Flexible electronics integrated with paper-thin structure for use in space

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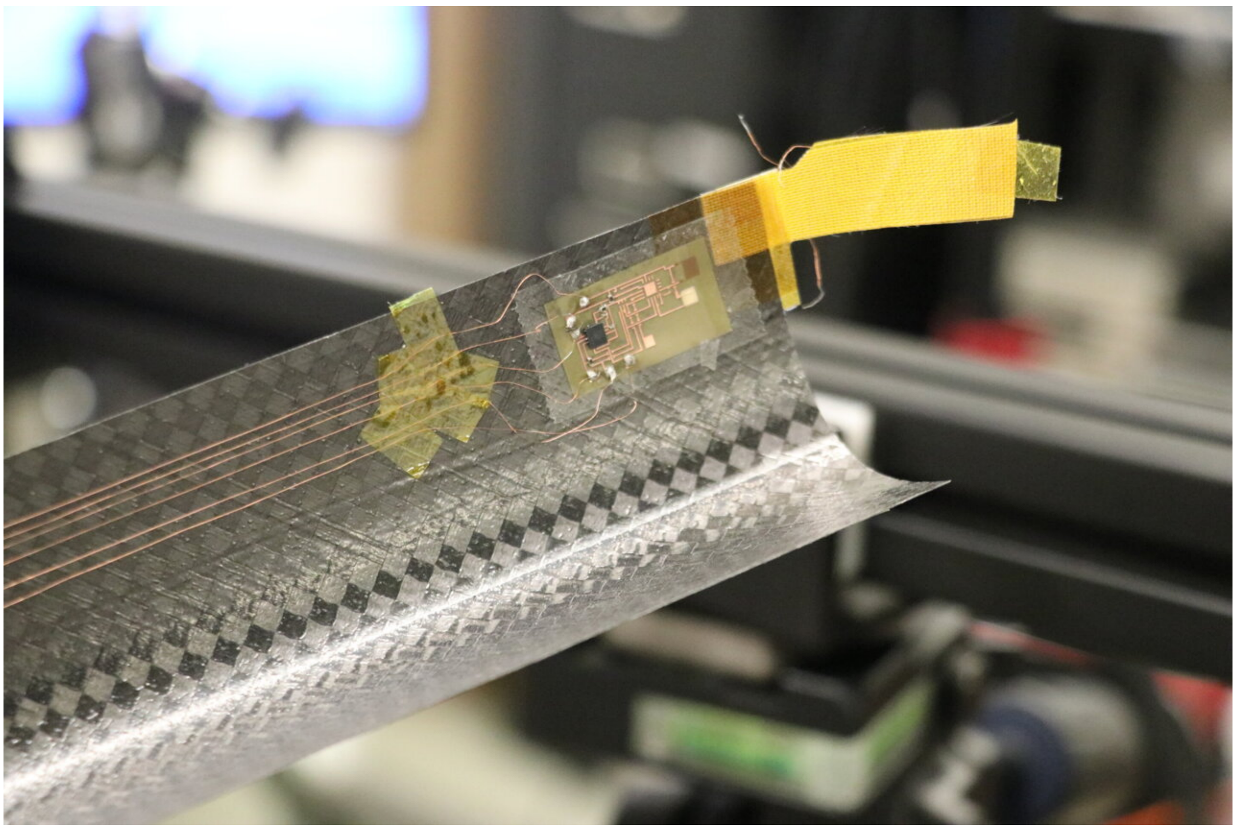

A close-up of the extended boom showing a lightweight, flexible electronics patch with a motion sensor, and a temperature sensor mounted on the boom tip. Credit: University of Illinois at Urbana-Champaign

Being lightweight is essential for space structures, particularly for tools used on already small, lightweight satellites. The ability to perform multiple functions is a bonus. To address these characteristics in a new way, researchers at the University of Illinois Urbana-Champaign successfully integrated flexible electronics with a three-ply, self-deployable boom that weighs only about 20 grams.

The study, "Multifunctional bistable ultrathin composite booms with flexible electronics," by Yao Yao and Xin Ning from Illinois, Juan Fernandez from NASA Langley Research Center and Sven Bilén at Penn State, is published in *Extreme Mechanics Letters*.

"It's difficult to get commercial electronics integrated into these super thin structures," said Xin Ning, an aerospace professor in The Grainger College of Engineering at U. of I. "There were a lot of engineering constraints adding to the challenge of making the electronics able to withstand the harsh environment of space."

Ning said the concept for the work began at a conference about two years ago. He presented his unique expertise in making multifunctional space structures that integrate lightweight, flexible electronics.

"It got the attention of Juan Fernandez from NASA Langley Research Center. He was making a boom structure for a Virginia Tech CubeSat project and saw the opportunity to collaborate and add multi-functional devices to the structures instead of just a pure structure," Ning said.

Ultimately, the boom to contain the electronics was made at NASA Langley Research Center, Ning said. It is a three-ply carbon fiber and epoxy composite material designed to be extremely thin—about as thick as a sheet of paper. It is rolled up like a tape measure with stored energy in its coils until it unfurls on its own in space.

"Virginia Tech had specific requirements for us to follow, some that created challenges," Ning said. "One was the length. They wanted to have power and data lines over a meter in length embedded in a paper-thin composite material. We tried different materials and different technologies.

"Eventually, we went with thin commercial wires coated with insulation and it worked. I think we were overthinking it at the beginning. We tried more difficult, fancier approaches, but they failed. This was a simple and reliable solution using off-the-shelf, readily available wires."

Another key component is a lightweight, flexible electronics patch with a motion sensor, a temperature sensor, and a blue LED, all mounted on the boom tip. Ning explained that the electronics needed to endure the harsh thermal-vacuum conditions of space while remaining flexible enough to withstand the sudden unfurling of the coiled boom. The motion sensor monitors the deployment and vibration of the boom, and the blue LED assists CubeSat cameras in seeing the structure in space once deployed.

Ning's team conducted comprehensive on-ground experiments and simulations to explore the mechanics of the bistable boom with flexible electronics, as well as its deployment and vibration behavior. Ning said that these fundamental studies could offer valuable insights for future designs of multifunctional space structures.

The Virginia Tech three-unit CubeSat with the multifunctional boom is aiming for launch in 2025.

"We are also working on making the flexible electronics more durable in space—ways to protect the electronics so they will be operational longer in the space environment."

More information: Yao Yao et al, Multifunctional bistable ultrathin composite booms with flexible electronics, *Extreme Mechanics Letters*

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