Researchers create method to alter polymers in plastics

By Ben Rakestraw | March 29, 2012

Duke researchers have developed a method to manipulate the surfaces of plastics on demand.

By subjecting polymers—the molecular chains that form plastics—to a specific electric voltage, it is possible to create a variety of textures and patterns—such as lines, dimples and circles—that can be easily reversed in the material. This is a notable finding given that previous research found polymers with permanent changes or damage to their structure.

“Applying patterns and deformations can induce failure of the polymer,” said researcher Xuanhe Zhao, assistant professor of mechanical engineering and materials science. “But by inventing this technology, we avoid the failure and produce dynamic patterns.”

The completely reversible changes in the surfaces occur in a fraction of a second, Zhao noted. Dynamic electrostatic lithography—the process of changing the surfaces to various patterns—is relatively simple.

“There are two control parameters,” he said. “One is applying the voltage. The other is physical deformation, such as stretching or bending the material beforehand.”

Zhao worked with Qiming Wang, a second-year doctoral candidate in mechanical engineering and first author of the paper. The pair has worked together for the past two years, and they initially began their research into polymers by investigating why the materials fail. Their technique is derived from the process of static electrostatic lithography, which is used to permanently alter plastic surfaces.

Zhao and Wang have demonstrated that their technique can be applied to polymers of many shapes and sizes. The patterns themselves can also take a wide range of sizes. The ability to use the lithography for such large surfaces sets their research apart from previous experiments, Zhao added.

“We can pattern surfaces from micron scales to nano scales, as well as over large and curved surfaces, such as covering the human body,” Wang said.

The versatility of the invention may lead to many practical applications in consumer materials and research, Zhao said. Material that can change texture on demand may be useful for products such as gloves, shoes or carpet and help create new technologies in self-cleaning surfaces or camouflage.

The real-world manifestations of the technology could replicate biological systems that could be useful to humans, said David Needham, professor of mechanical engineering who specializes in bio-inspired materials.
“If you have creased surfaces, like on a gecko’s foot, then you are getting into something interesting and useful,” Needham said.

Geckos, whose feet have millions of hairs nanometers wide, have the ability to scale smooth surfaces. The tiny hairs adhere to surfaces through van der Waals molecular attraction, Needham noted. If Zhao and Wang can create patterns small enough and intricate enough to produce the same effect, they may be able to invent a glove that can stick to materials such as glass.

“The closer they can approach nanoscale, the more they can approach adhesion,” Needham said.

“Being able to turn adhesion on and off with an electric current would be very cool.”

The researchers may have been the first humans to make their discovery, but they lag behind many creatures in the natural world that are able to change the texture of their skin on demand, Zhao noted.

“Cephalopods such as squids can change their surface texture to hide into the environment,” he said. “We were inspired by that.”

Zhao and Wang’s future research will involve searching for a way to make ever finer patterns in polymers, on the nanometer scale. They also plan to begin applying the technique in practical ways, such as in the biomedical and energy fields.