Using a shape memory polymer as a robot gripper

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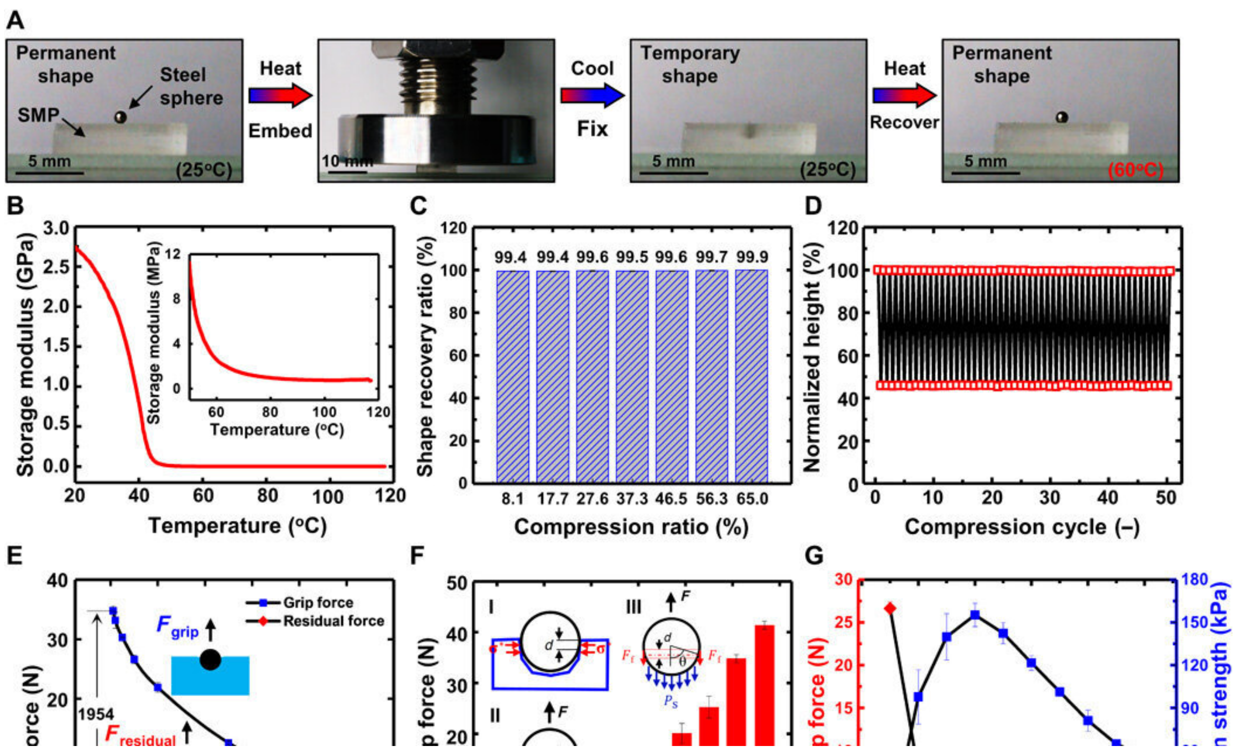

Characterization of the epoxy SMP material and the SMP gripper. (A) Demonstration of the temporary shape fixing and permanent shape memory effect of the SMP. (B) Storage modulus versus temperature of the SMP material. Insets: Magnification of the storage modulus versus temperature at higher temperatures. (C) Shape recovery ratio of the SMP under different compression ratios. (D) Performance of the SMP under repeated compression. (E) Comparison of the grip and residual forces as functions of the grip speeds. Parameters for the grip force measurement: temperature for embedding, 120°C; temperature for pulling, 30°C; embedding depth, 3 mm; indenter diameter, 5 mm. (F) Influence of the embedding angle on the grip force (temperature for embedding, 120°C; temperature for pulling, 30°C; indenter diameter, 5 mm; grip speed, 100 µm/s). Insets show the underlying mechanism of the gripping. (I and II) Profile illustrations showing the configuration evolution of the SMP gripper and the embedded sphere system during the gripping process. (III) Force diagram of the embedded sphere in the vertical direction. (G) Influence of the temperature on the grip force. The line with red rhombuses gives the grip force, while the line labeled by blue squares shows the adhesion. The grip force is obtained from the embedding and pulling out tests (temperature for embedding, 120°C; temperature for pulling, 30°C; indenter diameter, 5 mm; embedding depth, 3 mm; grip speed, 1000 µm/s), while the adhesion strength under the same separation speed (1000 µm/s) is obtained by pull tests between a glass plate and the SMP. Photo credit: Changhong Linghu, Zhejiang University. Credit: *Science Advances* (2020). DOI: 10.1126/sciadv.aay5120

A team of researchers at Zhejiang University has created a new robot gripper using a shape memory polymer. In their paper published in the journal *Science Advances*, the group describes the material, its use as a gripper, and how well it worked.

Over the past several decades, scientists have used a variety of approaches to give a robot the ability to pick up and manipulate objects and to set them back down—all without damaging the object. Much progress has been made in robot grippers, due mostly to advances in microchip technology, but there is still a lot of room for improvement. One of the biggest challenges is developing a gripper that can pick up and manipulate objects of nearly any shape, different sizes, and made from different materials. Creating a human hand-like gripper that is able to pick up a pin off of a table, carry a raw egg across a room or tie a child's ribbon in her hair, requires a very highly sophisticated gripper and associated software. In this new effort, the researchers have done away with the need for sophistication by taking an entirely different approach.

Prior research has shown that when certain polymers are heated, they expand slightly and grow soft. The researchers used both properties to create their new gripper. They created a polymer gripper that softens when heated to 45°C and then hardens again when exposed to 25°C. Its base shape is cuboid (a 3-D rectangle). They then affixed the gripper to a simple arm that was able to place the gripper down against a tabletop or lift it just above the table—enough to allow placement of various objects underneath.

Testing involved placing an object such as a small steel ball beneath the gripper and then heating the entire apparatus in an enclosure to 45°C. After a few minutes, the polymer had softened. The researchers then lowered the gripper to the object, allowing the object to be encompassed—similar to setting a softened stick of butter on a fork. The temperature in the enclosure was then reduced to 25°C. At that point, the polymer shrank slightly, gripping the object as it firmed. The researchers then raised the gripper and the object it was holding. To set the object back down, the researchers lowered the gripper to the table and raised the temperature in the enclosure to 45°C.

More information: Changhong Linghu et al. Universal SMP gripper with massive and selective capabilities for multiscaled, arbitrarily shaped objects, *Science Advances* (2020). DOI: 10.1126/sciadv.aay5120