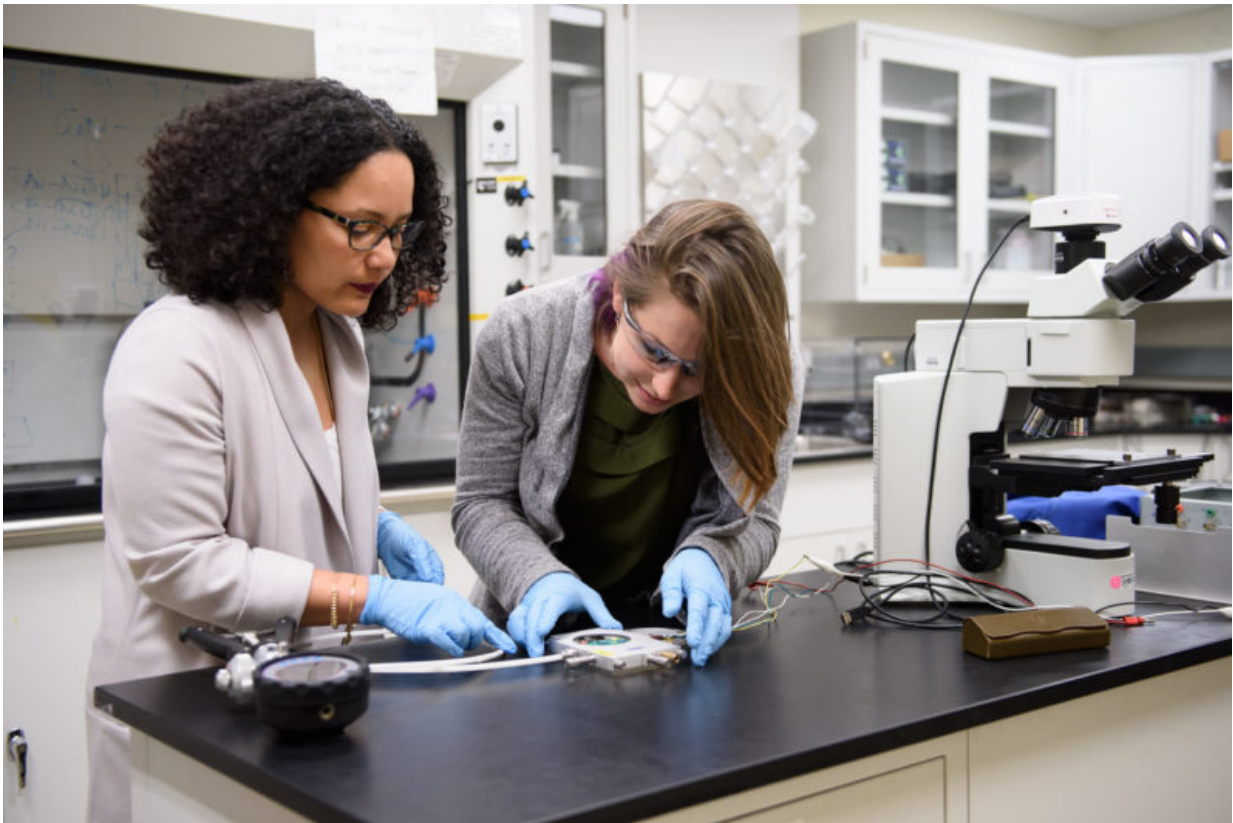


# New nano devices could withstand extreme environments of space

March 28 2017, by Ula Chrobak

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Professor Debbie Senesky, left, works with graduate student Caitlin Chapin on electronics that can resist extreme environments. Credit: L.A. Cicero

Behind its thick swirling clouds, Venus is hiding a hot surface pelted with sulfuric acid rains. At 896 F (480 C) degrees, the planet's

atmosphere would fry any of today's electronics, posing a challenge to scientists hoping to study this extreme environment.

Researchers at the Stanford Extreme Environment Microsystems Laboratory, or the XLab, are on a mission to conquer these conditions. By developing heat-, corrosion- and radiation-resistant electronics, they hope to move research into extreme places in the universe – including here on Earth. And it all starts with tiny, nano-scale slices of material.

"I think it's important to understand and gain new insight through probing these unique environments," said Debbie Senesky, assistant professor of aeronautics and astronautics and principle investigator at the XLab.

Senesky hopes that by studying Venus we can better understand our own world. While it's hard to imagine that hot and corrosive Venus ever looked like Earth, scientists think that it used to be much cooler. Billions of years ago, a runaway greenhouse effect may have caused the planet to absorb far more heat than it could reflect, creating today's scorching conditions. Understanding how Venus got so hot can help us learn about our atmosphere.

"If we can understand the history of Venus, maybe we can understand and positively impact the future evolution of our own habitat," said Senesky.

What's more, devices that can withstand the rigors of space travel could also monitor equally challenging conditions here on earth, such as in our cars.

## **Scorching heat**

One hurdle to studying extreme environments is the heat. Silicon-based

semiconductors, which power our smartphones and laptops, stop working at about 572 F (300 C) degrees. As they heat up, the metal parts begin to melt into neighboring semiconductor and don't move electricity as efficiently.

Ateeq Suria, graduate student in mechanical engineering, is one of the people at the XLab working to overcome this temperature barrier. To do that, he hopped into his bunny suit—overall lab apparel that prevents contamination—and made use of ultra-clean work spaces to create an atoms-thick, heat-resistant layer that can coat devices and allow them to work at up to 1112 F (600 C) degrees in air.

"The diameter of human hair is about 70 micrometers," said Suria. "These coatings are about a hundredth of that width."

Suria and others at the XLab are working to improve these nano-devices, testing materials at temperatures of up to 1652 F (900 C) degrees. For space electronics, it's a key step in understanding how they survive for long periods of time. Although a device might not be exposed to such temperature extremes in space, the test conditions rapidly age materials, indicating how long they could last.

The team at XLab tests materials and nano-devices they create either in-house in high-temperature probe stations or in a Venus simulator at the NASA Glenn Research Center in Cleveland, Ohio. That simulator mimics the pressure, chemistry and temperature of Venus. To mirror the effects of space radiation, they also test materials at Los Alamos National Laboratory and at NASA Ames Research Center.

## **Radiation damage**

More than just surviving on Venus, getting there is important, too. Objects in space are pounded by a flurry of gamma and proton radiation

that knock atoms around and degrade materials. Preliminary work at the XLab demonstrates that sensors they've developed could survive up to 50 years of radiation bombardment while in Earth's orbit.

Senesky said that if their fabrication process for nano-scale materials proves effective it could get incorporated into technologies being launched into space.

"I'm super excited about the possibility of NASA adopting our technology in the design of their probes and landers," said Senesky.

## **Hot electronics at home**

While space is an exciting frontier, Suria said that interest in understanding car engines initially fueled this research. Inside an engine, temperatures reach up to 1832 F (1000 C) degrees, and the outer surface of a piston is 1112 F (600 C) degrees. Current technology to monitor and optimize engine performance can't handle this heat, introducing error because measuring devices have to be placed far away from the pistons.

Electronics designed to survive the intense conditions of [space](#) could be placed next to the engine's pistons to directly monitor performance and improve efficiency.

"You just put the sensor right in the engine and get much better information out," said Suria.

Other fiery, high pressure earth-bound environments that would benefit from these robust electronics include oil and gas wellbores, geothermal vents, aircraft engines, gas turbines and hypersonic structures.

Provided by Stanford University

Citation: New nano devices could withstand extreme environments of space (2017, March 28)  
retrieved 26 September 2023 from

<https://techxplore.com/news/2017-03-nano-devices-extreme-environments-space.html>

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