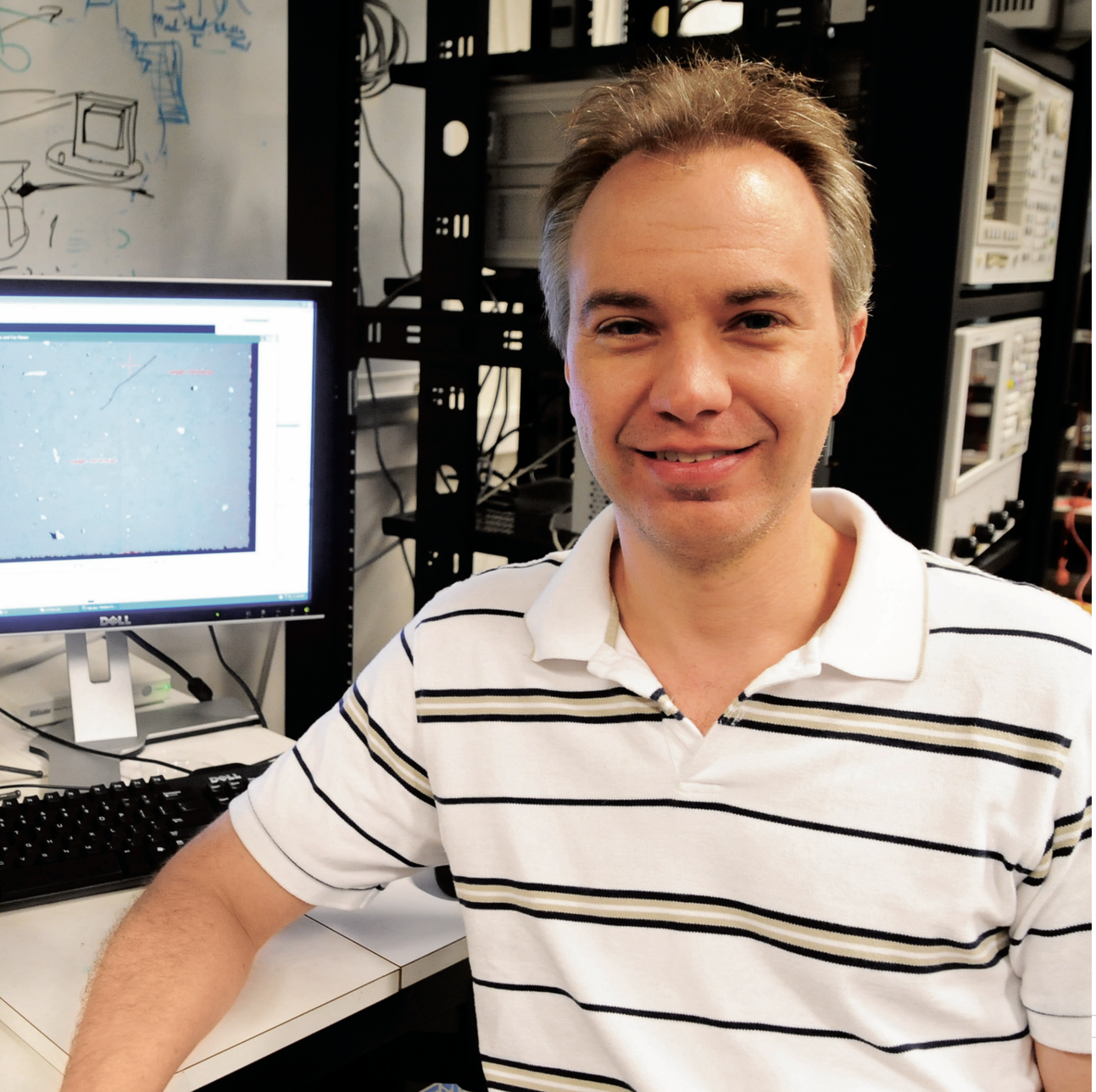

Integrating Biology in a Chip

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Welcome to the post-modern biology lab. It's made of silicon, measures 5mm on a side and costs just $20. It can also be deployed to harsh or distant locations and when an experiment is complete, it can be discarded. Welcome to Ken Shepard's lab—or at least one of the many he is designing. This new research combines expertise in chemistry, biology, and integrated circuit design in a manner that gives Columbia unique, high-impact capabilities. While most of the semiconductor industry is focused on continuing to try to scale integrated circuit technology according to Moore's Law, Shepard's lab is focused on "more than Moore" applications of IC technology.

Shepard and his team at the Bioelectronics Systems Lab employ the integrated circuits technology to build their own micrometer-scale arrays of sensors that can detect biological molecules or select strands of DNA. "There are definitely other techniques for doing these things, but they're difficult, time-consuming, and expensive," said Shepard. "The goal here is to come up with something that's as sensitive as the most sensitive instruments, if not more, and reduce everything else about it."

Very often, in order to detect a particular molecule, they have to first be labeled—physically attached to something such as a fluorescent dye that permits detection. Shepard and graduate student Matthew Johnston aim to circumvent this laborious process by directly detecting the weight of individual molecules.

When target protein molecules bond to the surface of one of their chips, it causes the frequency of a vibrating piezoelectric crystal to change. The magnitude of the change quickly confirms the presence of their target.

In their first test of the lab-on-a-chip, Shepard and Johnston are using a sensor designed to search dust samples for common airborne allergens that have been linked to high childhood asthma rates in urban areas. Shepard also envisions a day when his chip-based labs could be used to quickly and easily detect blood-borne cancer proteins.

Shepard's "more than Moore" activities have been funded by corporate sources (Semiconductor Research Corporation) and state and federal grants (New York State Foundation for Science, Technology, and Innovation; National Science Foundation; National Institutes of Health; and the Defense Advanced Research Agency). He is also a principal investigator on a large NSF Ph.D. training grant in the area of bioimaging technologies.

Shepard was given a Faculty Development Award in 2006 by the New York State Office of Science Technology and Academic Research. In 2008, he was named a finalist for the Blavatnik Award for young faculty by the New York Academy of Sciences. He is a fellow of the Institute of Eletrical and Electronics Engineers.

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