Liquid metal serves as stretchable hermetic seal in soft electronics

Soft electronics aims to revolutionize the architecture and design of conventional electronics that are rigid and fixed. Electronic devices that are flexible and elastic without losing their electrical and thermal conductivity properties, the integrity of the internal circuits, and the basic operating conditions are needed for many applications. Now, an international team of researchers reports in a recent issue of *Science* (https://www.science.org/doi/10.1126/science.ade7341) that it is possible to incorporate liquid metal to protect and insulate the active zone of some flexible electronic devices without compromising the elastic properties.

In general, the most easily deformable materials with lower Young's modulus, such as elastomers, are highly permeable to ambient gases such as oxygen and water vapor. In addition, in hard electronics, a stiff architecture is chosen that favors the isolation of the circuits, cables, and electrodes so that they do not suffer damage due to reactive species that can affect the performance and operation of the equipment.

Michael D. Dickey of North Carolina State University and colleagues take advantage of the physical properties of liquid gallium and its alloys—specifically eutectic gallium indium (EGaIn)—in lithium-ion batteries (LIBs) with a water-based electrolyte, in stretchable heat-transfer systems, and in wireless communication processes. The metallic nature of the material acts as a hermetic seal because metals normally serve as an impermeable barrier for many substances. As a fluid, liquid gallium is known to have little resistance to deformation and meets the main need for soft electronics.

Dickey told *MRS Bulletin,* "There are only a few metals that are liquid at room temperature. Mercury is a liquid but it is toxic. We focus on gallium because it can be patterned into a film due to the native oxide that forms on the surface of the metal." Dickey said that gallium, combined with other metals such as indium, tin, and zinc, form alloys with lower melting points. Other metals such as In and Sn could be used if higher temperatures are tolerated, he said.

By introducing the seal prepared with liquid gallium, the battery achieved significant improvement in its retention capacity after 500 charge and discharge cycles; likewise, a higher thermal conductivity was obtained in the heat transfer, and the transmission of wireless signals through the seals was verified.

"We have essentially created a stretchable metal container," Dickey said. "Metal containers normally act like Faraday cages, which block RF and wireless communication. The ability for the container to transmit wireless signals would enable the encapsulation of electronic devices built from materials that are stretchable but prone to oxidation or degradation from water vapor."

The prospects for the future of soft electronics are promising. "I personally take inspiration from human tissue, which is completely soft yet capable of doing amazing things like sense, actuate, compute, and heal," Dickey said. "The ability to mimic these properties can allow for electronics to be used in new ways."

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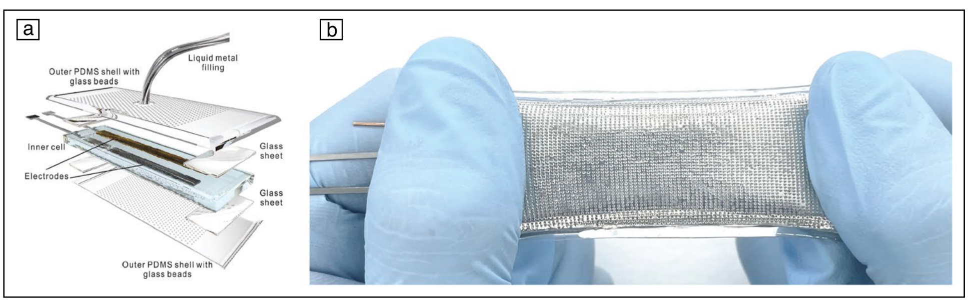

(a) Schematic showing the key components of the liquid–metal (LM)-based seal that is integrated into a stretchable lithium-ion battery (LIB). (b) Photograph of the LIB with the LM-based seal under stretching. PDMS, poly(dimethylsiloxane). Credit: *Science.*