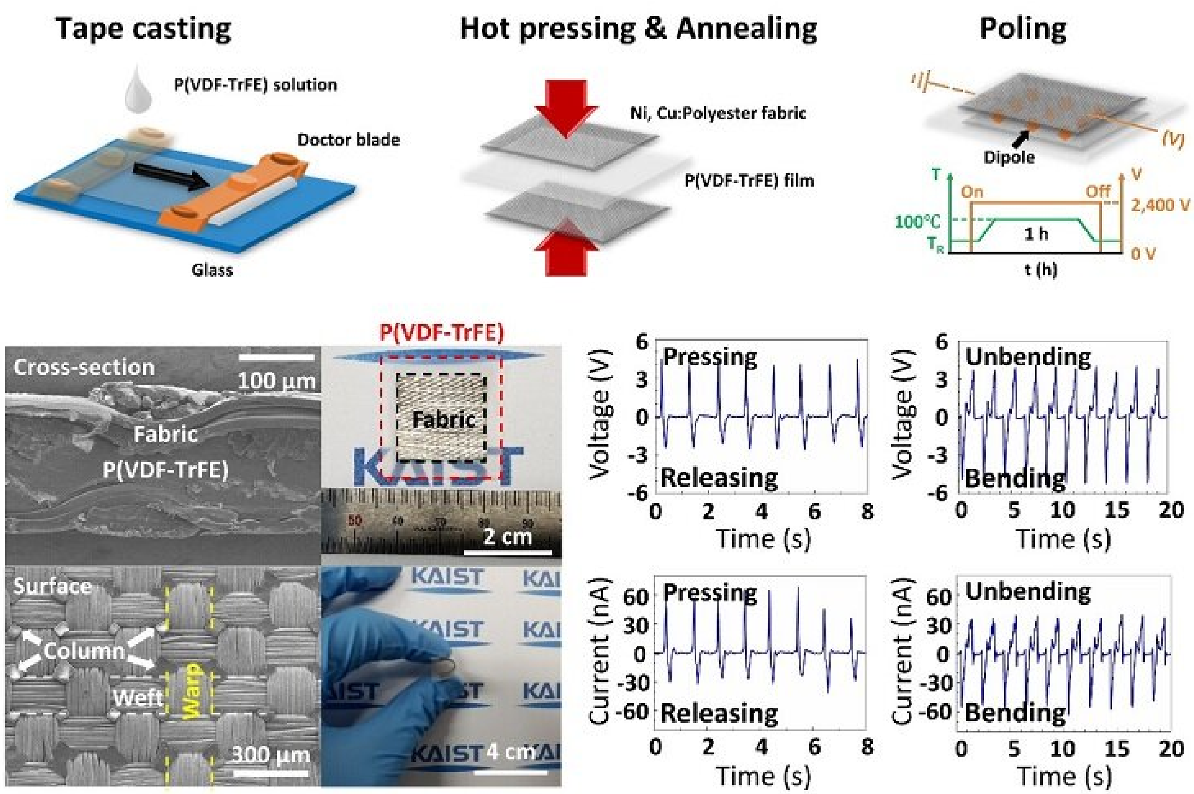
Sturdy fabric-based piezoelectric energy harvester takes us one step closer to wearable electronics

September 17 2020



Fabrication process, structures, and output signals of a fabric-based wearable energy harvester. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

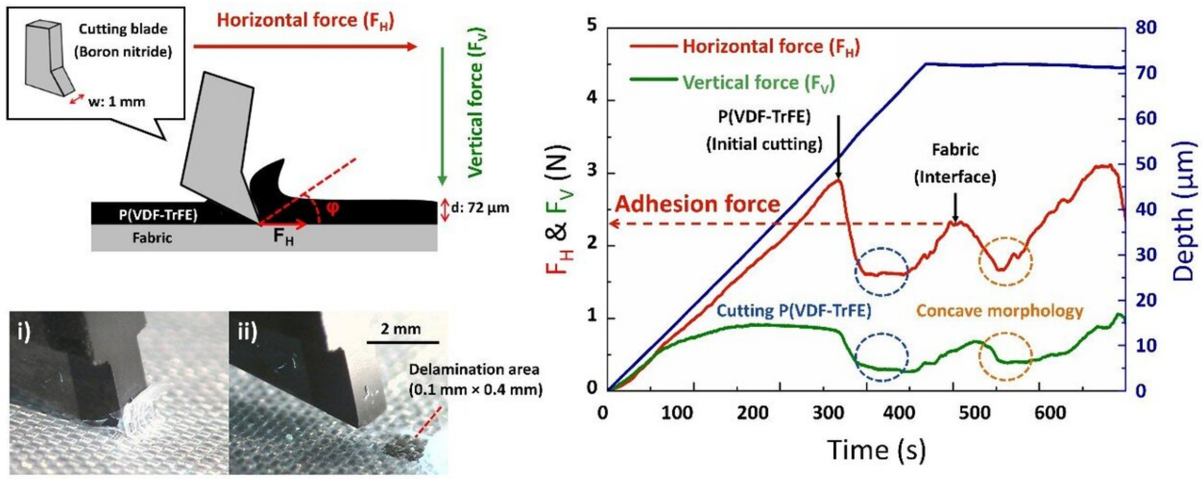
KAIST researchers presented a highly flexible but sturdy wearable piezoelectric harvester using the simple and easy fabrication process of hot pressing and tape casting. This energy harvester, which has record high interfacial adhesion strength, will take us one step closer to being able to manufacture embedded wearable electronics. A research team led by Professor Seungbum Hong said that the novelty of this result lies in its simplicity, applicability, durability, and its new characterization of wearable electronic devices.

Wearable devices are increasingly being used in a wide array of applications from small electronics to embedded devices such as sensors, actuators, displays, and energy harvesters.

Despite their many advantages, high costs and complex fabrication processes remained challenges for reaching commercialization. In addition, their durability was frequently questioned. To address these issues, Professor Hong's team developed a new fabrication process and analysis technology for testing the mechanical properties of affordable wearable devices.

For this process, the research team used a hot pressing and tape casting procedure to connect the fabric structures of polyester and a polymer film. Hot pressing has usually been used when making batteries and fuel cells due to its high adhesiveness. Above all, the process takes only two to three minutes.

The newly developed fabrication process will enable the direct application of a device into general garments using hot pressing just as graphic patches can be attached to garments using a heat press.



Measurement of an interfacial adhesion strength using SAICAS. Credit: KAIST

In particular, when the polymer film is hot pressed onto a fabric below its crystallization temperature, it transforms into an amorphous state. In this state, it compactly attaches to the concave surface of the fabric and infiltrates the gaps between the transverse wefts and longitudinal warps. These features result in high interfacial adhesion strength. For this reason, hot pressing has the potential to reduce the cost of fabrication through the direct application of fabric-based wearable devices to common garments.

In addition to the conventional durability test of bending cycles, the newly introduced surface and interfacial cutting analysis system proved the high mechanical durability of the fabric-based wearable device by measuring the high interfacial adhesion strength between the fabric and the polymer film. Professor Hong said the study lays a new foundation for the manufacturing process and analysis of wearable devices using fabrics and polymers.

He added that his team first used the surface and interfacial cutting analysis system (SAICAS) in the field of wearable electronics to test the mechanical properties of polymer-based wearable devices. Their surface and interfacial cutting analysis system is more precise than conventional methods (peel test, tape test, and microstretch test) because it qualitatively and quantitatively measures the adhesion strength.

Professor Hong explained, "This study could enable the commercialization of highly durable wearable devices based on the analysis of their interfacial adhesion strength. Our study lays a new foundation for the manufacturing process and analysis of other devices using fabrics and polymers. We look forward to fabric-based wearable electronics hitting the market very soon."

The results of this study were registered as a domestic patent in Korea last year, and published in *Nano Energy* this month. This study has been conducted through collaboration with Professor Yong Min Lee in the Department of Energy Science and Engineering at DGIST, Professor Kwangsoo No in the Department of Materials Science and Engineering at KAIST, and Professor Seunghwa Ryu in the Department of Mechanical Engineering at KAIST.

More information: Jaegyu Kim et al, Cost-effective and strongly integrated fabric-based wearable piezoelectric energy harvester, *Nano Energy* (2020). DOI: 10.1016/j.nanoen.2020.104992

Provided by The Korea Advanced Institute of Science and Technology (KAIST)