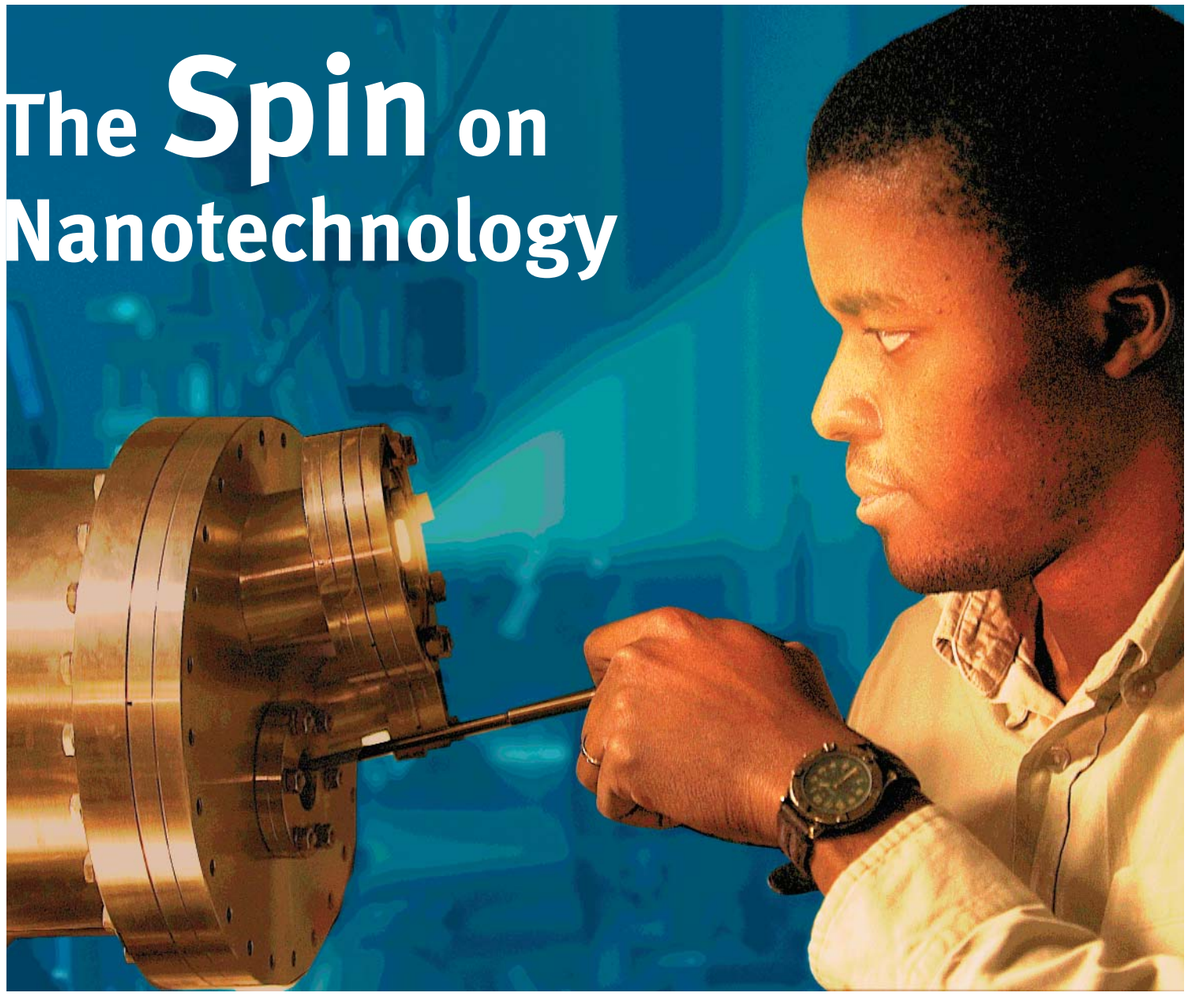
The Spin on Nanotechnology



Doctoral student Chaffra Awo-Affouda uses the scanning tunneling microscope or STM.

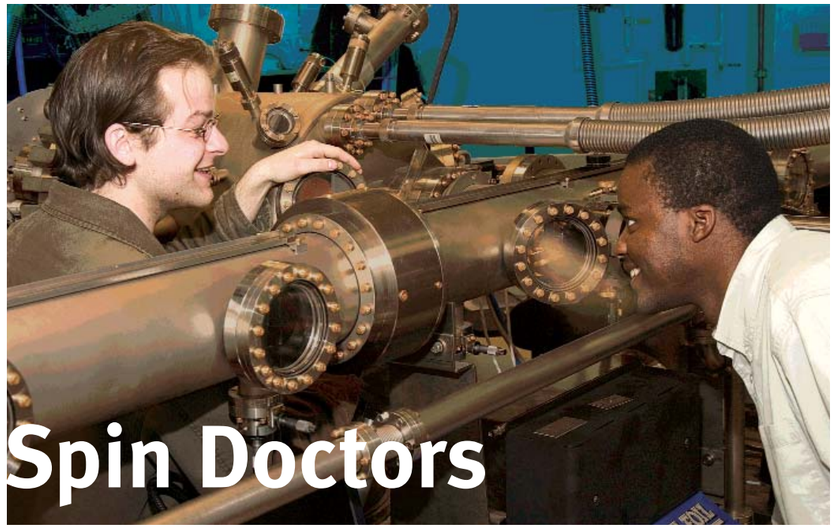
By Paul Grondahl
Photography by Mark Schmidt

At UAlbany's new College of Nanoscale Science and Engineering, the first college of its kind in the world, graduate students are taking the manipulation of matter on the atomic scale to new extremes.

It sounds like the pitch for a new reality TV show. Put two doctoral students and a post-doc — an African, an American and a German — in a laboratory with $2 million worth of state-of-the-art scientific equipment, including a machine nicknamed "Molly." Challenge them to figure out a problem that could revolutionize the computer industry: harness the natural spinning motion of electrons to create a magnetic field on a silicon wafer, even at high temperatures, to increase the speed and storage capacity. And give it a really cool name: Spintronics.

This may seem like the stuff that springs from the mind of TV producers, but at the

Spintronics: Attempting to make faster, cheaper computer chips by harnessing the natural spinning motion of electrons to create a magnetic field on a silicon wafer



Spin Doctors

Andrew Stollenwerk, left, and Chaffra Awo-Affouda use the Molecular Beam Epitaxy.

University's new College of Nanoscale Science and Engineering, the first college of its kind in the world, graduate students are taking the manipulation of matter on the atomic scale to new extremes. In the way that snowboarding revolutionized winter sports, spintronics is the big air of nanotechnology — a leap across today's scientific boundaries in the X Games that represent the brave new world found at the intersection of nanotechnology, physics, chemistry, mechanical engineering and business.

Essentially, UAlbany's spintronics team is attempting to make faster, cheaper and more powerful computer chips by replacing the 1's and 0's system and on/off control of electrical flow through semiconductors with a method that regulates the "spin" of electrons similar to the pull exerted by a magnet. Such a breakthrough would represent a quantum leap in the logic and memory capacity of computer chips.

"We're playing a football game where there is no end zone and we're on the field with the top 10 universities in the United States," says Alain Kaloyeros, the college's vice president and chief administrative officer who's also an architect of Albany NanoTech, the global research and development center that encompasses and synergizes the academic arm. "At the University at Albany, we're developing an outstanding reputation for research and education, which will help us lead the pack in this new and exciting science throughout the 21st century."

Nowhere is that more evident than in the spintronics lab, which is run by Assistant Professor Vincent LaBella. "We're among the first labs to prove that we can implant atoms from manganese into silicon to make it magnetic, which is the first step in using spintronics to transform semiconductors," LaBella explains.

"It's a dynamic new field, and we've had some exciting results already," says spintronics lab assistant and Ph.D. student Chaffra Awo-Affouda, 25, who grew up in the West African country of Benin, earned an undergraduate degree in electrical engineering in France and a master's degree in the same field at Union College in Schenectady, N.Y.

Awo-Affouda shares an apartment in Albany with lab partner and fellow Ph.D. student Andrew Stollenwerk, 24, a Seattle native. "I spend my days trying to catch one atom at the tip of a tiny probe so we can make an image," Stollenwerk says. "I've gotten lucky before and caught one on the first try. Other times I can be here night after night and on weekends without catching one. You have to be very patient." Stollenwerk is a kind of atomic artist; his touch with the tip in the scanning tunnel microscope is as precise as a brain surgeon's.

Michael Krause, 32, a post-doctoral researcher who holds a Ph.D. in physics from his native Germany, helped stumble upon a significant step forward in their research while celebrating the birth of his first child, Laura, on April 9, 2004. The proud father used an old, damaged tungsten tip to scratch "Laura" into the surface of a cast-off piece of silicon as a souvenir. The block letters were a few nanometers

Assistant Professor
Vincent LaBella

"The spintronics lab is open for business."

The Growth of Nanosciences at UAlbany

1993
New York State designates the University as a Center for Advanced Thin Film Technology. The designation carries with it state funding of $1 million for ten years, with a required industrial match of $1 million minimum, for a yearly budget of at least $2 million. A stated goal is to develop technologies to help strengthen New York and other U.S. industries, particularly in the fields of microelectronics and optoelectronics.

1997
The Center for Environmental Sciences and Technology Management (CESTM) opens in the spring, and the growing Center for Advanced Thin Film Technology is one of the occupants. Planning begins for an expansion of the building to include a pilot manufacturing line for semiconductors. The New York State budget includes $10 million for an addition to CESTM.

1998
UAlbany is designated the headquarters for Focus Center-New York for Gigascale Interconnects to develop science and technology for interconnects in the next generation of computer chips. The designation, carrying significant funding from the Semiconductor Industry Association and the Defense Advanced Research Projects Agency, is recognition of the University's national leadership in the field.

2001
New York Gov. George Pataki announces April 23 establishment of the Center of Excellence in Nanoelectronics at UAlbany, with $100 million in support from IBM and $50 million in state support. Construction of a "technology accelerator" begins.

2002
New York Gov. George Pataki announces July 18 that International SEMATECH will establish an R&D center at the Center of Excellence in Nanoelectronics with approximately $400 million in state and industry support over five years. Four months later, Tokyo Electron Limited (TEL) announces it is also establishing an R&D center, this one to perform advanced tool design and prototyping, with funding of $200 million from TEL and $100 million from New York State.

2003
NanoFab 300-South, initially called the "technology accelerator," opens. The 138,000-square-foot facility includes a business incubator, classrooms for what was then known as the School of Nanosciences and NanoEngineering, offices for Albany NanoTech, and large and small industrial sponsors and partners, including IBM, TEL, GE and International SEMATECH North. The School of Nanosciences and Nanoengineering officially welcomes its first students in the fall.

2004
The College of Nanoscale Science and Engineering officially welcomes its first students in fall; the College awards its first two Ph.D. degrees in December.

NanoFab 300-North, the third building in the complex, nears completion.

New York State again designates a Center for Advanced Technology in Nanomaterials and Nanoelectronics. The designation carries with it state funding of $1 million for ten years, with a required industrial/federal match of $1.5 million minimum, for a yearly budget of at least $2.5 million. A stated goal is to develop nanotechnologies to help strengthen New York and other U.S. industries, particularly in the fields of nanoelectronics and nanobioelectronics.

2005
Governor Pataki announces in his Jan. 5 State of the State Message that ASML Holding NV, IBM, and UAlbany's Center of Excellence in Nanoelectronics will collaborate to create a $400 million research and development center. He also announces a $450 million chip manufacturing research center with IBM, Applied Materials and Tokyo Electron. The two new centers are to be located at Albany NanoTech on the UAlbany campus.

Master's degree student in Nanoeconomics
Kasia Topol

"Nanotechnology is a really hot topic and I'm excited that I was able to structure a degree that combines science and economics."

tall, "probably the smallest "Laura" ever written," Krause figures. The researchers scanned the "Laura" image with the microscope and found the written name had been saved with the magnetic force of spin. "I was just fooling around, but that's how discoveries are made sometime," Krause says. He calculated that if they could advance this spintronics experiment, the one-square-centimeter piece of silicon (about one-half the size of a stamp) on which he doodled his daughter's name could store several hundred copies of the Bible.

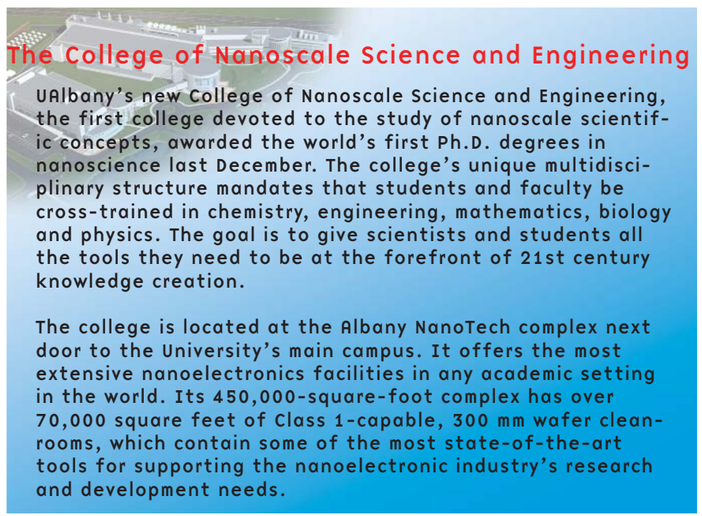
Not all discoveries are found in the lens of an electron microscope. Kasia Topol, a master's degree student in nanoeconomics, is charting new territory by combining economics and nanoscience. "Nobody else has done this here, but I studied economics in Poland, and I've got a scientific background," she says. "I think I can be an important bridge between business people who don't know much about technology and scientists who don't know much about business." Topol's older sister, Anna, earned a Ph.D. in physics from the University and works at IBM. Both sisters emigrated from Poland.

Topol's program includes a unique mix of M.B.A.-type courses and hands-on lab work where she uses a scanning electron microscope to study applications for light-emitting diodes and crystal structures in certain elements used in lasers. "Nanotechnology is a really hot topic, and I'm excited that I was able to structure a degree that combines science and economics," Topol says.

Topol is one of 70 master's and Ph.D. students in the college currently, with another 20 expected to be admitted for the fall semester. Within five years, that number is expected to surpass 200 students, says Robert Geer, assistant vice president for Academic Affairs. "We're aggressively expanding our programs and moving forward on all fronts," he says. There are 35 faculty members, and that number is growing, too, drawing upon UAlbany professors in a variety of departments and classes taught by researchers, including scientists with IBM, Tokyo Electron, ASML, Applied Materials and Infineon Technologies, onsite at Albany NanoTech. He adds that graduate students are now choosing the University over traditional powerhouses such as Cal Tech and MIT.

"There's nothing like this facility anywhere in the world," Geer says of the complex to which $2 billion worth of investment has been committed. "That's what sells our program." ■

For more information:
http://www.albanynanotech.org/



The College of Nanoscale Science and Engineering

UAlbany's new College of Nanoscale Science and Engineering, the first college devoted to the study of nanoscale scientific concepts, awarded the world's first Ph.D. degrees in nanoscience last December. The college's unique multidisciplinary structure mandates that students and faculty be cross-trained in chemistry, engineering, mathematics, biology and physics. The goal is to give scientists and students all the tools they need to be at the forefront of 21st century knowledge creation.

The college is located at the Albany NanoTech complex next door to the University's main campus. It offers the most extensive nanoelectronics facilities in any academic setting in the world. Its 450,000-square-foot complex has over 70,000 square feet of Class 1-capable, 300 mm wafer cleanrooms, which contain some of the most state-of-the-art tools for supporting the nanoelectronic industry's research and development needs.