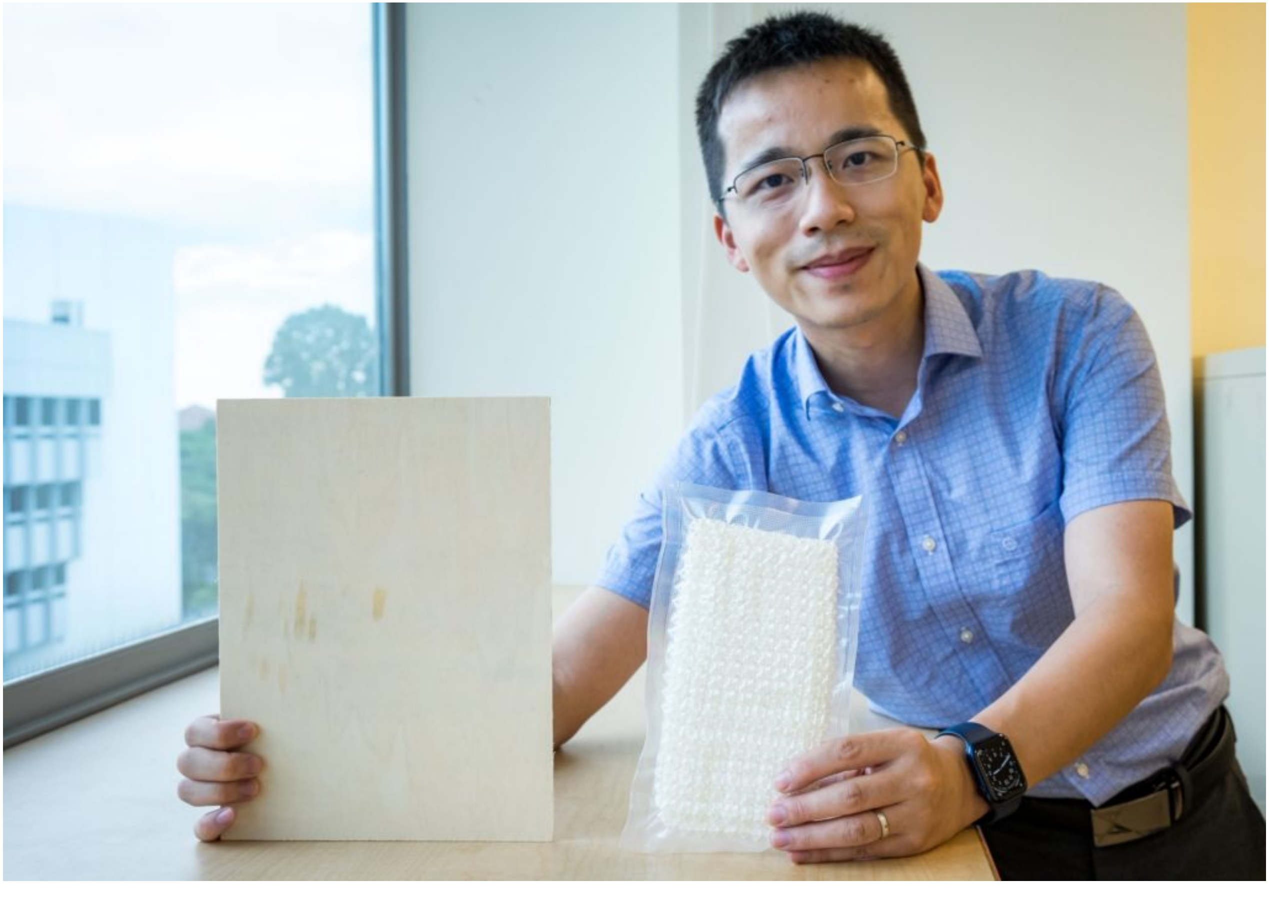
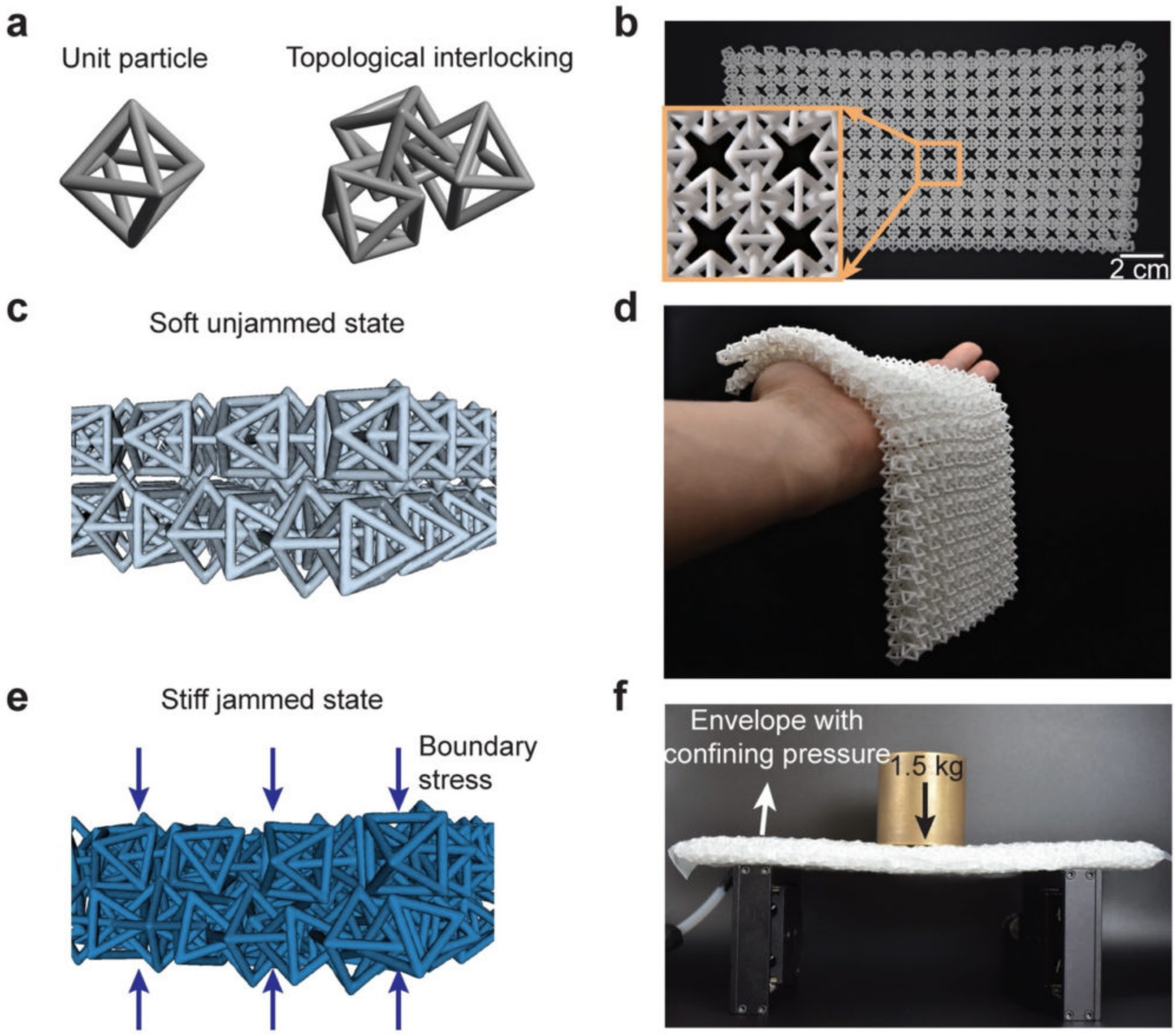
10 hours • by Joris Peels • 3D Printing • 3D Printing Metamaterials • 3D Printing Research • 4D Printing

Nanyang Technological University, Singapore (NTU Singapore) and California Institute of Technology (Caltech) researchers have created a polyamide chain mail which is flexible but can harden when needed.



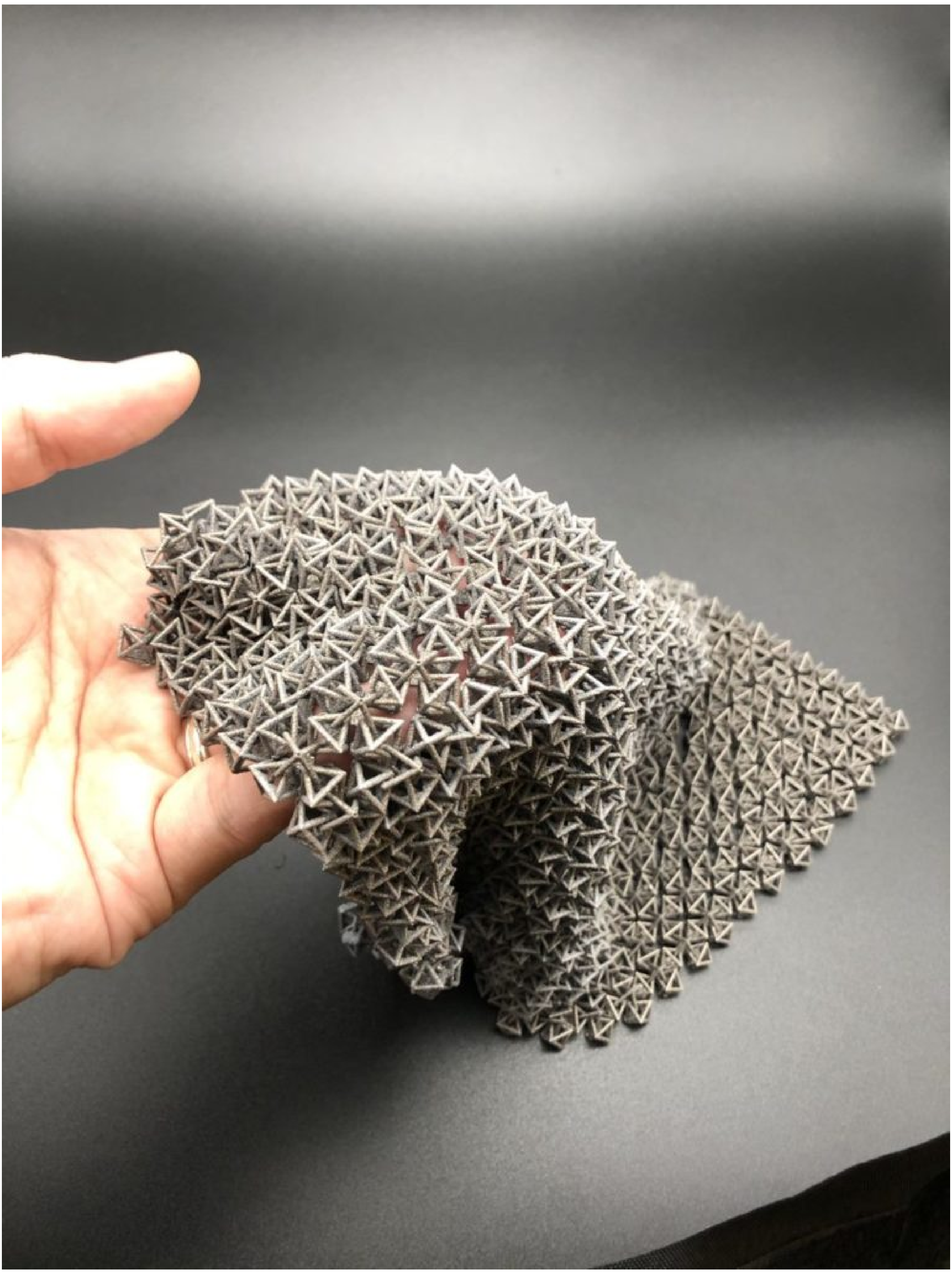
Made out of interlocking eight faced octahedrons that are wrapped in plastic, the structure becomes 25 times stiffer when vacuum packed. Similar to how your loose grains of coffee become a rigid mass when vacuum packed, the stiffer packed structure can actually act as a form of armor.



This could lead to “wearable structured fabrics” that would be soft enough for us to wear but stiffen when needed. Think of a pair of skate shorts that would be soft and flexible but could become rigid just before impact. Or consider a more comfortable bullet proof vest. Or imagine a robot arm that would soften just before it impacted a human nearby.

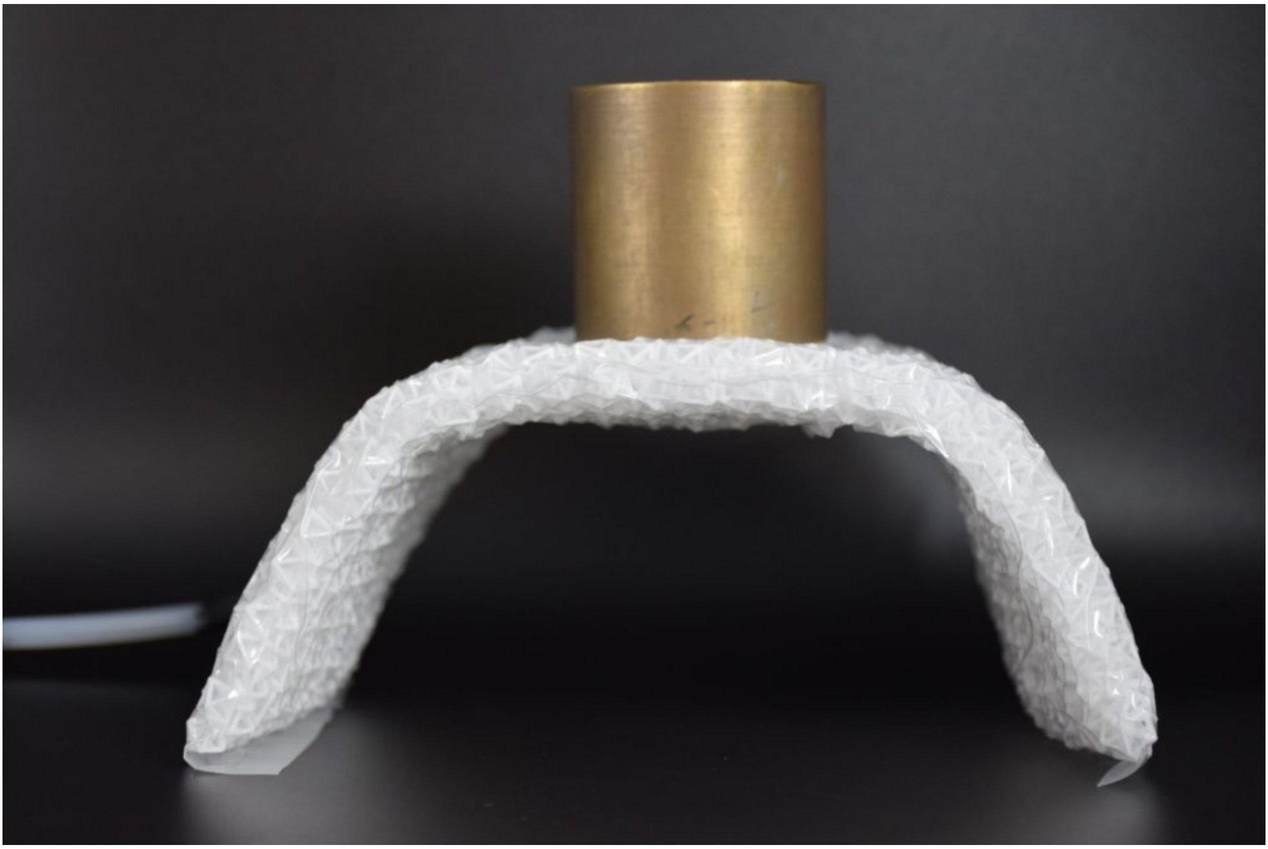
ical and Aerospace Engineering was the lead author of the research published in *Nature* today.

> "With an engineered fabric that is lightweight and tuneable – easily changeable from soft to rigid – we can use it to address the needs of patients and the ageing population, for instance, to create exoskeletons that can help them stand, carry loads and assist them with their daily tasks," Wang said. "Inspired by ancient chain mail armour, we used plastic hollow particles that are interlocked to enhance our tuneable fabrics' stiffness. To further increase the material's stiffness and strength, we are now working on fabrics made from various metals including aluminium, which could be used for larger-scale industrial applications requiring higher load capacity, such as bridges or buildings."



> "We wanted to make materials that can change stiffness on command. We'd like to create a fabric that goes from soft and foldable to rigid and load-bearing in a controllable way," stated Professor Chiara Daraio, Caltech's G. Bradford Jones Professor of Mechanical Engineering and Applied Physics.

The idea that this cloth is tunable and can be manipulated on demand is a powerful one. We've had a lot of chain mail like structures in 3D printing before. Also a number of helmet manufacturers have shown that we can 3D print geometries that optimally respond to both high-velocity, sharp impacts and slow, significant, blunt impacts. Now, we're getting a truly digital material that can be programmed and changed at will to respond to stimuli in the environment. Think of how pneumatics and actuators work nowadays. With this material, we could find a new way to move, grip, hold, levitate, and absorb impact all with the same material and the same manipulation.



These fabrics can be 3D printed in one go on one machine and still be comprised of different interlocking shapes. The number and size of these structures, as well as the size of the fabric itself, could be changed per application. The team states that, when the hollow nylon 3D printed fabric is stiff it can hold, "1.5kgs, more than 50 times the fabrics' own weight". They also measured a "six times reduction in penetration depth."

This is a very elegant solution that could lead to a lot of potential commercial applications. What I also really enjoy is that this is a soft robotics application. Soft robotics has always kind of remained an interesting idea waiting for an application and I can really see how this mechanism could lead to a lot of commercial products that can really make soft robotics more popular, prevalent and useful.

Tagged with: 3d printed chain mail • 4D • Caltech • change properties impact • flexible • helmets • impact altered • NSU • NTU • NTU Singapore • polyamide • research paper • singapore • soft robotics