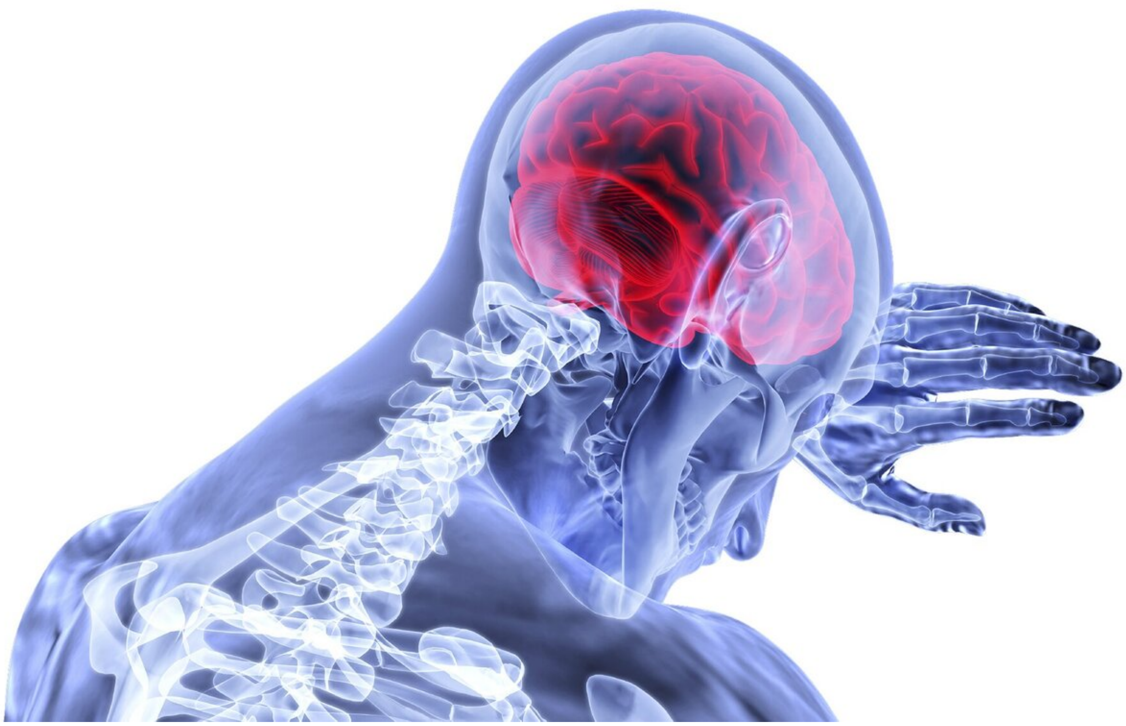
Hypersensitive strain sensor enables real-time stroke monitoring

December 20 2024



Credit: CC0 Public Domain

A research team led by Prof. Seung-Kyun Kang from the Department of Materials Science and Engineering at Seoul National University has developed a strain sensor with record-breaking sensitivity in collaboration with researchers from Dankook University, Ajou University, and Purdue University.

This study introduced a hypersensitive, flexible, and stretchable sensor by combining microcracks with meta-structures in an innovative way. The advanced technology enables real-time stroke diagnosis through continuous blood flow monitoring, opening new possibilities in the field of precision biomedical engineering.

The results of this study were published online on December 20 in *Science Advances.*

Flexible and stretchable strain sensors detect biomechanical signals or deformation of specific objects based on changes in the electrical resistance of conductive materials.

However, previous sensors are limited by low sensitivity and a significant decline in performance when measuring infinitesimal strains below 10^{-3}. This limitation poses critical challenges in the early diagnosis of diseases associated with mechanical physiological signals, as well as in structural reliability assessments and preemptive safety evaluations.

For instance, cerebrovascular diseases such as brain hemorrhage or ischemia are accompanied by infinitesimal strains smaller than 10^{-3} before they become life-threatening. Similarly, structural materials typically experience surface strain levels of 10^{-5} to 10^{-3} prior to catastrophic failure, which can lead to significant loss of life.

To address these challenges, Prof. Kang's team introduced a meta-structure with a negative Poisson's ratio, achieving up to 100 times greater sensitivity compared to the previous sensors. Their sensor is capable of detecting strains as small as 10^{-5} strains, equivalent to a change in length on the scale of a single atom on the surface of a human hair.

The sensor developed in this study achieved world-leading strain sensitivity by amplifying electrical resistance changes through controlled widening of nanoscale microcracks.

As a result, it demonstrated the capability to monitor infinitesimal deformations accompanying microbial growth processes, such as real-time detection of contact induced by the growth of mold hyphae on bread (generating strain levels as small as 10^{-5}).

The newly-developed sensor demonstrated significant potential for applications in biological environments. The research team successfully attached the sensors to the surface of cerebral blood vessels inside the skull, enabling real-time monitoring of blood pressure and blood flow changes.

This breakthrough highlights the potential of the sensor for early diagnosis of cerebrovascular diseases such as cerebral hemorrhage and ischemia, as well as cardiovascular disorders, while providing precise medical data.

Furthermore, the sensor consists of biodegradable materials, allowing it to decompose naturally without long-term residue in the body, ensuring patient safety without the need for additional surgeries or side effects.

The research team stated, "This study is not merely about improving sensor performance, but about presenting a groundbreaking approach that overcomes the fundamental limitations of the previous technologies. We anticipate wide-ranging applications not only in bioengineering and medical devices but also in fields such as robotics, disaster response, and environmental monitoring."

More information: Jae-Hwan Lee et al, Hypersensitive Meta-Crack Strain Sensor for Real-Time Biomedical Monitoring, *Science Advances*

(2024). DOI: 10.1126/sciadv.ads9258.
www.science.org/doi/10.1126/sciadv.ads9258

Provided by Seoul National University