

Rubbing, Tapping Paper-Like Material Creates Electrical Current

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Generators can be easily made from cheap, flexible, everyday materials.

Electric current sufficient to light a string of LEDs, activate an e-paper display or even trigger action by a computer can be generated by tapping or rubbing simple, flexible generators made of paper, thin sheets of plastic and other everyday materials, researchers at Disney Research, Pittsburgh, have demonstrated.

This new approach to energy harvesting uses electrets, materials with special electrical properties that already are used in microphones and in tiny MEMS devices. This latest application, developed by researchers at Disney Research, Pittsburgh and at Carnegie Mellon University, could make possible new types of interactive applications involving books, posters and other printed materials that require no batteries or external power.

The design of a Paper Generator is simple: one approach is to sandwich a thin, flexible sheet of polytetrafluoroethylene, or PTFE – best known by the brand name Teflon® – between two conductive layers, such as sheets of metallized polyester, that serve as electrodes. Electrical charge accumulates on the PTFE sheet when paper is rubbed against it. Then, if the electrodes are made to move relative to each other against the PTFE, a tiny, alternating electrical current is generated. This electrical current can be used to power a broad variety of devices such as LED arrays, e-ink displays, sound buzzers and infrared communication devices.

"Though the fundamental principles of operation remain the same, it's possible to build Paper Generators that respond to a number of different gestures, such as tapping, touching, rubbing or sliding," said Ivan Poupyrev, director of Disney Research, Pittsburgh's Interaction Group. "We can imagine any number of ways to use this to add sights, sounds and other interactivity to books and other printed materials inexpensively and without having to worry about power sources."

The researchers, who also include Mustafa Emre Karagozler and Yuri Suzuki of Disney Research, Pittsburgh and Gary Fedder of Carnegie Mellon's Department of Electrical and Computer Engineering and Robotics Institute, will present their findings at the ACM Symposium on User Interface Software and Technology (UIST), Oct. 8-11, in St Andrews, Scotland.

Electrets are the electrostatic equivalents of permanent magnets, carrying a quasi-permanent electric charge. These dielectric materials include natural materials such as quartz as well as man-made materials such as PTFE.

Other researchers have demonstrated that electrets could be used to convert finger

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Published on Wireless Design & Development (<http://www.wirelessdesignmag.com>)

tapping into power to light LEDs using expensive, microfabricated structures. The Paper Generators produced at Disney Research, Pittsburgh, by contrast, are decidedly low-tech and cheap.

"There's nothing here that I can't build by hand in five minutes," Karagozler said of the Disney Research, Pittsburgh demonstration devices, which included a cartoon of a rocket ship outlined by a string of LEDs that light up when a paper button is tapped. The researchers also printed Paper Generators using conventional ink-jet printers equipped with cartridges with conductive ink. "That's the future of this technology," Karagozler added.

Though the current produced by the devices is low – measured in hundreds of microamperes – the voltage is high, up to 1000 volts. That is ideal for triggering e-paper displays, Karagozler said. One demonstration device, for instance, features cartoon characters of astronauts and friendly aliens; when the energy harvesting patch is rubbed, an e-paper display reveals H-E-L-L-O one letter at a time.

Running the alternating current through a small rectifier converts the power to DC to operate LEDs. The power also can be fed into store-and-release circuitry, enabling a buzzer to sound when enough power is stored, or to send an infrared signal to trigger action by a computer. Transmitting the current to an analog voltmeter produces mechanical motion of the needle.

"It's very simple, it's flexible and it's printable using conventional printers," Karagozler said. "It's a technology with potential applications we've only begun to explore."

For more information visit <http://www.disneyresearch.com> [1].

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