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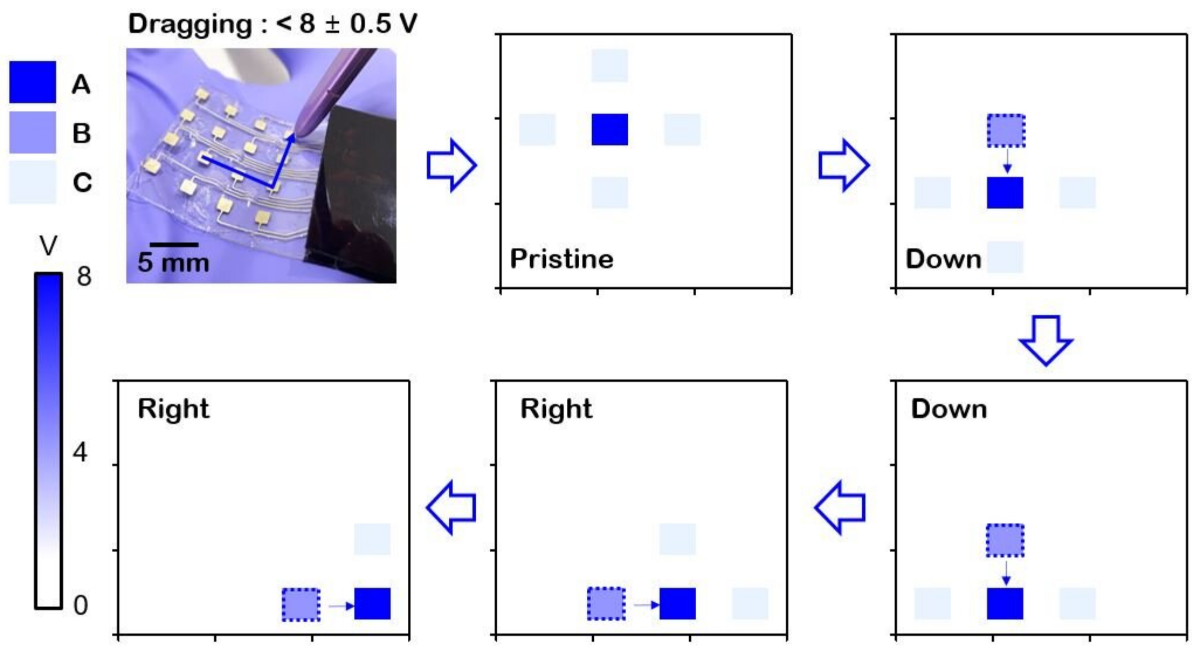

Wearable touch sensor on flexible substrat. Credit: Korea Institue of Science and Technology(KIST)

Super-micro, low-power sensors and devices that can send and receive signals and information anytime, anywhere will become an integral part of people's lives in a hyper-connected world driven by the Internet of Things (IoT). An important issue is continually supplying electricity to the countless electronic devices connected to the system. This is because it is difficult to reduce the size and weight of the battery using the conventional way of charging and changing it.

A possible solution to this problem is deployment of triboelectric generators. These generate energy in a semi-permanent manner by inducing triboelectricity from contact between different materials, just as static electricity is produced.

A team of researchers with the Korea Institute of Science and Technology (KIST) led by Dr. Seoung-Ki Lee has developed a touch sensor that enhances the triboelectrification efficiency by more than 40% via crumple-structured molybdenum disulfide. This breakthrough is the result of a collaboration with Chang-Kyu Jeong, professor of advanced materials engineering at JeonBuk National University.

General triboelectric generators could not be used for wearable electronic devices since they would have to be excessively large and heavy to raise their capacity to generate sufficient electricity. There are currently studies underway that involve applying a two-dimensional semiconductor material that is atomically thin and has excellent physical properties as an active layer in generating triboelectricity.

The intensity of the triboelectricity generated varies according to the type of two materials coming in contact. In past studies with two-dimensional materials, the transfer of electric charges with the insulating material did not occur smoothly, substantially lowering the output of energy produced from triboelectricity.

In the current study, the joint research team adjusted the properties of molybdenum disulfide (MoS_2), a two-dimensional semiconductor, and changed its structure to boost the triboelectricity generation efficiency. The material was crumpled during a strong heat treatment process that is applied in a semiconductor manufacturing process, which resulted in a material with wrinkles to which internal stress has been applied. These wrinkles increase the contact area per unit area, and the resulting surface-crumpled MoS_2 device can generate around 40% more power than a flat counterpart. Additionally, the triboelectricity output was maintained at steady levels in a cyclic experiment even after 10,000 repetitions.

By applying the crumpled two-dimensional material to a touch sensor like those used in touchpads or touchscreen displays, the joint research team came up with a lightweight and flexible self-powered touch sensor that can be operated without a battery. This type of touch sensor with high power generation efficiency is sensitive to stimulation and can recognize touch signals even at a low level of force, without any electric power.

Dr. Seoung-Ki Lee from KIST said, "Controlling the internal stress of the semiconductor material is a useful technique in the semiconductor industry, but this was the first time that a material synthesis technique involving synthesis of a two-dimensional semiconductor material and application of internal stress at the same time was implemented... It presents a way to increase the triboelectricity generation efficiency by combining the material with a polymer, and it will serve as a catalyst for the development of next-generation functional materials based on two-dimensional substances."

More information: Seoungwoong Park et al, Laser-directed synthesis of strain-induced crumpled MoS2 structure for enhanced triboelectrification toward haptic sensors, *Nano Energy* (2020). DOI: 10.1016/j.nanoen.2020.105266

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