Flexible insulator offers high strength and superior thermal conduction

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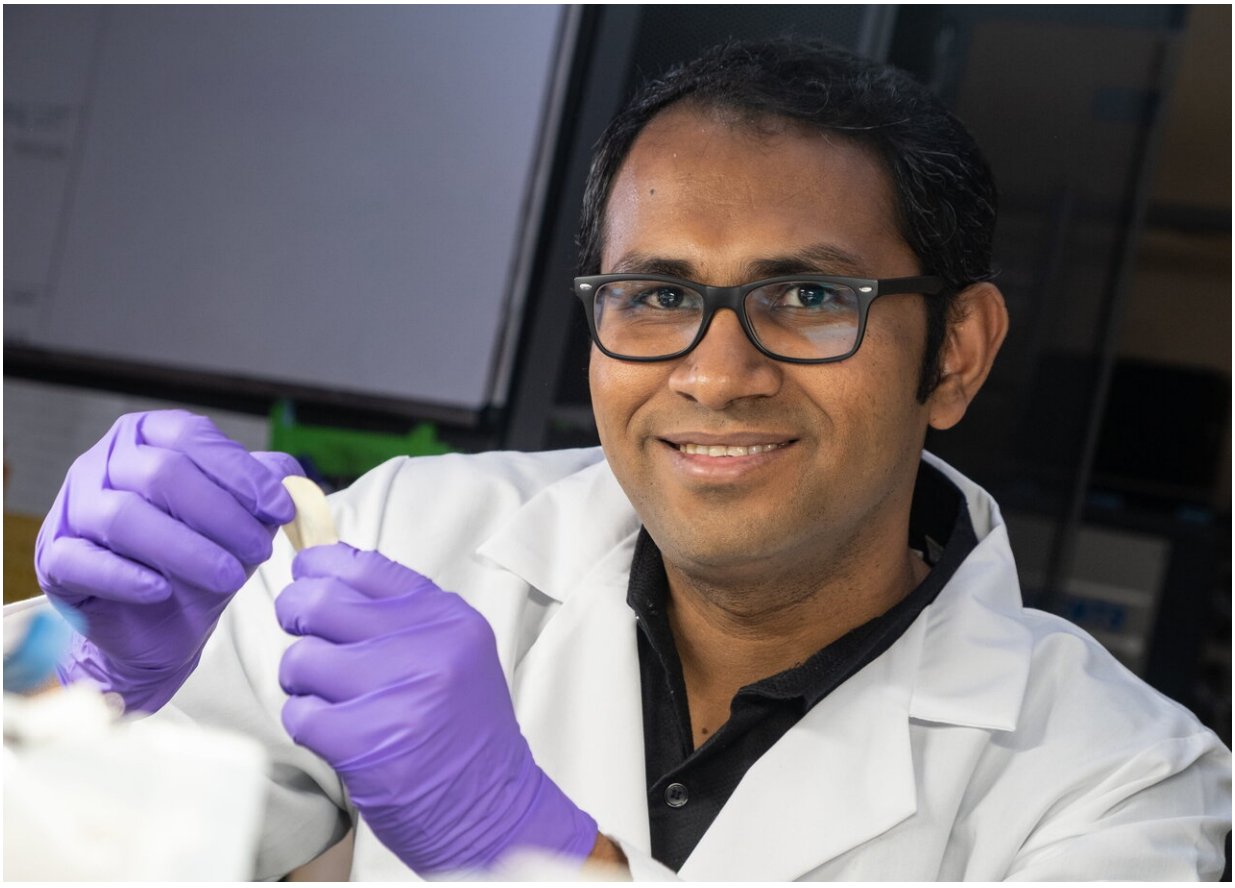

Rice University research scientist M.M. Rahman holds a flexible dielectric made of a polymer nanofiber layer and boron nitride. The new material stands up to high temperatures and could be ideal for flexible electronics, energy storage and electric devices where heat is a factor. Credit: Jeff Fitlow/Rice University

A nanocomposite invented at Rice University's Brown School of Engineering promises to be a superior high-temperature dielectric material for flexible electronics, energy storage and electric devices.

The nanocomposite combines one-dimensional polymer nanofibers and two-dimensional boron nitride nanosheets. The nanofibers reinforce the self-assembling material while the "white graphene" nanosheets provide a thermally conductive network that allows it to withstand the heat that breaks down common dielectrics, the polarized insulators in batteries and other devices that separate positive and negative electrodes.

The discovery by the lab of Rice materials scientist Pulickel Ajayan is detailed in Advanced Functional Materials.

Research scientist M.M. Rahman and postdoctoral researcher Anand Puthirath of the Ajayan lab led the study to meet the challenge posed by next-generation electronics: Dielectrics must be thin, tough, flexible and able to withstand harsh environments.

"Ceramic is a very good dielectric, but it is mechanically brittle," Rahman said of the common material. "On the other hand, polymer is a good dielectric with good mechanical properties, but its thermal tolerance is very low."

Boron nitride is an electrical insulator, but happily disperses heat, he said. "When we combined the polymer nanofiber with boron nitride, we got a material that's mechanically exceptional, and thermally and chemically very stable," Rahman said.

The 12-to-15-micron-thick material acts as an effective heat sink up to 250 degrees Celsius (482 degrees Fahrenheit), according to the researchers. Tests showed the polymer nanofibers-boron nitride combination dispersed heat four times better than the polymer alone.

In its simplest form, a single layer of polyaramid nanofibers binds via van der Waals forces to a sprinkling of boron nitride flakes, 10% by weight of the final product. The flakes are just dense enough to form a heat-dissipating network that still allows the composite to retain its flexibility, and even foldability, while maintaining its robustness. Layering polyaramid and boron nitride can make the material thicker while still retaining flexibility, according to the researchers.

"The 1D polyaramid nanofiber has many interesting properties except thermal conductivity," Rahman said. "And boron nitride is a very interesting 2-D material right now. They both have different independent properties, but when they are together, they make something very unique."

Rahman said the material is scalable and should be easy to incorporate into manufacturing.

More information: Muhammad M. Rahman et al. Fiber Reinforced Layered Dielectric Nanocomposite, *Advanced Functional Materials* (2019). DOI: 10.1002/adfm.201900056

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