Jim Mayer can make a case for in-depth materials analysis. Why? Because materials make up everything in the world around us.

By John Matthews
Thin films are a vital phenomena in the physical world. Thin films are tiny layered sandwiches that might measure only a few atoms in thickness. Such minuscule structures include the coatings that protect expensive wood furniture, prevent rust in metal objects, or allow titanium to be an excellent base for paint. James Mayer says that if the subject involves electronic materials, then talk about thin films often is not far behind. When it comes to electronics and the production of integrated circuits, thin films are essential. Mayer directs the Center for Solid State Science at Arizona State University. He also is a Regents’ Professor of Materials Science Engineering. At a laboratory, he and his colleagues have built a special ion beam microscope. Ions are atoms or groups of atoms that carry a specific positive or negative charge. Beams of ions can be used as a tool to probe the tiniest nooks and crannies of all kinds of materials. Mayer, representing Hughes, teamed with John Davies, a Chalk River scientist. The Chalk River researchers studied ion implantation techniques and a series of fruits of their collaboration included a book on ion implantation – exactly how ions interact with solids. They also studied the range of radioactive particles found in fissionable materials, and other phenomena, Mayer says.

The students said that if they could look at insects under the microscope, they also could look at m&m candies, Mayer continues. “We’ve established a user-friendly, interdisciplinary group.”

A variety of scientists benefit from the technology and the expertise available at Mayer’s facility. To date, a school’s anthropologists and archaeologists have found the analytical technique particularly useful. Researchers can use ion beam analysis to determine the chemical composition of ancient artifacts, regardless of their size or unusual shape. Students also have access to both the instruments and the staff’s knowledge on how to use them for quality results.

Sharing with students the wealth of information accumulated through decades of research is important to Mayer. He is deeply involved with an outreach program that targets local elementary and junior high school teachers. Talented Arizona high school students also are encouraged and invited to work in his laboratory.

A special project-oriented class, “Patterns in Nature,” offers hands-on experience to improve science education from kindergarten through high school.

The course, offered in the spring, fall, and summer, is coordinated by Mayer’s wife, Elizabeth, faculty liaison for a school’s Office of Youth Preparation. The course is just one part of the “Collaborative Program for Excellence in Teacher Preparation,” a National Science Foundation-supported project headed by Susan Wyckoff, an Arizona professor of physics and astronomy.

“We take a program that teachers normally would offer their students, such as looking at objects through an optical microscope, and carry it a step further,” Mayer explains. “For example, in one course we taught students how to make their own optical microscopes – just as early scientists made them – and then moved on to depths beyond the single-lens microscope.”

The students also got hands-on instruction in the use of the scanning electron microscope at a school’s Goldwater Materials Science Laboratory.

“The students decided that if they could look at insects under the microscope, they also could look at m&m candies,” Mayer continues. “What they learned is that the bright white Ms stamped on each colorful round piece were titanium-based, just like paint pigment. The little letter actually is silk-screened onto each candy.”

The students discovered that each time they devoured an m&m, green, red, yellow, brown, orange, or blue, they also were ingesting titanium white.

“The amount of titanium ingested is harmless, unless of course you were to eat a million or more of the candies in one day. That would be a significant amount of titanium in the human system,” Mayer explains. “Of course, no one is going to eat a million m&ms in one day, except maybe Barney the purple dinosaur.”

The students carried the experiment a step further when Mayer instructed them in techniques for analyzing the pigment.

“Using titanium-based white letters is logical. The white-out correction fluid familiar to typists is titanium-based,” Mayer says. “I painted my nose with titanium to show the class how really fantastic it is as a covering agent.”

As the students learned about m&ms, they also became more interested about science education.
“I’ve found that students get interested in science early,” Mayer says. Keeping them interested is the challenge. “It’s our job to expose them to science and to the excitement of what’s happening at the university.”

Mayer is happy in Arizona, but he does miss the Pacific Ocean.

“I saw the Pacific every day while working at Hughes in Malibu. And while teaching at Caltech, I moonlighted as a scuba instructor,” he laughs. “I helped certify all graduate and undergraduate students who needed an underwater diving license.”

Scuba diving came naturally to Mayer who always was a good swimmer. He accompanied his sons in a basic scuba course. He later enrolled in an advanced seminar.

“I realized that Caltech was having trouble attracting and keeping scuba instructors,” he says. “So, I decided to take the 300-hour instructor course offered by the Los Angeles County Underwater Instructors’ Association. It nearly killed me.”

Mayer survived, advanced to the National Association of Underwater Instructors’ (n a u i) Certification Program, and went on to teach scuba diving at Caltech for 10 years.

“It was a tremendous experience that indirectly nourished my interest in undergraduate students,” Mayer continues. “I became Master of Student Houses at Caltech. During my last five years there I was responsible for the non-academic side of undergraduate life.”

A desire to serve minority students also attracted Mayer to a S u . In 1991 he chaired the “Vision 2021” conference in Phoenix. During that conference, the director of the U.S. Bureau of the Census told the group that a dramatic shift in college population would occur by the year 2030. Minority students would become the majority.

“That really struck me,” Mayer says. “I realized that when I attended organized scientific conferences, few Hispanics, African-Americans, or Native Americans attended. It’s a dilemma. People of all backgrounds need to become effective mentors.”

Mayer was successful in his efforts at both Caltech and Cornell in attracting women to science. But he realized he could do little for minorities at Cornell, located in upstate New York. He discovered that a S u was amenable to minority outreach, and he already knew several faculty members.

“I wanted to foster interdisciplinary research and realized that some barriers were insurmountable at well-established, older universities,” he says. “Also, I wanted to test my outreach program in the industrial community. Again, a S u was already doing this. So far, my work with minority students is progressing nicely.”

When he is not mentoring students or monitoring ions, Mayer enjoys ogling art scientific displays.

Before leaving Cornell, he co-taught “Art, Isotopes, and Analysis,” with Stan Taft, an assistant art professor. They explored with students the science present in art and the art present in science.

“Art lures me to strange, unusual places where I get involved in a behind-the-scenes analysis,” he says. “I guess I’m a museum freak. When I visit a city I usually find a museum where I look at paintings and study various techniques.”

When art experts visit Arizona, they usually locate Mayer’s home.

“Not long ago, a Smithsonian scientist spent three days with us discussing paintings,” he says. “She is interested in analyzing pigments recently found in a cave in France. Shortly after her visit, a representative of the Louvre stopped by to discuss pigments.”

Although Mayer’s scientific interests are wide and varied, he never really intended to pursue science as a career.

“I was going to follow what my father did; he was a sales engineer,” the a S u professor admits. “I’m glad I changed my mind. Over the years, I’ve definitely found much more satisfaction keeping an eye on the ion than I would have selling bulldozers.”

Supported by the National Science Foundation, James Mayer has developed an ASU interdisciplinary undergraduate program in materials synthesis and processing involving students in physics, chemistry, and engineering. For more information, contact James W. Mayer, Ph.D., Director, ASU Center for Solid State Science, 602.965.4544.