Making stretchable and self-healable hydrogel artificial skin possible

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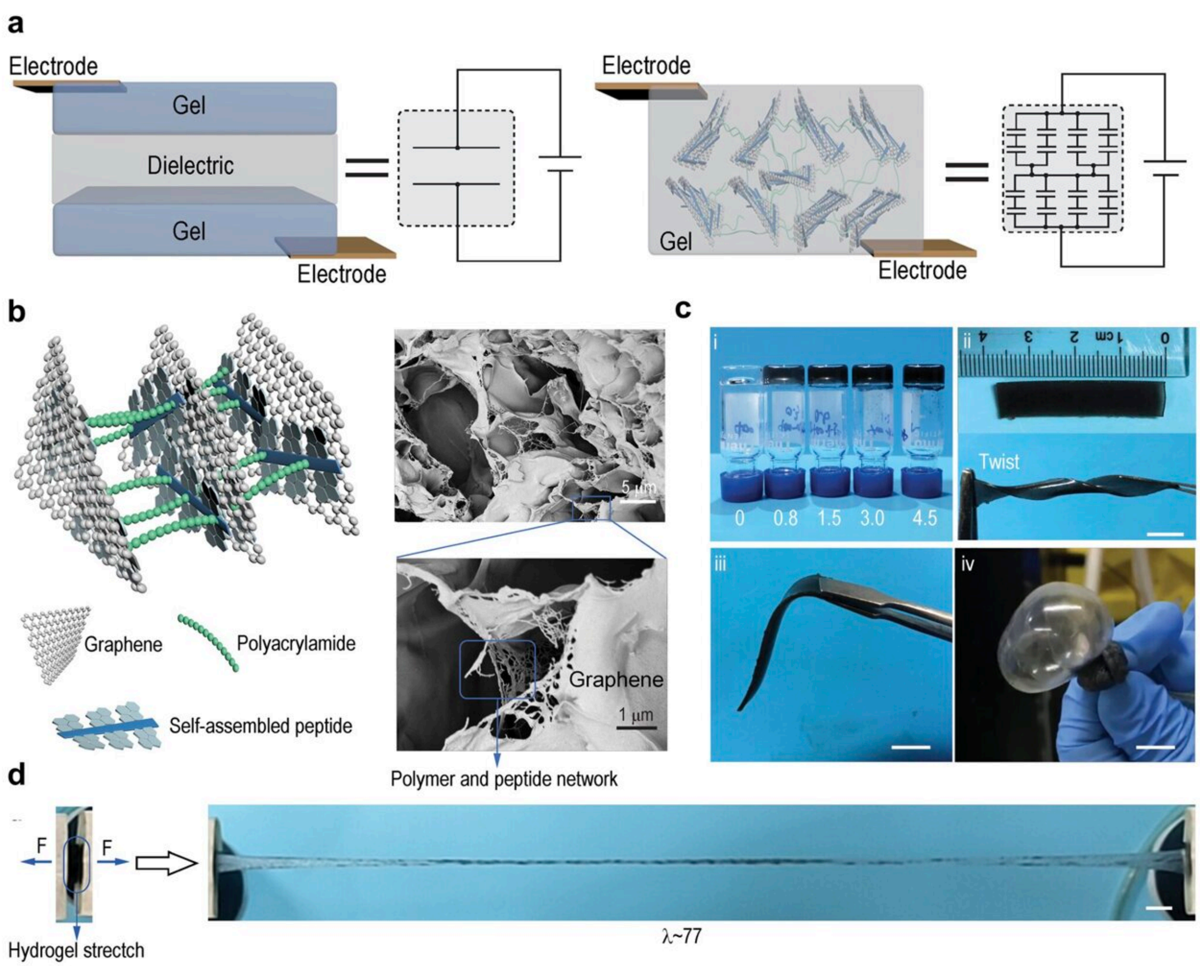
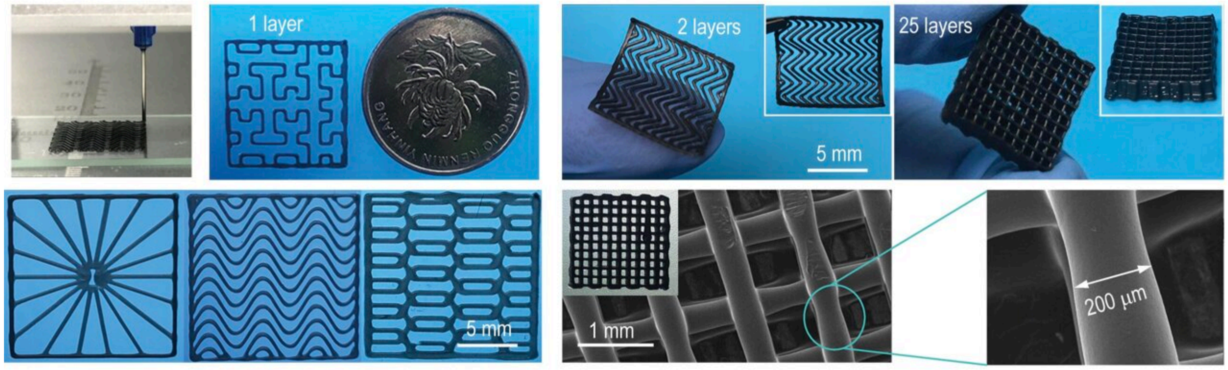


a) Design of SHARK; b) Microstructures of SHARK c-d) Ductility and stretchability of SHARK. Credit: Science China Press

Prof. Yi Cao (Department of physics, Nanjing University) and Prof. Wei Wang (Department of physics, Nanjing University) propose a single-layer hydrogel artificial skin, termed 'SHARK', that combines high stretchability, self-healing properties, and ultrasensitive mechanical sensing.

Hydrogels have emerged as promising materials for the construction of skin-like mechanical sensors. The common design of hydrogel-based artificial skin requires a dielectric sandwiched between two hydrogel layers for capacitive sensing. However, such a planar configuration limits the sensitivity, stretchability and self-healing properties. The unmatched mechanical properties of the hydrogel and the elastomer layers can often result in delamination under multiple strain cycles. Achieving simultaneous self-healing of the hydrogel and the elastomer layers to fully recover the functionalities of hydrogel artificial skins is almost impossible. Despite significant progress, realizing highly stretchable yet self-healable hydrogel-based mechanical sensors requires novel design concepts.

In this work, the team reported the first design of single-layer composite hydrogels with bulk capacitive junctions as mechanical sensors. They engineered dielectric peptide-coated graphene (PCG) to serve as homogenously dispersed electric double layers in hydrogels. The whole system can be considered a bulk capacitor junction formed by the series-parallel connection of numerous microcapacitors. As such, SHARK features larger equivalent electric double layer areas and thus higher sensitivities than planar-shaped hydrogel sensors. Any mechanical motions that affect the microscopic distributions of PCG in the hydrogels can significantly change the overall capacitance. "The microcapacitors are dispersed in the gel matrix of SHARK, forming distributed yet interconnected mechano-sensors akin to the human skin" Yi says.



3D printing of SHARK based sensors with predefined shape and microstructures. Credit: Science China Press

The mechanical and electrical properties of SHARK are also recommendable. Thanks to the strong yet dynamic interfacial interactions between the hydrogel network and graphene, the hydrogel artificial skins can be stretched up to 77 times their original length and completely self-heal of their mechanical and electrical properties in less than a minute. They are of high sensitivity with a gage factor of 1.39 for strain sensing and can effectively sense strain and pressure in both air and aqueous environments. Moreover, they are remoudable and printable, making it convenient to construct SHARK based sensor chips.

Considering the improved mechanical, electrical and self-healing properties of SHARK, the researchers expected that this novel capacitive hydrogel sensor can have broad applications for next-generation flexible iontronics.

More information: Bin Xue et al, Stretchable and self-healable hydrogel artificial skin, *National Science Review* (2021). DOI: 10.1093/nsr/nwab147

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