Researchers discover super-elastic shape-memory material

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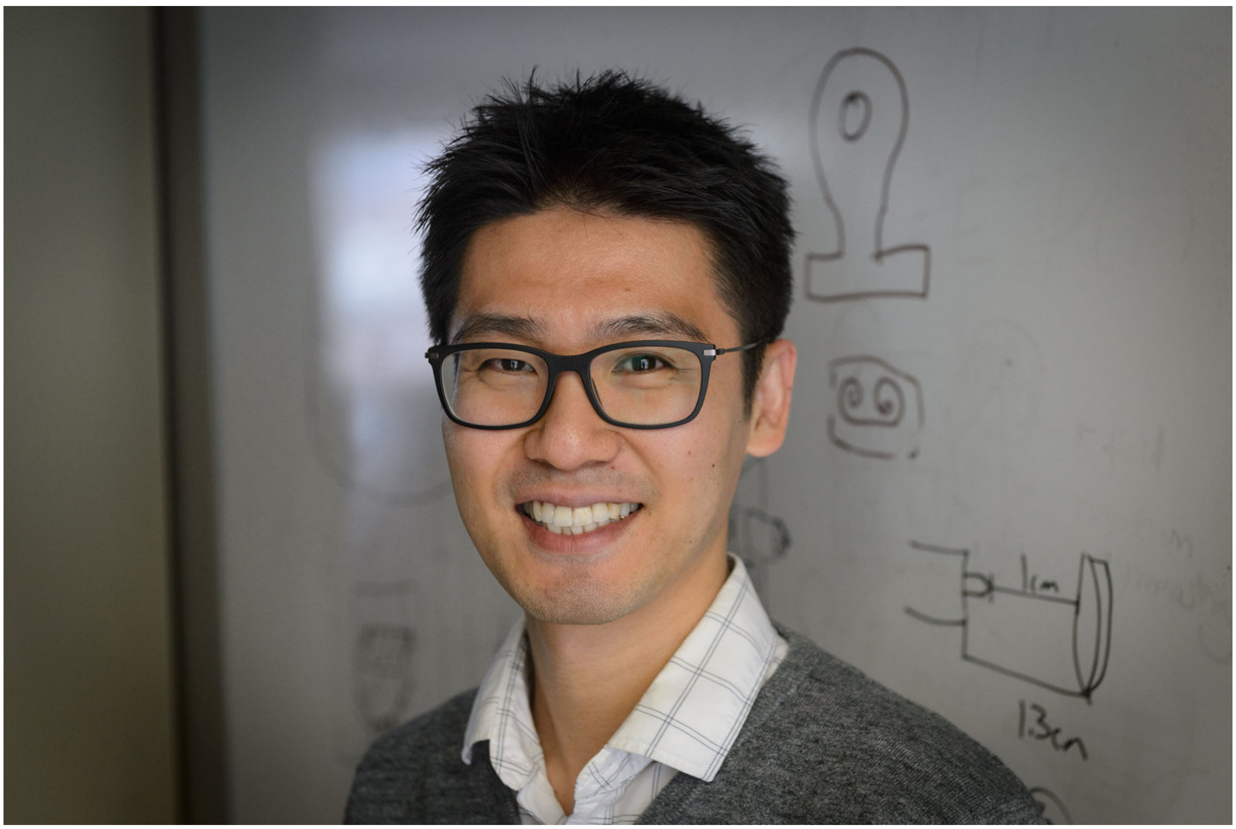

Materials science and engineering professor Seok-Woo Lee and colleagues have discovered super-elastic shape-memory properties in a material that could be used in the harshest of conditions, such as outer space. Credit: Peter Morenus/UConn Photo

UConn materials science and engineering researcher Seok-Woo Lee and his colleagues have discovered super-elastic shape-memory properties in a material that could be applied for use as an actuator in the harshest of conditions, such as outer space, and might be the first in a whole new class of shape-memory materials.

If you have ever had braces or wear eyeglasses, you may have already come in contact with shape-memory materials. With applications in a wide range of consumer products such as "unbreakable" frames for glasses, and civil industrial structures like bridges, materials with shape-memory properties can return to their original shape by magnetic forces or heat even after being significantly deformed.

Lee, who is Pratt & Whitney assistant professor of materials science and engineering, studied calcium iron arsenide, or $CaFe_2As_2$, which is an intermetallic better known for its novel superconducting properties. Since the material is commonly used in high-temperature superconductors, extensive research had already examined the compound's superconducting and magnetic properties. Inspired by previous research conducted at the U.S Department of Energy's Ames Laboratory by Paul Canfield on calcium iron arsenide's electronic properties, Lee set out to measure the material's high degree of pressure and strain sensitivity for potential applications as a structural material.

Working with a team of graduate and undergraduate students at UConn and collaborators at Ames Laboratory, Drexel University, and Colorado State University, Lee discovered that not only did $CaFe_2As_2$ exhibit the ability to "bounce" back into its original shape, it showed "giant super-elasticity." While normal metal alloys or intermetallics recover 0.5 percent of the pre-deformation shape once the compressing force has been removed, $CaFe_2As_2$ recovers more than 13 percent.

In addition to the crystal's large ability to recover, the team saw evidence of calcium iron arsenide's ultra-high strength and significant fatigue resistance, which would guarantee structural performance and integrity if used as a structural material. They also noted another unique property when testing $CaFe_2As_2$ at extremely cold temperatures. The existence of shape-memory effect was confirmed when tested at temperatures as low as 50 Kelvin, or about -370 degrees Fahrenheit. This could lead to the development of technologies that change shape at low temperatures for use in deep space travel.

But Lee is most excited about what these discoveries could indicate about other materials in the same family as calcium iron arsenide.

"Our results can be applied to more than 400 similar materials. This discovery opens up an entirely new area of research on superelastic materials," Lee says. "We see great potential for our findings to be applied by fellow scientists in future research and by industry in the development of new technologies."

The findings were published in *Nature Communications* online on Oct. 20 in a paper titled "Superelasticity and Cryogenic Linear Shape Memory Effects of $CaFe_2As_2$."

More information: John T. Sypek et al. Superelasticity and cryogenic linear shape memory effects of CaFe2As2, *Nature Communications* (2017). DOI: 10.1038/s41467-017-01275-z

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