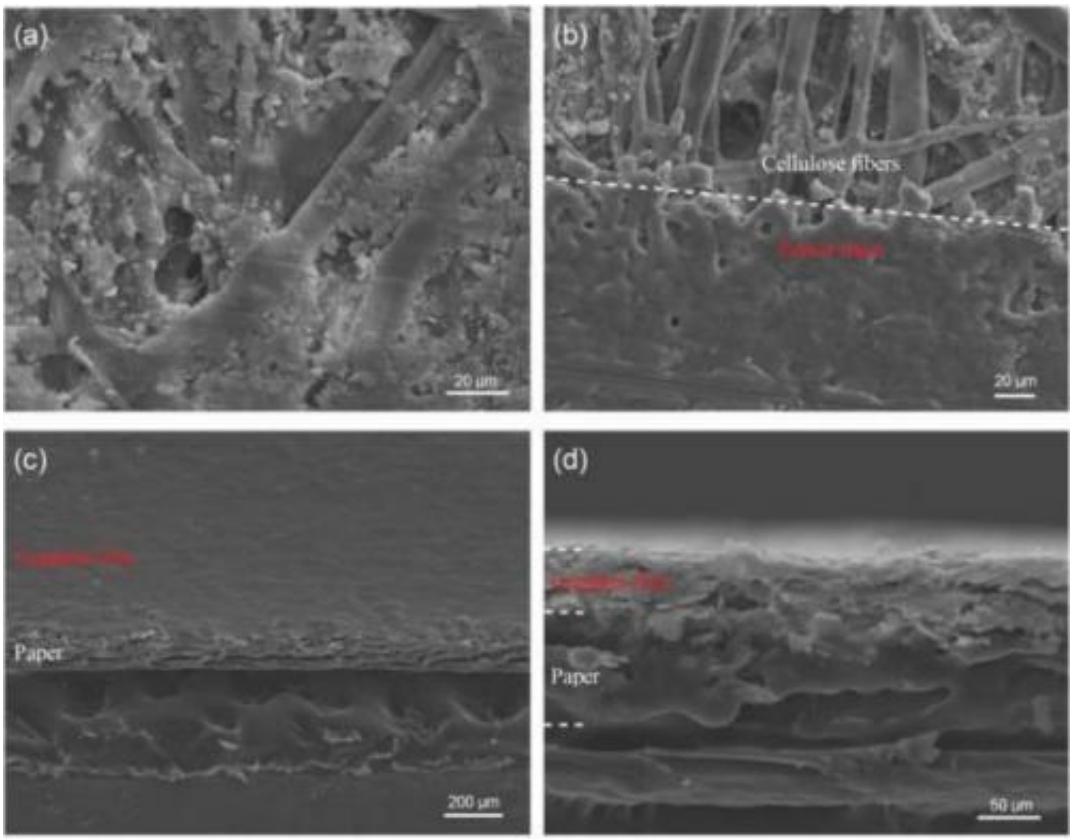
Ordinary paper and pencil used to create primitive sensor

March 20 2015, by Bob Yirka



SEM images of a) unmodified printing paper and b) part of pencil-trace drawn on the paper. c) 45° Side view and d) cross-sectional image of the paper coated with graphite film. Credit: *Advanced Functional Materials*, DOI: 10.1002/adfm.201500094

(Phys.org)—A team of researchers at China's University of Science and

Technology has found that lines drawn on paper by an ordinary pencil can be used as a simple sensor. In their paper published in *Advanced Functional Materials*, the team describes how they tested the paper and pencil sensor idea and suggest applications for which it might be useful. Newscientist offers some background on the work done by the team.

When a person draws a line on a piece of paper with a pencil, they are laying down a layer of graphite, a material that is not very conductive. But, the researchers note, by measuring how much resistance occurs when electricity is sent though the graphite, it is possible to note changes that occur, such as when the page is bent. If a large rectangle is drawn on a piece of paper, for example, it is possible to tell by measuring resistance alone, which way the paper is bent and how much—that constitutes a sensor.

To see if their sensor might be useful, the researchers applied it to a single finger and found they were able to detect degrees of finger bending, the same thing occurred when gluing it to a ruler, they were able to tell how much it was being bent. They also found that when placed in an open book, they could deduce the angle created. The simple sensor, they note can be operated using nothing more than two small batteries constituting just 3 volts—it also demonstrated fast response/relaxation times—just 110ms.

The point of the research, the team explains, is to explore new possibilities for wearable sensors. They acknowledge that the paper/pencil sensor would not work right for that application, but believe it could work with alarm systems, or with other simple applications or even as a teaching aid for young people. They note that their crude sensor proved to work as well as commercially available sensors, which suggests it might provide a way to mass produce very inexpensive sensors for a wide variety of applications, particularly for short term uses or where sensors need to be replaced often.

More information: Flexible and Highly Sensitive Strain Sensors Fabricated by Pencil Drawn for Wearable Monitor, *Advanced Functional Materials*, onlinelibrary.wiley.com/doi/10 … m.201500094/abstract

Abstract

Functional electrical devices have promising potentials in structural health monitoring system, human-friendly wearable interactive system, smart robotics, and even future multifunctional intelligent room. Here, a low-cost fabrication strategy to efficiently construct highly sensitive graphite-based strain sensors by pencil-trace drawn on flexible printing papers is reported. The strain sensors can be operated at only two batteries voltage of 3 V, and can be applied to variously monitoring microstructural changes and human motions with fast response/relaxation times of 110 ms, a high gauge factor (GF) of 536.6, and high stability >10 000 bending–unbending cycles. Through investigation of service behaviors of the sensors, it is found that the microcracks occur on the surface of the pencil-trace and have a major influence on the functions of the strain sensors. These performances of the strain sensor attain and even surpass the properties of recent strain sensing devices with subtle design of materials and device architectures. The pen-on-paper (PoP) approach may further develop portable, environmentally friendly, and economical lab-on-paper applications and offer a valuable method to fabricate other multifunctional devices.