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A new flexible piezoelectric composite for 3-D printing

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Credit: Wang et al.

Researchers at Peking University, Southern University of Science and Technology and the University of Jinan in China have recently designed a ceramic-polymer composite that can be used to print complex 3-D grid architectures. This composite, first presented in a paper published in *Nano Energy*, was found to exhibit a number of desirable properties, including high flexibility and a high electromechanical energy conversion rate.

Piezoelectric ceramic materials, such as $Pb(Zr,Ti)O_3$ (PZT) typically have remarkable electromechanical energy conversion capabilities. However, most of these materials are inherently rigid, which makes them far from ideal for the fabrication of flexible electronics.

"Normally, piezoelectric ceramics are brittle, therefore, they are not suitable for integration into flexible electronics directly," Shuxiang Dong, one of the researchers who carried out the study, told TechXplore. "We wanted to develop a 3-D-printed, soft piezoelectric ceramic composite material that is a heat-curable polymer exhibiting mechanical flexibility and a large electromechanical voltage in response to environmental mechanical vibrations or force stimuli. Luckily, we made it, and our composite has great potential to be used for future soft sensors."

The material created by Dong and his colleagues is comprised of a polydimethylsiloxane (PDMS) elastomeric matrix doped with silver-coated PNN-PZT ceramic particles. Its design and composition differ substantially from those of other piezoelectric ceramic materials designed in the past.

The new piezoelectric ceramic material is also far easier to produce, as more conventional piezoelectric ceramic materials typically require time-consuming, high-temperature sintering fabrication methods or expensive laser 3-D printing processes involving a technique called stereolithography. Its unique design and fabrication process ultimately make it far more flexible than similar materials developed in the past, giving it elastic properties.

"After the electric polarization process, our composite shows excellent electromechanical coupling with a great force-to-voltage response (i.e., piezoelectric voltage coefficient), which is one order of magnitude higher than that of PZT based brittle ceramics," Dong said. "The most meaningful findings of our work are our composite's great force-to-voltage response, as well as more flexible and elastic performance."

As part of their study, Dong and his colleagues used the new composite they designed to print a number of complex 3-D grid structures. Their results suggest that the material has the potential to replace a number of brittle piezoceramics currently used to print electronic devices for converting electromechanical energy or touch sensors.

This study could have important implications for the production of parts of soft robots, as well as other technological devices. The composite designed by Dong and his colleagues could, for instance, be used to print artificial limbs, muscles or sensors that can detect biological signals.

"We will now continue to develop soft piezoelectric ceramic composite materials and 3-D printing methods," Dong said. "Of course, we are also looking for possible collaborations that could enable the use of the soft piezoelectric composite material we developed for robotic applications."

More information: Zehuan Wang et al. 3D-printed flexible, Ag-coated PNN-PZT ceramic-polymer grid-composite for electromechanical energy conversion, *Nano Energy* (2020). DOI: 10.1016/j.nanoen.2020.104737