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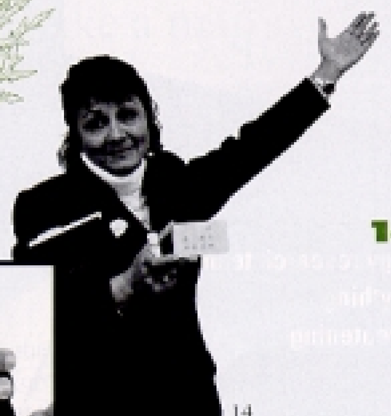

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All photos by Eugene Zakusilo

In just two years at Northwestern, Professor Manijeh Razeghi has forged new links between the optoelectronics industry and the University.

FORCE

By Marylee MacDonald

Students crowd into the office on the fourth floor of the Materials and Life Sciences Building. Seated at a table, Professor Manijeh Razeghi faces two renowned physicists from Poland. Three graduate students sitting beside her take notes as fast as they can. One student passes the visitors a three-dimensional drawing of something that looks like a multilayered pastry. It is an enlarged view of a tiny semiconductor-like device with unique optical properties.

One of the Polish visitors nods enthusiastically as Razeghi describes how the device was made, but he looks as though he's fighting sleep. Deep shadows underline his eyes. For 48 hours, he has met virtually nonstop with Razeghi and her students and colleagues. He spent most of the night in the "clean room," the high-tech lab officially called the Center for Advanced Quantum Devices and unofficially the best MOCVD (metal-organic chemical vapor deposition) research laboratory in the world.

The students look weary, too. Only Razeghi, who has put in equally long hours, brims with energy. The visitor asks if they may come back. Razeghi's "absolutely, absolutely" stays close to "absolument" in French, the language she spoke as a student and researcher in Paris, and conveys her enthusiasm about welcoming visitors. Standing and shaking hands, she reluctantly tears herself away from what she loves most: the energy and excitement of collaboration.

Razeghi is in the vanguard of the fast-changing, highly technical field of optoelectronics, and she keeps on top by producing impressive research and collaborating with colleagues around the world. "She is one of the two or three best in the world," says Jerome B. Cohen, dean of the Robert R. McCormick School of Engineering and Applied Science, who persuaded Razeghi to leave a lucrative industry job in France and move to Evanston. "She has really been a leader in putting the electrical engineering part of the electrical engineering and computer science department on the map."

Manijeh Razeghi with students and technicians in the clean-room laboratory

When Razeghi arrived at Northwestern two years ago as Walter P. Murphy Professor of Electrical Engineering and Computer Science, she faced a formidable challenge. The University had no active research program in the newly emerging field of solid-state optical devices — small semiconductor chips that use light instead of electrical energy to store and transfer information. To bring the University up to speed, Razeghi has applied her enormous energy, creativity and curiosity to building a top research team.

Already Razeghi is one of the top funded researchers in the University, bringing in approximately $2 million annually. Visitors from around the world come to see her state-of-the-art laboratories. She receives financial support from many industry and government sources, but her most important goal is not the money or the labs, she says. She came to Northwestern to create a "center of genius."

More than 30 people from industry and government labs both in the United States and abroad have joined Razeghi's research team. It also includes students, PhD and undergraduate.

"This is a genius," she says, waving in an undergraduate who's poked his head into her office. "He's one of my BS-PhD students." The student moves a chair to the computer in the corner of her office — Razeghi's computer — and begins working.

Few faculty members would be so willing to share office space, let alone a computer, with an undergraduate. Even graduate students, who take up most of a top professor's time, normally do not get to barge in and use the computer. "By the time he finishes his four-year degree," Razeghi says proudly, "he will have published two or three scientific papers. And he will have carved out a unique research niche for his PhD work."

"Professor Razeghi has been an inspiration to undergrads as well as graduate students," says Dean Cohen. "Despite the intense schedule she expects from her research team, students are standing in line to work with her."

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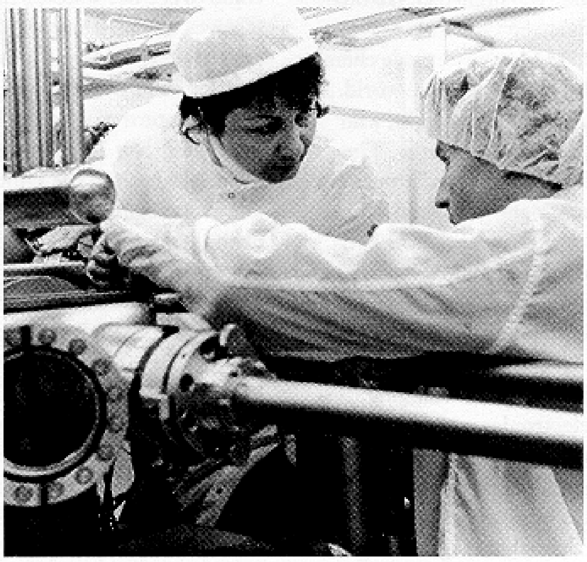
"They prefer to go to the labs in the clean room instead of going to the beach or a movie," Razeghi says. "I help people here to look at the things they do as a hobby. If you like this more than anything, you'll stay here." Razeghi's students also know that their work with her will bring them jobs and enormous credibility.

Razeghi is eager to show off the clean room. Before entering, she slips off her shoes in an antechamber and puts on Tyvek shoe covers, a lab coat and a hair cover. The clean room, a sophisticated high-tech lab, is not a single room but a series of adjoining rooms entered through the "clean" antechamber.

The rooms are clean in more ways than one — they are remarkably free of clutter. Except for areas where scientists are working, every bench is clear. Even the beakers in the cupboards are stacked neatly — and safely. Razeghi points out warning lights on walls that indicate even tiny amounts of gas. With its state-of-the-art equipment, her lab may be the safest in the world.

She introduces colleagues from Russia, Bulgaria, Poland, Germany, France, China, Japan and federal labs. Her research sponsors include Amoco, TRW, Spectra Diode Labs, Opto Power Corp., Lawrence Livermore Lab, Fermi Lab, Kopin Corp., the Jet Propulsion Laboratory, Advanced Photonic Technology, Spire Corp., McDonnell Douglas and Aixtron as well as the Army, Navy and Air Force research offices and the Advanced Research Projects Agency. Their funds cover salaries and tuition for all those in her lab.



Razeghi and Philippe Bove, a visiting postdoctoral scientist, discuss the molecular beam epitaxy reactor, in which laser wafers are grown.

A traditionally trained physicist, Razeghi grew up in Iran and was educated at Tehran University and the University of Paris. When she completed her PhD in 1980, she knew about atoms, electrons, solids and crystals — the standard building blocks of nature familiar to anyone who has taken high school physics. But then she began looking for connections between simple natural phenomena. She asked herself why the eye, nothing more than a collection of atoms, can see. What properties does it have? And why do crystals come in so many colors? How do impurities affect the color? She found answers by manipulating atoms one at a time to create a sort of microscopic lattice.

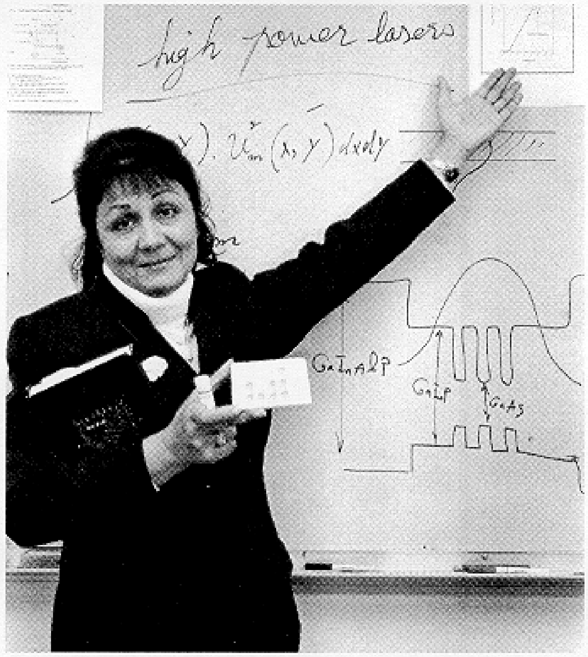
Standing beside a piece of machinery that looks like an oversized microwave oven, she explains the connection between this steel incubator and the atomic particles she studies. The equipment allows her to manufacture devices that behave something like the human eye. Asked where her inspiration comes from, she always replies, "Nature."

"Our best optoelectronic detector is the eye," she says, explaining that an optoelectronic device uses light, rather than electricity, to transfer information. Her machine lays down layers of gas, one atom at a time, on a semiconductor base. By controlling the shape of the layers, as in a layered pastry, Razeghi and her colleagues produce optoelectronic devices that can do amazing things.

Leaving the clean room, she walks briskly to another lab and asks a student to place one of the devices under a microscope. Using tweezers, he picks up a small rectangle about the size of a crystal of sugar and places it under the microscope's lens. The device looks like tiny fingers of light. This optoelectronic device, a miniature laser, produces two watts of light.

Laser technology, already used in compact disks, laser printers and fax machines, allows consumer electronics to be miniaturized, just as the transistor replaced the bulky vacuum tube in radios.

The most immediate application for the miniature lasers is in telecommunications. Televised images require red, green and blue to create a true picture, but current technology distorts natural color. Coupled with fiber-optic cable, which also uses light to transmit information,



the new tiny lasers will produce images that are completely natural, clearer and cleaner, Razeghi says. The optotechnology will be used in both the detector and the transmitter.

Another innovation emerging from her lab is infrared photodetector technology that could be used in medical imaging, military applications, smoke alarms, measurement of pollutants and observation of the behavior of nocturnal animals and life undersea or underground. Automakers are also interested in the technology. "In low visibility," Razeghi says, "the detector will sense the presence of another vehicle and set off a warning."

She is never content with just the obvious uses for her lab's innovations. "As soon as an innovation occurs in the laboratory, students in class brainstorm new applications," she says. "They recently proposed using the small laser chips to detect fingerprints. Another group believes the tiny lasers can be used to find defects in semiconductors."

Once a new device is developed in her laboratory, she gives it to industry to try out. That helps dispel any skepticism about so much research coming from a university. "Once they see for themselves," she says, "they believe we are really on to something...and when we come again asking for money, they are happy to help."

Razeghi's connections stretch from industry leaders to contract officers in military research. Gail Brown, a military contract officer from Wright-Patterson Air Force Base, praises Razeghi's "experience, expertise, innovation and above all enthusiasm," and adds that she has "high scientific ability," as evidenced by 30-plus patents and 500-plus publications. In 1987 Razeghi won the prestigious IBM Europe Science and Technology Prize.

As director of research for Thomson CSF in Orsay, France, Razeghi studied quantum effects — the physical laws that affect subatomic particles. "For the past 50 or 60 years, the fundamental science hasn't changed," she says. "The technology has advanced, not the science. We now have better control of the atoms."

Fascinating as Razeghi finds her work, she also wants her discoveries to improve people's lives. "Human beings can be creative for good or bad," she says. "We hope to steer our discoveries toward the good. It's better to know [the eventual application] and be in control."

She envisions tiny lasers that will replace knives in plastic surgery; computers that will weigh less and take up less space because optoelectronic devices replace wires inside keyboards; and technology that might be used to detect cancer cells, selectively destroying them and leaving healthy cells untouched.

Through openness and cooperation with industry, she believes laboratory discoveries will find their way quickly to beneficial uses. The United States learned its lesson after falling behind Japan in semiconductor technology, she says; the difference between the two countries was the level of cooperation between academic institutions and industry. "At Bell Labs they had thousands of individual patents and excellent individual research," she says, "but they never took the next step to production. That is the link I try to make."

In just two years at Northwestern, Razeghi has forged new links between industry and the University. She has put a generation of students in contact with the best international research and ideas. By fostering the confidence and contribution of each individual "genius," her research team will maintain its momentum toward innovation. "We humans," she says, "don't like monotone. The role of leader is to create an atmosphere of change."

Professor Razeghi's leadership has made Northwestern a player in a field where change is the only way to stay out front.

Marylee MacDonald is a freelance writer based in Evanston, Ill.

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