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Sour Milk? The Carton Cap Will Tell You

Using 3-D printing, scientists create a sensor; no need for power

By **DANIEL AKST**

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People have used 3-D printing to make things as different as hamburgers and small houses. Now scientists have employed this new technology to create a canary in a coal mine. It may not sing, but it doesn't have to die to do its job.

The canary in this case is a milk-carton cap that can tell when milk is going sour. As a wireless device that needs no power, it also serves as a prototype for a wide range of unpowered sensors that might someday detect all sorts of contaminants. Scientists at the University of California, Berkeley, and National Chiao Tung University in Taiwan developed the device to demonstrate the potential of 3-D printing for creating electronics.

Typically, 3-D printers follow the instructions they receive from a computer to "print" objects by laying down layers of plastic. Because plastic isn't a conductor, today's 3-D printing isn't ideal for making electronic components. Researchers are trying hard to develop solutions for that. Some have worked with carbon-based inks, while others have sought greater conductivity using silver particles. Voxe8, for example, a company started by Harvard University 3-D printing expert Jennifer Lewis, has developed a 3-D printer that can make a hearing aid by simultaneously laying down plastic and silver ink.

For the milk-carton cap, the scientists used a printer that lays down not just a polymer but also wax in a sort of vascular network. After the printing process, the tiny tubes could be cleared and filled with silver paste that hardens at room temperature and gives the sensor conductivity. Turning the carton upside down once enables the cap to capture a little milk. When the scientists left the carton sitting at room temperature for 36 hours, the cap detected changes in electrical signals indicating the increasing presence of bacteria—the milk was going sour.

"You go to the supermarket, and you don't have a good idea if the milk is fresh or not," says Liwei Lin, a mechanical engineer at Berkeley who

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EWV THAT SMELL Scientists have developed a milk-carton cap that can tell when milk is going sour. As a wireless device that needs no power, it also serves as a prototype for a wide range of unpowered sensors that might someday detect all sorts of contaminants. ILLUSTRATION: ILLUSTRATION BY TIM LAHAN

was one of the scientists involved. Even if the expiration date is OK, Dr. Lin says, the milk may have spent time at room temperature while it was being transported.

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Instead of having its own power, the cap relies on a reader operated by users that sends an electrical signal to the device, which responds with the desired information. Dr. Lin notes that this is much like the way radio-frequency identification tags operate, quietly holding on to their data until they receive an electromagnetic impulse from a reader. He adds that a reader could be designed to work with a smartphone or even be incorporated into one.

Dr. Lin sees many possible uses for 3-D printed sensors. One could provide daily diabetes data for tracking by a physician. Or implantable versions could report on blood pressure and drug concentrations. Dr.

Lin says that the technology could also gauge exposure to chemicals on a battlefield or—going back to that canary idea—in a coal mine.

“3D-printed microelectronics for integrated circuitry and passive wireless sensors,” Sung-Yueh Wu, Chen Yang, Wensyang Hsu and Liwei Lin, Microsystems & Nanoengineering (July 20)

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