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New stretchable, self-healing and illuminating electronic material for wearables and soft robots

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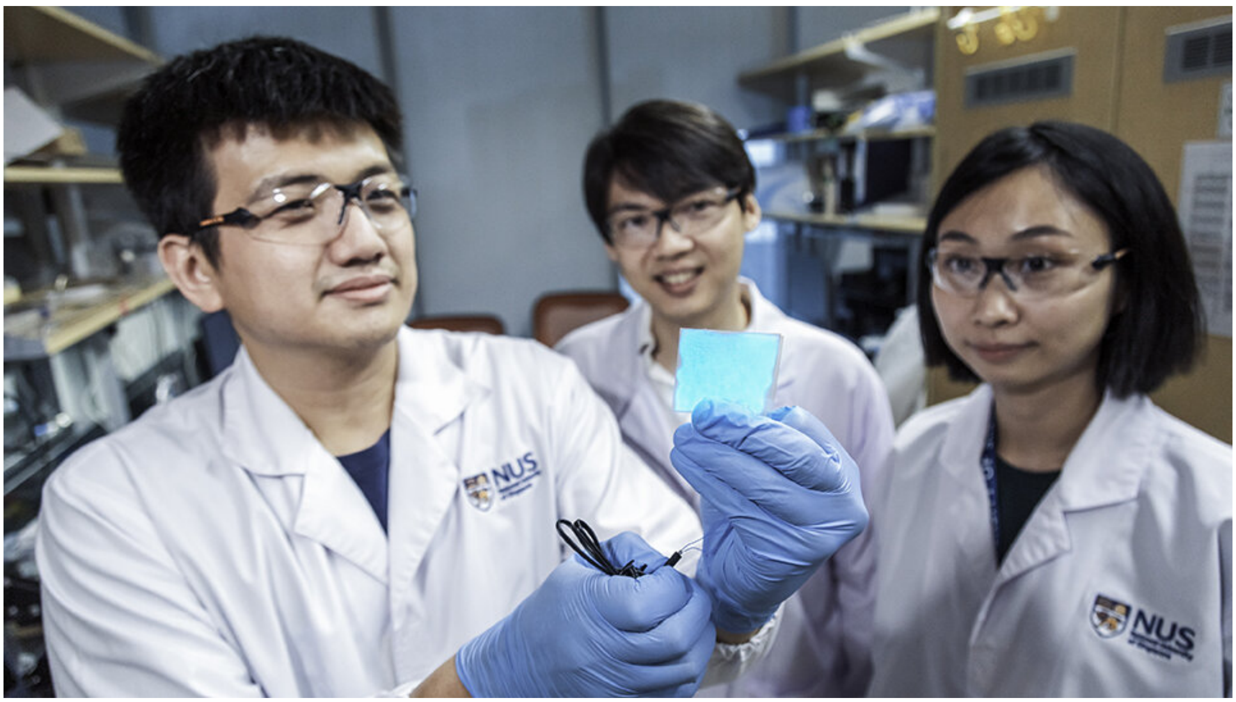

The NUS research team behind the novel electronic material is led by Assistant Professor Benjamin Tee (centre). With him are two team members: Mr Wang Guanxiang (left), who is holding a sample of the illuminated material, and Dr Tan Yu Jun (right). Credit: National University of Singapore

Imagine a flexible digital screen that heals itself when it cracks, or a light-emitting robot that locates survivors in dark, dangerous environments or carries out farming and space exploration tasks. A novel material developed by a team of NUS researchers could turn these ideas into reality.

The new stretchable material, when used in light-emitting capacitor devices, enables highly visible illumination at much lower operating voltages, and is also resilient to damage due to its self-healing properties.

This innovation, called the HELIOS (which stands for Healable, Low-field Illuminating Optoelectronic Stretchable) device, was achieved by Assistant Professor Benjamin Tee and his team from the NUS Institute for Health Innovation & Technology and NUS Materials Science and Engineering. The results of the research were first reported in *Nature Materials* on 16 December 2019.

Durable, low-power material for next-gen electronic wearables and soft robots

"Conventional stretchable optoelectronic materials require high voltage and high frequencies to achieve visible brightness, which limits portability and operating lifetimes. Such materials are also difficult to apply safely and quietly on human-machine interfaces," explained Asst Prof Tee, who is also from NUS Electrical and Computer Engineering, N.1 Institute for Health and the Hybrid Integrated Flexible Electronic Systems program.

To overcome these challenges, the team of five NUS researchers began studying and experimenting with possible solutions in 2018, and eventually developed HELIOS after a year.

In order to lower the electronic operating conditions of stretchable optoelectronic materials, the team developed a material which has very high dielectric permittivity and self-healing properties. The material is a transparent, elastic rubber sheet made up of a unique blend of fluoroelastomer and surfactant. The high dielectric permittivity enables it to store more electronic charges at lower voltages, enabling a higher brightness when used in a light-emitting capacitor device.

Unlike existing stretchable light-emitting capacitors, HELIOS enabled devices can turn on at voltages that are four times lower, and achieve illumination that is more than 20 times brighter. It also achieved an illumination of 1460 cd/m^2 at 2.5 V/μm, the brightest attained by stretchable light-emitting capacitors to date, and is now comparable to the brightness of mobile phone screens. Due to the low power consumption, HELIOS can achieve a longer operating lifetime, be utilized safely in human-machine interfaces, and be powered wirelessly to improve portability.

HELIOS is also resistant to tears and punctures. The reversible bonds between the molecules of the material can be broken and reformed, thereby allowing the material to self-heal under ambient environmental conditions.

Describing the potential impact of HELIOS, Asst Prof Tee said, "Light is an essential mode of communication between humans and machines. As humans become increasingly dependent on machines and robots, there is huge value in using HELIOS to create 'invincible' light-emitting devices or displays that are not only durable but also energy-efficient. This could generate long-term cost savings for manufacturers and consumers, reduce electronic waste and energy consumption, and in turn, enable advanced display technologies to become both wallet and environmentally friendly."

For example, HELIOS can be used to fabricate long-lasting wireless displays that are damage-proof. It can also function as an illuminating electronic skin for autonomous soft robots to be deployed for smart indoor farming, space missions or disaster zones. Having a low-power, self-repairing illuminating skin will provide safety lighting for the robot to maneuver in the dark while remaining operational for prolonged periods.

The NUS team has filed for a patent for the new material, and is looking to scale up the technology for specialty packaging, safety lights, wearable devices, automotive and robotics applications.

More information: Yu Jun Tan et al. A transparent, self-healing and high-κ dielectric for low-field-emission stretchable optoelectronics, *Nature Materials* (2019). DOI: 10.1038/s41563-019-0548-4

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