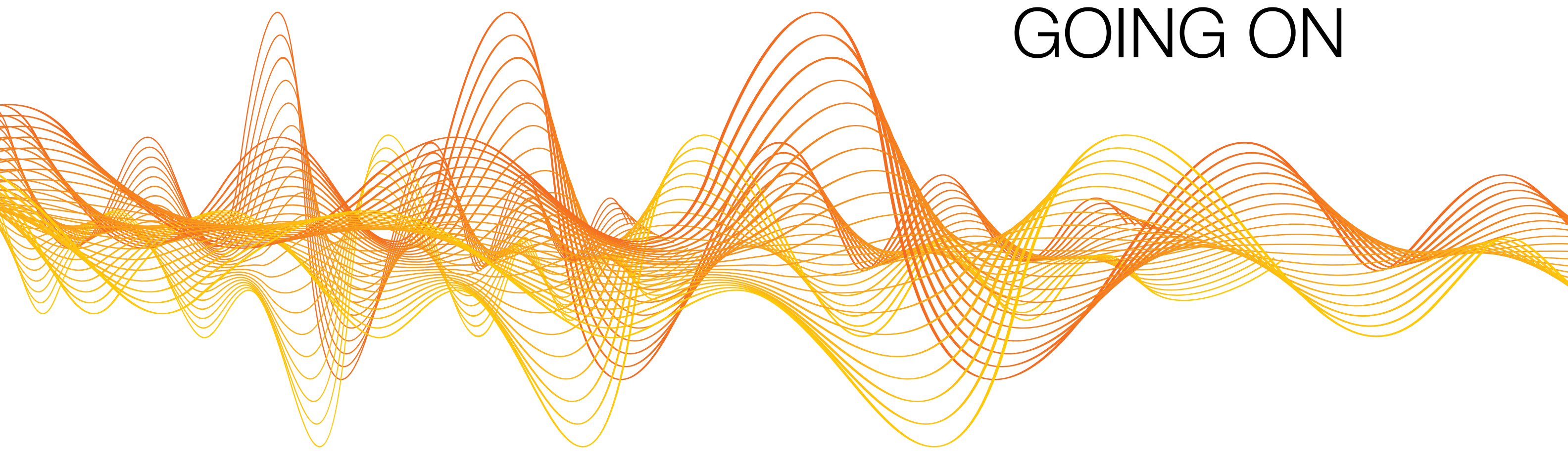
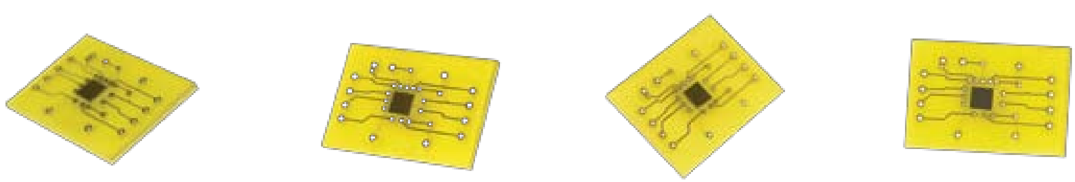
WHOLE LOT OF SHAKING GOING ON



Tiny devices may lead to advances for technology ranging from cell phones to air bags



THE VIBRATIONS START.

A LIGHT SWITCH FLIPS. A CAR CRASHES.
THE EARTH MOVES.

A TINY STRUCTURE INSIDE A
MICROCHIP SENSES THE CHANGE,
AND SIGNALS A CHANGE ITSELF.

THE LIGHT TURNS ON. THE AIR BAGS DEPLOY.
A SEISMIC METER TWITCHES.

For years scientists have known that tiny parts within tiny chips vibrate, and those vibrations, triggered by motion stopping or starting, can in turn trigger an action. But just as mothers know chicken soup works for a cold — without understanding the science behind it — engineers are still studying why these tiny vibrations occur, and how to harness them.

Mohammad Younis has worked for years to understand the vibrations and mechanics of these miniscule micro-electromechanical systems, known as MEMS. Younis' work combines materials and chemical engineering with physics in a multi-million-dollar Binghamton University laboratory with a multi-disciplinary team. He believes that knowing how to control the vibrations will lead to better uses of the chips — faster air bags, more accurate seismic readings or scores of other uses no one has thought of yet.

"It's like the invention of airplanes," Younis said. "The Wright brothers made their plane. But without understanding the laws of physics and the airplane and aerodynamics, we would not have the planes we have today."

"It's sort of the same," he said of MEMS. "People fabricated MEMS, and then there was a lag between understanding the physics and the fabrication."

Younis grew up in Jordan, where his interest in math and science was piqued as a child. He studied mechanical engineering at the Jordan University of Science and Technology in Irbid, Jordan, and came to the United States for his master's and doctoral degrees at Virginia Tech. It was there, in Blacksburg, Va., that Younis first discovered MEMS.

His adviser warned him that his chosen path of study wasn't a typical master's-level project — it was more. Younis still finished in a year and a half and continued the work as a doctoral student.

The interdisciplinary nature of the study intrigued him.

"You need to know mechanical and electrical engineering," he said. "You need to know, for example, about solid mechanics, electricity, so it's what I call multi-physics. … I'm trying to tackle those disciplines — thermal, fluid, electrical, you name it."

The MEMS and Nanotechnology Exchange, a clearinghouse for MEMS' interests both corporate and academic, defines MEMS as "the integration of mechanical elements, sensors, actuators and electronics on a common silicon substrate through microfabrication technology."

Sensors gather physical data, which is processed by the chips' electronics and, through some decision-making capability, directs a response.

Take, for example, MEMS uses for air bags in cars. Vehicles have a complicated system of components, including sensors, that triggers the deployment of the safety device, Younis said. His work takes the sensor mechanism a step further, suggesting that car companies could build a single device, using MEMS technology, that would simultaneously sense the change in acceleration and trigger the air bag.

The MEMS components could be programmed to expect certain velocities as the driver naturally starts, stops and drives. But an impact that suddenly halts a high velocity, such as a crash, could interrupt the MEMS system. That interruption could cause the chip to trigger an air bag.

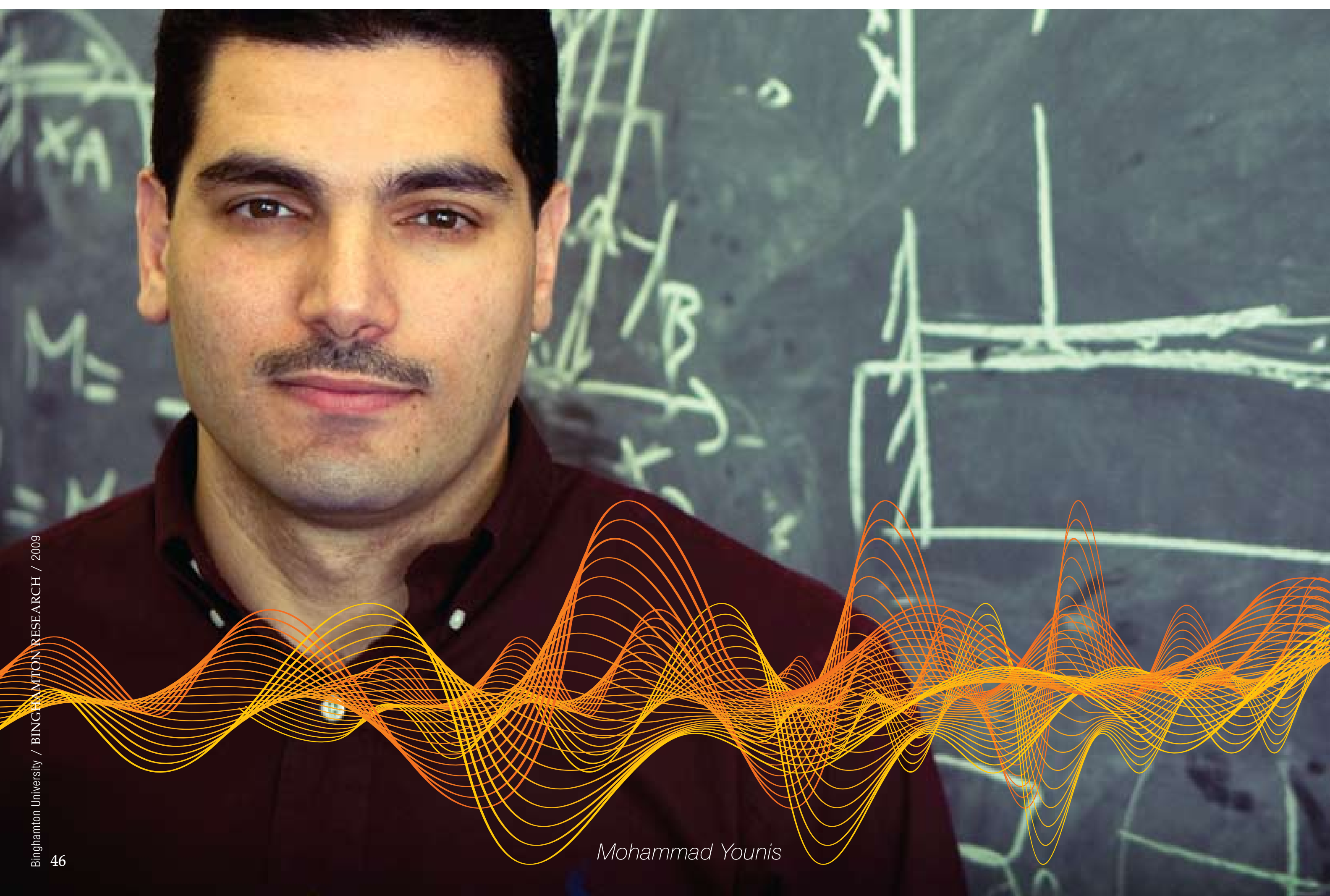
A single device that could serve as both sensor and trigger would be cheaper to fabricate than a system that requires several different parts. Such a MEMS device might also use less power, and be less susceptible to shock, even as the mechanism's settings could be adjusted to cover a wide — or narrow — range of acceptable motion. The technology could be used to protect personal electronics such as cell phones, preventing damage when they are dropped, Younis said. Or it could help govern major systems such as missile defense to prevent accidental deployment.

Younis is one of three Binghamton University faculty members, with Ronald Miles and James Pitarresi, who received a $280,000, three-year National Science Foundation grant for their work. General Electric, along with Binghamton's Integrated Electronics Engineering Center, awarded him another $50,000.

Miles has worked closely with Younis since Younis came to Binghamton several years ago. Younis' grasp of theoretical mathematics and practical knowledge of dynamics offer a new perspective on the field, Miles said.

"He's really working hard to take that stuff and figure out how to work that into practical devices," Miles said. "He's able to have a very deep understanding of mechanics. That combination is something that not everybody has."

The NSF grant funds Younis' work in a lab testing the thresholds of MEMS. In one experiment, he mounted a chip on a shaker that in turn was connected to



Mohammad Younis

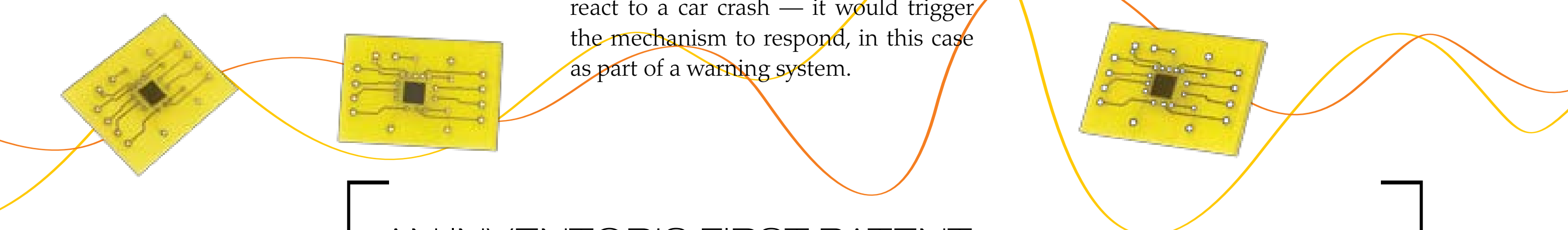
a lamp. When the shaker caused the chip's vibrations to accelerate past a certain threshold, the lamp lit. A computer connected to the system measured the signals.

For his next project, Younis seeks to tap chemistry and biology to use MEMS to build a detection system for dangerous materials such as TNT vapor and anthrax, again working in conjunction with Binghamton researchers. Younis and his colleagues propose to explore the feasibility of including a sponge-like substance on a chip that would trigger a response when certain particles are captured in the sponge's cavities. The MEMS would react to the chemicals caught in the spores much like other systems would react to a car crash — it would trigger the mechanism to respond, in this case as part of a warning system.

The project involves not only creating a trigger mechanism, but also crafting a layer sensitive to biological molecules, as noted by project participant Omowunmi Sadik, director of the Center for Advanced Sensor Research and Environmental Systems at Binghamton.

It's work that Binghamton is uniquely positioned to support, Younis said, through the Small Scale Systems Integration and Packaging Center devoted to microelectronics. "I'm working on very small devices and structures," he said, "and the University has a unique center with sophisticated equipment geared for those tiny devices." ■

— *Anne Miller*



AN INVENTOR'S FIRST PATENT

Mohammad Younis received his first patent last year for a MEMS device that would detect acceleration and mechanical shock.

The device, he said, would be able to recognize when something crashed with a high level of force and then perform a desirable task. Applications might range from protecting the hard disk of a laptop computer to deploying a side-impact air bag.

"This invention represents a revolutionary concept that provides a potentially low-cost, reliable and manufacturable solution for electronic shock sensors, which could be embedded in packages and products to detect abuse, and possibly protect sensitive components from damage," said Steven M. Hoffberg, the lawyer who worked on Younis' patent application and a partner with the firm Milde & Hoffberg of White Plains, N.Y.

Younis is working on other inventions as well.

He has another patent pending on a similar device that would detect a lower level of acceleration. That innovation could prove useful in gas drilling, navigation systems and even early earthquake detection.

He's also working with Binghamton chemistry Professor Omowunmi Sadik on a "smart" sensor that can perform an action. The idea is to develop a two-in-one device that would be able to detect a small mass — such as a biological or chemical gas — and then trigger an alarm or perform some other action.