Self-healing polymer exhibits autonomous alignment

Soft materials can give devices the capability to repair themselves, like human skin. The next step is the creation of thin polymers that can self-heal without manual intervention. In a study recently published in *Science* (https://www.science.org/doi/10.1126/science.adh0619), Christopher B. Cooper and colleagues at Stanford University demonstrate a thin multilayer polymer that self-aligns.

In order to autonomously heal, the layers of a thin material must find themselves across a damaged region, and the structure must align with itself. Otherwise, it will only heal if the material is realigned from the outside. Currently, researchers often fashion self-healing materials from single polymers, but these often do not self-align well.

An alternative approach to making self-aligning thin materials is to combine multiple layers of multiple polymers. The researchers took this approach, stacking alternating layers of poly(dimethylsiloxane) (PDMS) and poly(propylene glycol) (PPG). These two polymers have different surface energies, preventing them from mixing with each other. At the same time, the two have identical dynamic bonds, which allow them to adhere and prevent them from delaminating.

The researchers first constructed an 11-layer film of PDMS and PPG. Then, they sliced clean through the film. Within 24 h, under 70°C heat, the layers realigned and reattached. This structure was then used to fabricate a few simple self-healing devices: a thin-film pressure sensor, a fiber structure with a magnetic-microflake-containing composite, and an underwater circuit that powered up a light-emitting diode. The devices themselves are simple, but what the researchers find exciting is that they are only in the order of 10-µm thick.

"To get realignment at those small length scales is basically impossible when you're manually aligning things by eye," Cooper, who is now a postdoctoral scholar at the National Institute of Standards and Technology and an incoming professor at Washington University in St. Louis, told *MRS Bulletin*.

"It is a really beautiful example of how fundamental polymer properties can drive advances in emerging fields like soft electronics and soft robotics," Michael Bartlett, an associate professor at Virginia Tech, who was not involved in the research, told *MRS Bulletin*.

The research team views the devices and their two-layer material as a starting point for more complex devices and, certainly, more complex materials: ones with five- or six-layered polymers, for example.

"A pressure sensor is still relatively simple," Cooper told *MRS Bulletin*. "What if we want to do this with a transistor? Or, what if we want to do this with a layer that's at the nanometer-length scale?"

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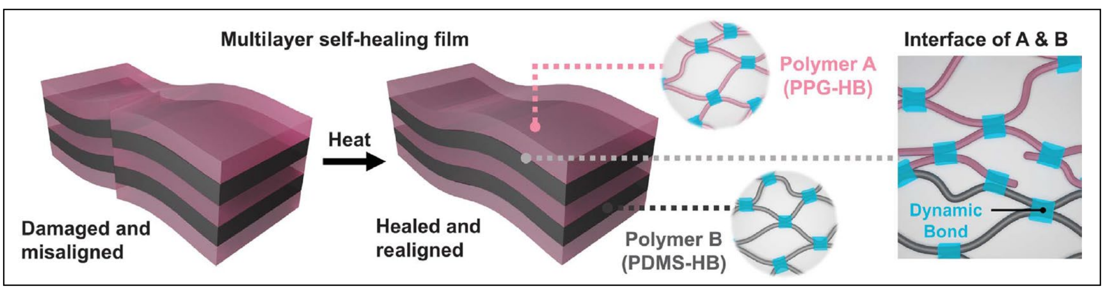

Schematic showing the principle of surface tension–mediated realignment and healing of a fractured multilayer laminate. The difference in surface energy between the two polymer backbones (type A and type B) drives realignment, while the dynamic bonds in both polymers promote interlayer adhesion for device performance. Credit: *Science*.