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Dr. Gang Chen with a model of the hexagonally-stuctured mesoporous silica he uses to harness the confinement effect. His current research has implications for super-fast computing in the future.

NSF grant advances computing technology

In his second year of research funded by the National Science Foundation, Dr. Gang Chen is developing technology that will harness phase changes to revamp computer memory systems.

Phase change memory materials are already used in everyday devices such as Blu-Ray discs. "We hope that we can improve this technology and make it faster and able to store more information," he explained.

To build on this technology at the nanoscale, Chen synthesized hexagonally-structured nanoporous silica and germanium antimony telluride, or GST. When cooled and shrunken, liquid GST placed within this "honeycomb" solidifies faster and releases less heat.

"We could have a computer memory that's at least 1000 times faster and store information at least 10 terabytes per square inch," he explained.

So far, Chen and his research group have synthesized the nanoporous silica and GST and learned how to control the size and composition of each material.

"A year from now we hope that we can put these individual components

See **CHEN**, page 3

Physicists witness new entangled states of matter

Entanglement has long intrigued physicists. Without physically touching, two entangled items react instantaneously and identically to stimuli applied to one member of the entangled pair. Scientists collaborating between Ohio University and the Eindhoven University of Technology in the Netherlands recently observed new excited states of matter through this phenomenon.

The study highlights the first observation of hybrid excitons and appeared as an Advance Online Publication in Nature Physics on May 23. The observance of hybrid excitons in particular brings physicists a step closer to quantum information processing.

Using lasers, scientists targeted electrons in quantum dots positioned near a metallic layer within a lattice-shaped atomic structure. When the laser struck the quantum dots, electrons leapt from low to high energy levels, creating quasiparticles called excitons.

Excitons consist of an excited electron and hole, or space left behind at the low energy of a semiconductor. As excited electrons relax, they release secondary photons that can be studied to reveal properties of quantum dots.

"Looking at the spectrum of emis-

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Director's Corner

Excelling at nanoscale research and education at home and abroad

Dear Colleagues,

Nanoscience and atomic-scale science are visionary research areas, and the Ohio University Nanoscale & Quantum Phenomena Institute is committed to excel in this field. NQPI researchers are carrying out innovative projects, spanning from the optical properties of nanostructures, to investigations of single molecules and spin in nanoscale structures.

Combining two colleges and 8 departments into a cohesive interdisciplinary research unit, the NQPI pools minds and resources in order to pursue such exciting research frontiers. While collaborative research projects are at the heart of NQPI, infrastructure developments are also essential. For example, the new helium liquefier facility, when completed (now aiming for late 2010), will enable a dramatic growth in various high profile research areas.

At the same time, the NQPI's educational initiatives – including sending students abroad for internships at partner institutes such as the Institute of Applied Physics in Hamburg, bringing students across departments together for lively discussion forums, and providing for interdepartmental co-mentoring – all are aimed at developing the next generation of critically-thinking researchers.

I hope you enjoy this 4th issue containing the latest developments within the NQPI.

Arthur R. Smith, NQPI Director

Nanobytes

Dr. Horacio Castillo renewed a $103,539 grant to study phase transitions in glass.

Dr. Eric Stinaff won a grant of $180,000 to study entangled spin states in quantum dot molecules.

Dr. Mauricio Garrido, a recent graduate from the Stinaff group, accepted a postdoctoral position at Columbia University.

Dr. Savas Kaya received funding in the amount of $39,000 to modernize NQPI's MOCVD Material Growth System.

NEWS BRIEFS:

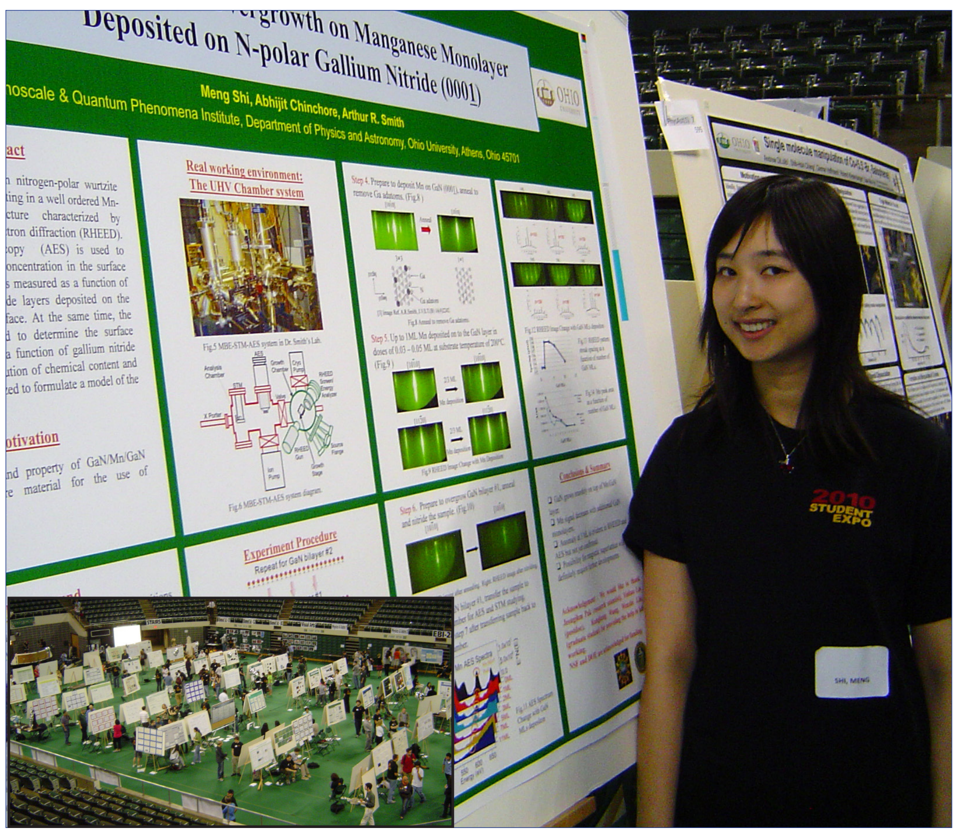
Thanks to a $400,000 National Science Foundation grant, NQPI now has access to OU's new ultrafast laser spectrometer, one of 12 of its kind in the world.

NQPI Director **Dr. Art Smith** and graduate student **Andrew DiLullo** returned from Germany, where they collaborated with scientists from the University of Hamburg in spin polarized scanning tunnelling microscopy.

NQPI recently added **Elizabeth Stinaff** to its staff as the Outreach Coordinator and Business Manager. She comes from OU's Voinovich School of Leadership and Public Affairs where she is the current Leadership Program Coordinator.

Graduate student **Swati Ramanathan** attended the "Workshop on Entrepreneurship for Physicists and Engineers from Developing Countries" in Trieste, Italy and held an open forum to discuss entrepreneurship and physics upon her return.

NQPI students share research at annual expo



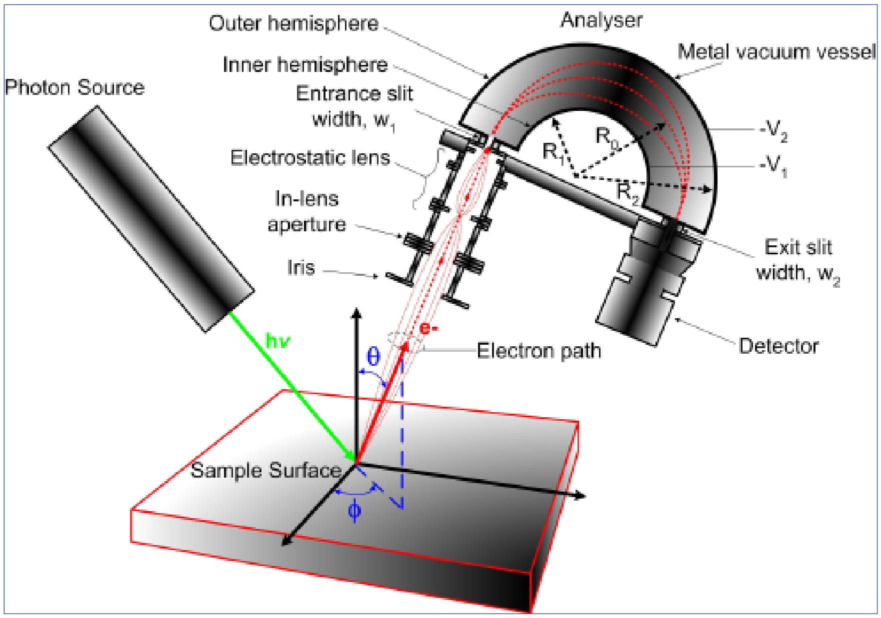
Meng Shi waits for judging at the Ohio University Research & Creativity Expo. Twelve NQPI students and research groups took home awards from the competition, which drew hundreds of community members and students from OU and local schools. Inset: More than 600 students from around the university gathered to share their projects.

Fellowship award fuels student's research on properties of thin film

Mohammad Ebdah, a doctoral student in physics, won Ohio University's annually-awarded Graduate College Fellowship on May 17. The award includes a $14,487 stipend and a tuition and fee waiver.

"I was so, so excited at that time because when I checked the results, I was at home and my wife was also waiting. When I checked, it was a very good surprise," he said.

As part of the application process, Ebdah and his advisor, Dr. Marty Kordesch, detailed Ebdah's proposed research for the next year. Kordesch, who has worked closely with Ebdah since becoming his advisor in 2007, described him as, "Fast, smart, motivated…He's all the things you want," and noted that Ebdah works as rapidly as he speaks.

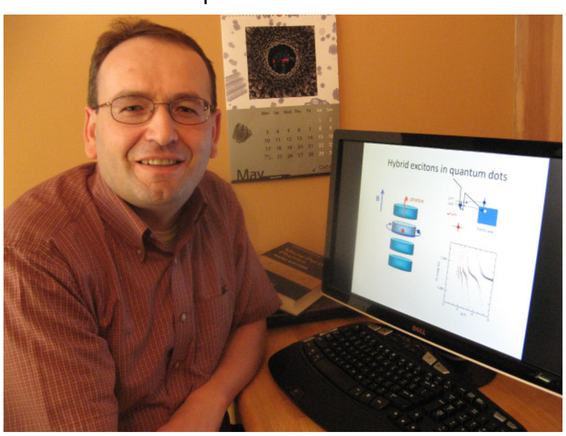


During ultraviolet photoelectron spectroscopy, a photon beam hits a thin film, causing valence electrons to be emitted. These photoelectrons are captured by a hemispherical detector and studied to reveal properties of thin films. Courtesy of Mohammad Ebdah

The fellowship will allow Ebdah to research thin films that have implications for the future of energy technologies. This includes semiconductor thin films made from amorphous indium zinc oxide that are prepared using a reactive magnetron sputtering technique. To determine the electronic properties of the thin film, Ebdah will use ultraviolet photoelectron spectroscopy. Ebdah determines optical and electrical properties of the thin film using spectroscopic ellipsometry and Hall Effect measurements, respectively.

EXCITONS, from page 1

sion, we understand more about the state of the electron. The spectrum gives us the information about the hybrid [entangled] state, the state of the exciton, and the state of the electron and how it's entangled," said Sasha Govorov, a theoretical physicist from Ohio University's Nanoscale and Quantum Phenomena Institute who co-authored the paper.



NQPI professor Sasha Govorov used optics to see unusual and previously unseen electron states including hybrid excitons. His research should further the development of quantum information processing.

Unlike previous research that examined this type of entanglement, this study used optics to more directly observe unusual electron states. As scientists examined the properties of photons given off by relaxing electrons, they were also able to identify hybrid excitons. These quasiparticles were created through entanglement of an electron from a quantum dot and electrons from the metallic film.

Quantum dots are groups of atoms five to 50 nanometers wide that function as "artificial atoms." Controlled by voltage, they can be arranged to form designer crystal structures and have become a popular research topic.

In a 2003 study, Govorov and his co-authors predicted that hybrid exciton states would exist and be observable under certain conditions. Before this project, however, this type of electron entanglement had not been observed in the optical spectra.

The Ohio University Biomimetic Nanoscale and Nanotechnology group and Condensed Matter and Surface Science Program provided funding for this research. Experimental work was led by Professor Paul M. Koenraad and performed at the Eindhoven University of Technology. Koenraad's team included Joost van Bree, Niek Kleemans, Andrei Silov, Joris Keizer, Rian Hamhuis and Richard Nötzel.Theory was developed by Govorov at Ohio University.

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together. Basically, we have to fill the honeycomb with honey," he said.

The project has implications for technology based on phase changes, or a material's change from a disordered, amorphous phase to an ordered crystalline state. "Unlike random-access memory, this memory is nonvolatile, which means the information stored inside will be there forever," Chen said. Translation: future students may carry an entire library on a handheld drive.

Quantum dot expertise leads to unusual internship for OU student

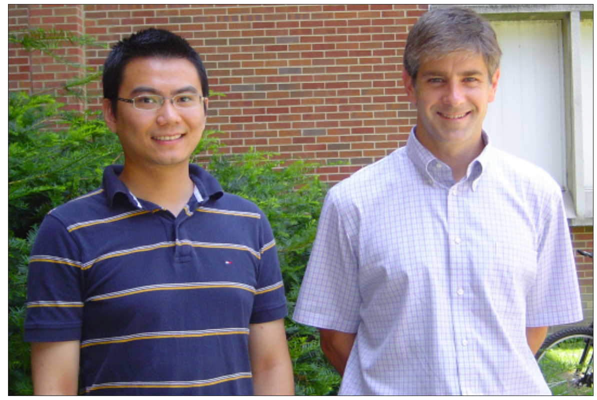
While scores of doctoral students hunkered down in laboratories this summer, Yueran Yan moved to a new city, to make practical use of his lab skills.

"I know a lot of people, they have the ability to do research, but they don't like to talk to people, they will be shy presenting in front of people. You need to tell people you can do it. I think that's the most important thing," Yan said.

After presenting his research on quantum dot shells at the American Chemical Society's annual meeting in San Francisco last March, the president of Sun Innovations offered Yan an internship at the company's laboratory in Fremont, California.

Yan's advisor, Dr. Greg Van Patten, said Yan would likely teach the company as much about quantum dots as he learns from them. "If nothing else, he'll come back with a new understanding of how the materials he's working with can fit into new technologies ... these [quantum dots] haven't really been used in the industry yet," Van Patten said.

As an assistant engineer, Yan will synthesize quantum dots tailored for specific customers.

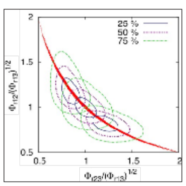


(L to R) Yueran Yan and his advisor, Dr. Gregory Van Patten in Athens.

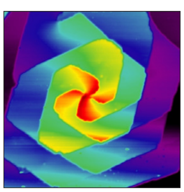
Yan's work focuses on synthesizing quantum dots, or designer atoms, with two shells that protect unstable cadmium telluride at the dot's core. While Yan hopes to enter the industrial sector in a research or development position someday, he's currently focused on completing his Ph.D.

NanoGallery

NQPI faculty share nano images from their labs



Probability contours for "dynamical heterogeneities" in a simulation of glassy polymers. Castillo Group.



STM image of spiraling growth of gallium nitride. Smith Group.

Temperature image of a gold pattern fabricated by e-beam lithography. The nominal linewidths are approximately 100 nanometers. The gold is excited optically and the temperature increase is measured through Er^{3+} photoluminescence spectrum. The heat conversion occurs on a picosecond timescale. Richardson Group.

Design & writing by Robin Donovan. Editing by Dr. Eric Stinaff and Ben White. Please email nqpi@ohio.edu with comments.

Ethical challenges not new, reminders needed

Saving money, saving lives, and being environmentally friendly are oft-cited goals of research because they match societal values. But when ethical issues arise, scientists must consider the balance between progress and risk.

While nanoscience and nanotechnology pose few new ethical challenges compared to other emerging technology, these growing fields present an opportunity to incorporate the study of the ethical implications of science and technology into scientific curricula according to NQPI's Dr. Arthur Zucker.

Zucker, a philosophy professor who has tackled applied ethics from business to medicine to nanotechnology, said, "Applied ethics is, in some sense, a lot of social and political philosophy. What are the roles of science and advances in technology in society?"

Advances in the beginnings of nanotechnology and fields like medicine, computing, and communication are subject to value-related decisions. Questions such as, "What should scientists study?" and "What is a desirable outcome?" are at the core of applied ethics and social and political philosophy.

When ethics is integrated into existing courses, it becomes as much a part of the thought pattern of scientists as the scientific method. And that, Zucker said, "just has to be a good thing."

Institute adds new minds for shared research

Three new faces and two new fields recently joined NQPI: Drs. Eric Masson (chemistry), Gerardine Botte (electrochemical engineering) and Tatiana Savin (mathematics). Adding diverse disciplines to NQPI's roster means members can easily reach across campus when funding opportunities arise.

"When NSF [the National Science Foundation] has an opening. . .I just say, 'OK, Saw, David, we have a subtopic that matches. Do you want to go for it?'" says Botte, who is currently using chemicals abundant in wastewater to develop materials for producing clean fuels from coal.

Masson, who came to Ohio University in 2007 hopes NQPI will help him find collaborators for research that examines the way molecules interact with other molecules, DNA, or proteins.

Savin, who checked in from abroad via email, also sees potential: "I am happy to meet outstanding researchers at NQPI. . . . Dr. Smith invited me to have a tour in his lab, and some of his experiments are in the scope of my interests as a mathematician."