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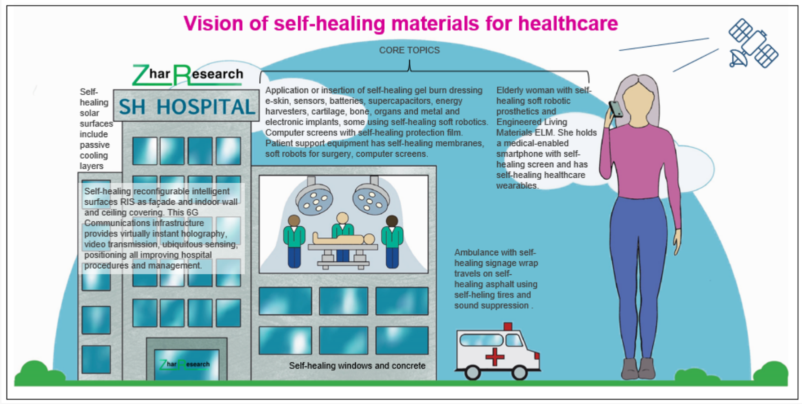
Self-Healing Elastomers and e-Skin Trend Strongly in 2023

The exponential growth in sales and research of self-healing materials has moved up a gear in 2023 with breakthroughs in both new markets and new technologies.



Vision of self-healing materials for healthcare. Source, Zhar Research report, "“Self-Healing Engineering Materials, Markets, Technology 2024-2044”. www.zharresearch.com

Reference	Approach to making self-healing e-skin
Science https://doi.org/10.1126/science.ade0086 (2023).	**Hydrogel**
Front Chem. 2023 Apr 28;11:1198067. doi: 10.3389/fchem.2023.1198067. eCollection 2023.	**Silicone**
Science Advances 9 Feb 2018 Vol 4, Issue 2m	**Polyimine.** The first dynamic covalent thermoset-based e-skin. Fully recyclable, malleable. Tactile, temperature, flow, and humidity sensing.
Adv. Mater. 25 (2013) 1589-1592.	**Supramolecular rubber** with Ga-In microchannels
Adv. Funct. Mater. 20 (2010) 1721-1727: https://doi. org/10.1002/adfm.201000159.	**Poly(urea-formaldehyde) microcapsules with tetrathiafulvalene (TTF) tetracyanoquinodimethane (TCNQ)**
Adv. Mater. 24 (2012) 25782581. https://doi.org/10.1002/adma.201200196.	**Polyurethane** embedded with capsules of silver paste

Examples of the many candidate materials for e-skin on humans and robots. Source: Zhar Research report, “Self-Healing Engineering Materials, Markets, Technology 2024-2044”.

LONDON, UNITED KINGDOM, July 22, 2023 /EINPresswire.com/ -- The exponential growth in sales and research of self-healing materials has moved up a gear in 2023 with breakthroughs in both new markets and new technologies. About 70% of the business remains engineering with attention to self-healing cementitious products and asphalt being overtaken by other possibilities mostly polymers and their composites. Indeed, a twenty-year view must also embrace such things as “grow yourself a prosthetic” using Engineered Living Material ELM. New Zhar Research reports span all of that. “Self-Healing Engineering Materials, Markets, Technology 2024-2044” addresses about 70% of this emerging market and “Self-Healing Healthcare Materials, Markets, Technology 2024-2044” covers most of the rest.

Dr Peter Harrop CEO of Zhar Research advises, “Overall, a CAGR of 21% will drive this market to over $100 billion in 2044 with many new billion-dollar enterprises created on the way. Consequently, interest is now intense. Take self-healing elastomers as an example. That starts with shock absorbers, thermal interface materials and so on but advanced forms can be e-skin for soft robotics and humans. From body patches to implants, some sense condition and act accordingly, for example automatically delivering drugs in amount and timing determined by the patch's sensors and microprocessor. Alternatively, by stimulating the neural system with electrical signals, e-skin sends messages to the brain that portray what the skin is feeling. In robots, e-skin improves the way the robot interacts with human environments."

At their simplest, those e-skins start with elastomer substrates supporting non-elastic serpentine interconnects that can expand and rigid chips too small to be a problem to overall stretchability. To some extent, such things have already been commercialised, mostly as smart sensors.
Elastic, self-healing electronic components.

Later, the researchers plan that we shall employ elastic transistors and more. A start is elastomer electric conductors where Incorporating conductive inorganic material into nonconductive polymers is one approach. The inorganic part provides conductivity, and polymer part provides self-healing ability to the material. For the proper functioning of self-healing material, the inorganic material should be in good compatible with the polymer matrix for the easy movement of inorganic part along with polymer during the crack healing and to avoid the phase separation thereby providing electrical healing. However, some researchers report excellent electrical healing but poor mechanical healing. Back to the drawing board.
Harrop adds,

"There is already considerable research on all of that. It is very sophisticated in choice of materials because self-healing is never the only thing on the wish list for a given application. For example, bacterial rejection and self-cleaning may also be demanded. In a different case, e-skin at the University of Colorado, Boulder, when exposed to a stimulus, physically transforms and when the stimulus is removed, the elasticity of the material leads it to morph back into its original shape. "

Hydrogels

Stanford University is a leader in the hydrogel approach, using versions reinforced with silica nanoparticles to create a strong elastic surface. Added to this is a 2D titanium carbide MXene sensor using highly-conductive nanowires. Usefully, hydrogels are composed of more than 70% water, which makes them compatible with human skin tissues. The scientists say this invention could imbue prosthetics with the ability to monitor biological information, including changes in blood pressure. The data could then be shared and stored on the cloud via WiFi. Perhaps 6G Communications at THz (far infrared) frequencies could also be accommodated when it is available but that poses other materials challenges.

Fluoropolymers

At the other extreme, THz-transparent self-healing protective overlayers on 6G reconfigurable intelligent surfaces RIS over the sides of buildings may need similar materials, derisking investment. Candidates for this include fluoropolymers in the view of Zhar Research. Which is interesting because there are so many self-healing fluoropolymers the research pipeline. For instance, in 2021, Singapore researchers developed a smart foam material that allows robots to sense nearby objects and repairs itself when damaged, just like human skin. This “Artificially innervated Foam”, or AiFoam, is a highly elastic polymer formed by mixing – yes - fluoropolymer with a compound that lowers surface tension. They also develop a healable, low-field illuminating optoelectronic stretchable HELIOS device by introducing a transparent, high permittivity polymeric dielectric material. HELIOS is an elastic rubber sheet made up of a blend of fluoroelastomer and surfactant.

Silicones

Shaanxi University of Technology has recently reported on its silicone route to e-skins. This year, it gave a review on the development of stretchable and self-repairing materials applied to electronic skin Front Chem. 2023 Apr 28;11:1198067. doi: 10.3389/fchem.2023.1198067. eCollection 2023.
This predicts that flexible electronic devices will play a key role in the fields of flexible batteries, electronic skin and flexible displays. It agrees that the application areas of electronic skin in new energy, artificial intelligence and other high-tech applications are increasing. It considers that semiconductors are an indispensable part of electronic skin components. Indeed, the design of such semiconductor structure not only needs to maintain good carrier mobility but also extensibility and self-healing capability, which is always challenging. Research on self-healing semiconductors, light emitters etc. continues apace. However, Dr Harrop of Zhar Research expects that chips will be with us for a long time in e-skin. Very small chips are extremely unlikely to break. Researched stretchable alternatives to chip LEDS, microprocessors or memory are, sadly, many magnitudes worse in parameters.

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