rises back up "like a wounded soldier," she says. "It's unreal, isn't it?" Greer often rushes to meetings around campus on Rollerblades and talks so fast that she demands focused listening. Peering into this beautiful, otherworldly nanolattice on her computer screen, she slows down for a while.

If materials like Greer's could be produced in large quantities, they could replace composites and other materials used in a wide range of applications, because they'd be just as strong at a fraction of the weight. Another possibility is to greatly increase the energy density of batteries—the amount of power they can hold at a given size. To do that, researchers have been trying to develop electrodes that are lighter than the ones used in today's batteries but can store more energy. However, promising electrode materials such as silicon are prone to cracking under strain. An electrode made by coating a metal nanolattice with silicon could have crack-resistant toughness in its very structure.