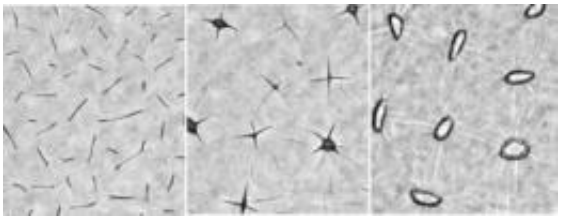
# Creasing to cratering: Voltage breaks down plastic (w/ Video)

March 4 2011



This photo shows the creasing to cratering in soft polymer. Credit: Qiming Wang

A Duke University team has seen for the first time how soft polymers, such as wire insulation, can break down under exposure to electrical current.

Researchers have known for decades that polymers, such those insulating wires, may break down due to deformation of the polymers. But the process had never been seen.

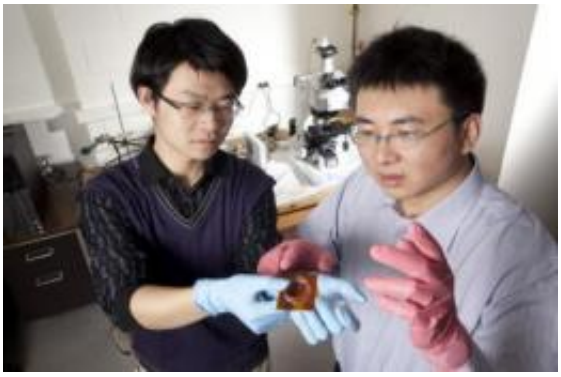
In a series of experiments, Duke University engineers have documented at the microscopic level how plastic deforms to breakdown as it is subjected to ever-increasing electric voltage. Polymers can be found almost everywhere, most commonly as an insulator for electrical wires, cables and capacitors.

The findings by the Duke engineers could help in developing new materials to improve the durability and efficiency of any polymer that

must come into contact with electrical currents, as well as in the emerging field of energy harvesting.

"We have long known that these polymers will eventually break down, or fail, when subjected to an increasing electrical voltage," said Xuanhe Zhao, assistant professor of mechanical engineering and materials science at Duke's Pratt School of Engineering. He is the senior scientist in the series of experiments performed by a graduate student Qiming Wang and published online in the Physical Review Letters. "Now we can actually watch the process as it happens in real time."

The innovation the Duke team developed was attaching the soft polymer to another rigid polymer layer, or protective substrate, which enabled observation of the deformation process without incurring the breakdown. They then subjected this polymer-substrate unit to various electrical voltages and observed the effects under a microscope.



Qiming Wang and Xuanhe Zhao are researchers at Duke University. Credit: Duke University Photography

"As bread dough rises in a bowl, the top surface of the dough may fold in upon itself to form creases due to compressive stresses developing in

the dough," Zhao said, "Surprisingly, this phenomenon may be related to failures of electrical polymers that are widely used in energy-related applications."

"When the voltage reached a critical point, the compressive stress induced a pattern of creases, or folds, on the polymer," Zhao. "If the voltage is increased further, the creases evolved into craters or divots in the polymer as the electrical stress pulls the creases open. Polymers usually break down electrically immediately after the creasing, which can cause failures of insulating cables and organic capacitors."

The substrate the researchers developed for the experiments not only allowed for the visualization of the creasing-to-cratering phenomenon, it could also be the foundation of a new approach to improving the ability of wires to carry electricity.

Provided by Duke University

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