The sensitive strain sensor that can detect the weight of a feather

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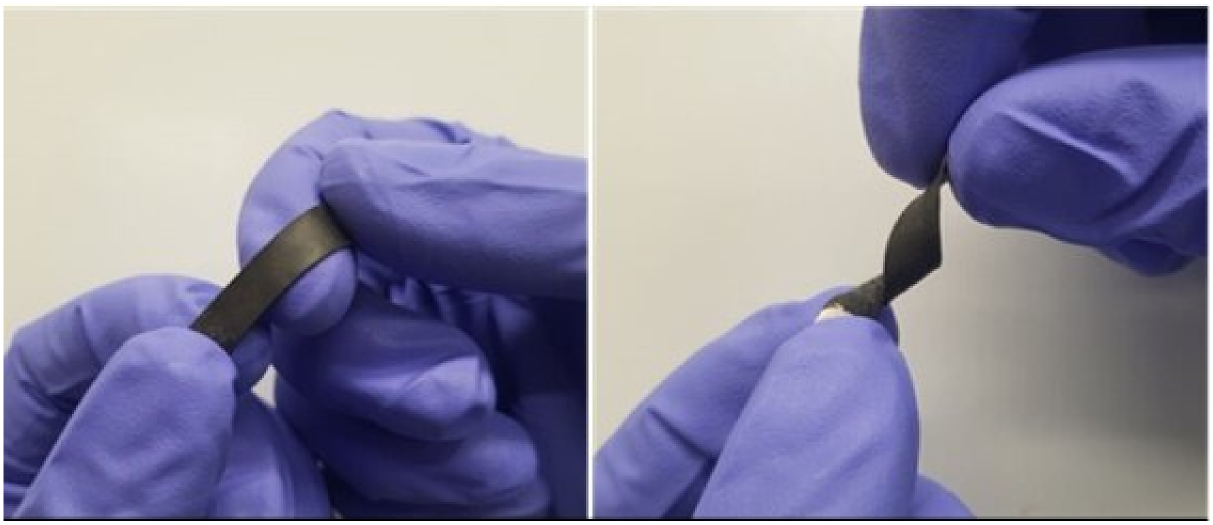


Stretching and twisting the ultra-sensitive strain sensors. Credit: University of Sussex

Physicists have created the most sensitive strain sensor ever made, capable of detecting a feather's touch.

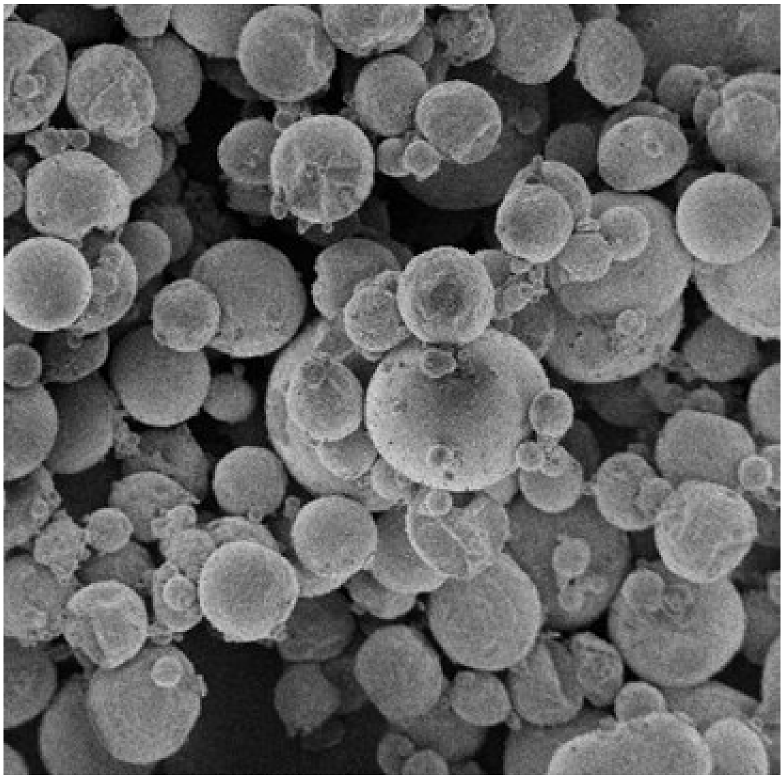
The sensor, developed by the Materials Physics Group at the University of Sussex, can stretch up to 80 times higher strain than strain gauges currently on the market and show resistance changes 100 times higher than the most sensitive materials in research development.

The research team believe the sensors could bring new levels of sensitivity to wearable tech measuring patients' vital signs and to systems monitoring buildings and bridges' structural integrity.

Marcus O'Mara, from the School of Mathematical and Physical Sciences at the University of Sussex, said: ""The next wave of strain sensing technology uses elastic materials like rubber imbued with conductive materials such as graphene or silver nanoparticles, and has been in development for over a decade now.

"We believe these sensors are a big step forward. When compared to both linear and non-linear strain sensors referenced in the scientific literature, our sensors exhibit the largest absolute change in resistance ever reported."

Alan Dalton, Professor of Experimental Physics at the University of Sussex, said: "This promising technology may prove especially useful in established fields such as healthcare, sports performance monitoring and rapidly growing fields such as soft robotics.



Scanning Electron Microscopy (SEM) Image of G-balls under high magnification. Credit: University of Sussex

"Our research has developed cheap, scalable health monitoring devices that can be calibrated to measure everything from human joint motion to vitals monitoring. Multiple devices could be used across the body of a patient, connected wirelessly and communicating together to provide a live, mobile health diagnostics at a fraction of the current cost."

The new paper, published in the journal *Advanced Functional Materials*, details the process for incorporating large quantities of graphene nanosheets into a PDMS matrix in a structured, controllable fashion that results in excellent electromechanical properties.

The authors say the method has the potential to be extended to a wide range of two-dimensional layered materials and polymer matrices. The sensors deliver greatly enhanced conductivity at all measured loading levels with no apparent percolation threshold.

Commercial gauge devices suffer from relatively low sensitivity and strain range, with gauge factors ranging from 2-5 and maximum strains of 5% strain or less, resulting in the resistance increasing by less than 25% and preventing high-strain sensing required for bodily motion monitoring.

The new sensors are able to detect strains less than 0.1%, due to their higher gauge factor of ~20, and up to 80% strain, where the exponential response leads to the resistance changing by a factor of more than one million.

This allows both high-sensitivity low-strain sensing for pulse monitoring and high-strain measurement of chest motion and joint bending as a result of the record resistance change.

Photograph of G-balls resting in a glass vial. Each ball has a soft polydimethylsiloxane (PDMS) core and is coated with microscopic sheets of graphene. Credit: University of Sussex

Dr. Sean Ogilvie, Research Fellow in Materials Physics at the University of Sussex, said: "Commercial strain sensors, typically based on metal foil gauges, favour accuracy and reliability over sensitivity and strain range. Nanocomposites are attractive candidates for next generation strain sensors due to their elasticity, but widespread adoption by industry has been hampered by non-linear effects such as hysteresis and creep due to the liquid like nature of polymers at the nanoscale which makes accurate, repeatable strain readouts an ongoing challenge.

"Our sensors settle into a repeated, predictable pattern which means that we can still extract an accurate read-out of strain despite these effects."

The work was made possible with the support of US-based rubber company Alliance.

Jason Risner, V.P. of Sales & Marketing at Alliance, said: "Alliance has a long history of innovation and it is vital for us to play an active role in leading edge rubber technology that uses a disruptive nanomaterial like graphene. It is critical that we partner with scientific leaders like Professor Alan Dalton at the University of Sussex.

"We are thrilled to see the products that could potentially come out of our partnership. Graphene is an astonishing material that can revolutionize our lives. Our company is proud to be on the cutting edge of something so new."

More information: Marcus A. O'Mara et al, Ultrasensitive Strain Gauges Enabled by Graphene-Stabilized Silicone Emulsions, *Advanced Functional Materials* (2020). DOI: 10.1002/adfm.202002433

Provided by University of Sussex