Silencing Electronic Noise

Zeynep Çelik-Butler

By Kathleen Tibbetts

An old expression says, "If life gives you lemons, make lemonade," and Zeynep Çelik-Butler has incorporated that philosophy into her research. She is finding ways to use one of electronic technology's most annoying problems – low-frequency noise – to provide important data about the performance of solid-state electronic devices.

Working under a three-year grant from the National Science Foundation, Çelik-Butler is measuring low-frequency noise in the devices' metallization – the thin metal lines on a printed circuit board that conduct electricity to its components. Over time, failures occur in these boards because of electromigration, or the shifting of the metal layer's component atoms caused by electrical current.

"You want to predict that a device will last 10 years," says Çelik-Butler, associate professor of electrical engineering in the School of Engineering and Applied Science. "But at the same time, you can't actually operate it in a lab for 10 years just to be positive." Her research demonstrates that the amount of noise produced in a device corresponds to the amount of electromigration taking place – meaning that the noise measurements can be used to predict the devices' reliability. That data also may be used to determine which materials provide the greatest reliability in electronic devices.

Çelik-Butler's research in the measurement and characterization of electronic noise can be traced to her graduate studies at the University of Rochester, New York. As a predoctoral fellow in programs sponsored by IBM and Eastman Kodak, she wrote her Ph.D. dissertation on low-frequency noise in semiconductor devices. She has written or co-written more than 40 journal articles and conference papers since 1985.

After joining SEAS as an assistant professor in 1987, Çelik-Butler established herself through her research. In 1990 she was named the first recipient of the J. Lindsay Embrey Trustee Professorship in Electrical Engineering. That three-year professorship and a corresponding one in mechanical engineering were endowed by Dallas civil engineer Embrey ('45, '47) to support junior SEAS faculty members who have demonstrated outstanding potential in teaching and research.

Çelik-Butler also maintains a long-standing interest in electronic imaging technology. As an undergraduate at Bogazici University in Istanbul, she wrote her Bachelor's thesis on the design and implementation of a video motion detection system. At SMU, she is participating in research to help create a new generation of infrared imaging devices.

Most infrared-detection research has been supported by the U.S. Army's night-vision projects, which have produced such high-resolution infrared cameras as those used during the Persian Gulf War. But with the recent decline in defense-related orders, the companies that developed the technology are hoping to convert it to commercial use.

Çelik-Butler's research, which she is conducting with her husband, Associate Professor of Electrical Engineering Donald Butler, is geared toward making infrared technology affordable for consumer applications. Some U.S. auto manufacturers are interested in installing night-vision devices in their high-end luxury cars, an idea that brings the cost issue into sharp focus. For such a venture to be successful, the biggest factor will be the price of the finished product. Simply put, "you cannot build a $20,000 camera and put it in a $50,000 car," Çelik-Butler says.

Most state-of-the-art infrared cameras require cooling, "and when I say cooling, I don't mean down to 0 degrees Celsius," Çelik-Butler says. "I mean *real* cooling – to the temperature of liquid nitrogen – to 77 Kelvin. And that's costly." To eliminate that expense, the researchers are trying to find reliable materials that work at room temperature and still are sensitive enough to do the job. The Butlers' calculations show that infrared devices built around thermal-detective, or bolometric, substances could achieve a level of sensitivity within striking distance of the ultrasensitive photon detectors currently in military use.

Unlike photon detectors, which isolate an electrical image of the object in view, bolometric detectors "sense the *temperature* of what they're staring at," she says. "And because infrared is basically heat anyway, [these materials] can map that out quite effectively."

It will be at least a decade, however, before these new-generation infrared cameras hit the consumer marketplace, Çelik-Butler says. Some promising thermal-detective materials are incompatible with the silicon technology used to process the electronic signals, and research into overcoming those difficulties has just begun. But when the technology does arrive, she says, "it should be inexpensive, reproducible, and it should work well." ▪