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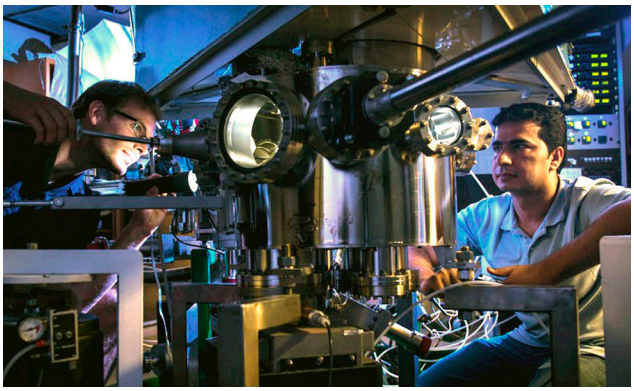
Hybrid SP-STM/MBE/PLE System Achieving Results

Sept. 6, 2013 is a day that will forever be remembered by members of the Smith team. After years of development, this is the day the hybrid system, consisting of a spin-polarized scanning tunneling microscope combined with a dual function molecular beam and pulsed laser epitaxy system, took flight by achieving atomic resolution on gallium nitride at LHe temperature.

"The hybrid aspect of the system is that it integrates a custom LT (4.2 K) SP-STM with a custom MBE and PLE thin film growth facility. It is essentially three machines in one. The SP-STM was built into a split-coil, 4.5 Tesla superconducting magnet, and we also designed a separate chamber just for magnetic tip preparation and magnetic sample and tip storage. The thin film growth part of the facility allows the preparation of new types of spintronic-layered materials by MBE or via the second complementary method of PLE," said Art Smith, a professor of physics at Ohio University.



Graduate students Andrew Foley and Khan Alam perform a wobble-stick manipulation within the LT-STM chamber. Photo by Rob Hardin.

The beauty of this unique hybrid system is that it constitutes three techniques that are rarely combined into one system. Building the system themselves, the Smith team was able to combine all these elements at a fraction of the cost of a commercially bought system. But of course, they have encountered some obstacles since the beginning of the design phase; most importantly, how to handle the many competing demands of so many inter-related sub-systems.

"Getting a new LT-STM system working has enough problems, like vibration isolation and cryogen hold time, but combining this with MBE and PLE results in a whole new set of sometimes conflicting requirements, which can be complicated. For example, the LT-STM sample holder should be small with high thermal conduction to the surroundings, while that for MBE is typically large (in our case 2" wafers can be handled) with low thermal conduction to the surroundings," Smith said.

Wenzhi Lin, a former physics graduate student, worked on the system from the beginning design phase.

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NQPI to Host SP-STM-5 Conference in July 2014

NQPI is proud to announce that it will host the next edition of the Spin-Polarized Scanning Tunneling Microscopy Conference (SP-STM-5) in July 2014. SP-STM-5 will be held at the beautiful Sawmill Creek Resort in Huron, Ohio, along the shores of Lake Erie.

The conference will take place July 15-19, 2014, and will include in-depth discussions on all topics of spin-polarized scanning tunneling microscopy and spectroscopy of magnetic and spintronic materials. The conference will also include an outing to the historic island village of Put-in-Bay, famously known as an important battle site in the War of 1812.

SP-STM-5 will also coincide with the International Conference on Nanoscience + Technology (ICN+T 2014), which will be held the week following SP-STM-5 from July 20-25, 2014, at the Vail Cascade Resort and Spa in Vail, Colorado.

Those traveling by airplane should plan to arrive at the Cleveland-Hopkins International Airport, approximately one hour from Huron. A shuttle will pick up guests arriving on the afternoon or evening of July 15 and return guests departing for the airport on the morning of July 19.

Sponsorships of the conference are still available. For more information, and to register for the conference, please visit www.spstm.org, or contact NQPI Business Manager Kay Kemerer at kemererb@ohio.edu.

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Director's Corner

Dear Colleagues,

Welcome to the 10th Edition of the NQPI Newsletter! I hope you find of interest the various stories in this issue, including those about our research and also those about our educational activities.

With the fall semester wrapping up, there will soon be some peaceful winter break time to finish up a paper, or to work on a grant proposal. In fact, NQPI members have been submitting lots of proposals recently in order to hit various fall funding agency deadlines, some of which were extended due to the recent federal government shutdown.

In the world of scanning probe microscopy, there is a lot going on. I recently traveled to Tsukuba, Japan, for ACSIN-12/ICSPM21, a combined conference which drew speakers from around the world to talk about the latest advances in STM and AFM, as well as in the area of atomically controlled surfaces, interfaces, and nanostructures. The program also included a special memorial session devoted to the late Heinrich Rohrer, founding father of STM and nanoscience in general. This conference followed the week after the AVS 60th International Symposium in Long Beach, California.

Also on the subject of conferences, 2014 has plenty of SPM-related conferences to consider attending, for example, SP-STM-5 hosted by NQPI next July (second cover article), followed by ICN+T and NSS-8, all within a three-week period and all in interesting locations – check them out!

Finally, a brief update is in order on the $90-million Interdisciplinary Science Facility (ISF), the new building planned to replace Clippinger Laboratories. So far, an architectural firm is in the process of being selected. The yet-to-be-determined design should ultimately result in a new facility with vastly improved conditions for nanoscale research. Future newsletters will include updates on this monumental undertaking.

Best Wishes for a Happy Holiday Season!

Arthur R. Smith, NQPI Director

NanoBytes

Grants

Arthur Smith and Jeongihm Pak have received $200,000 from the U.S. Department of Energy to conduct spin-polarized scanning tunneling microscopy studies of nanoscale magnetic and spintronic nitride systems.

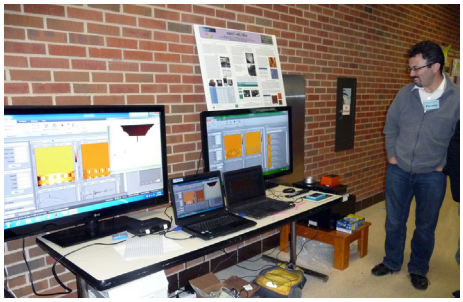
Saw-Wai Hla was awarded $137,886 from the U.S. Department of Energy to investigate the manipulation of molecules and nanoscale molecular superconductivity.

Nancy Sandler and Sergio Ulloa received $134,622 from the National Science Foundation to study symmetry, local-environment, and time-dependent effects in nanoscale systems.

Eric Stinaff was awarded $24,000 from Battelle Memorial Institute to research entangled photon generation using periodically poled lithium niobate.

For a full list of grants as well as publications, please visit www.ounqpi.org.

Prof. Savas Kaya speaks with a family visiting the nanO stUdio during the Physics Open House in October.



Prof. Savas Kaya demonstrates the nanO stUdio's Scanning Tunneling Microscopy equipment at the Physics Open House.

nanO stUdio Brings Nanoscience to Young Scientists

One unique laboratory has recently started its mission to educate young scientists in the concepts of nanotechnology and nanoengineering at Ohio University.

The nanO stUdio, an interactive laboratory designed to educate young scientists and undergraduate students in concepts of nanomaterials, nanostructures, nanosensors, nanodevices, and advanced microscopy techniques, received its first official visitors, the Ohio Young Scholars, on Oct. 1.

NQPI member Savas Kaya, a professor of Electrical Engineering and Computer Science in the Russ College of Engineering and Technology, received a $200,000 grant from the National Science Foundation in October 2012 to build the immersive educational platform.

Kaya hopes that one day the technology in the nanO stUdio will be integrated into high school classrooms, so students can learn the value of nanoscience in an accessible way.

For now, young scientists can enjoy the traveling mobile nanO stUdio exhibit, which made stops at Ohio University's Electrical Engineering and Computer Science Showcase, the Science Café, and the Physics Open House in October.

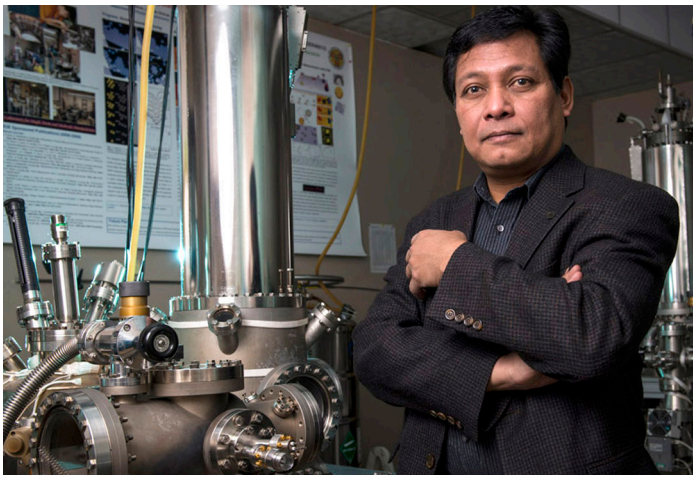
One Athens teacher who attended the Physics Open House said that she loved the nanO stUdio. "This is how students should be learning science!" she remarked.

The nanO stUdio, located in the Academic and Research Center at Ohio University, will hold a grand opening ceremony for the public in January 2014.

Hla Group Advances Nanomachine Development

The research team who recently created a molecular motor is continuing research into ways to control interactions at the atomic level in the development of nanomachines.

Saw-Wai Hla, a professor of physics at Ohio University and research group leader for the Center for Nanoscale Materials at Argonne National Laboratory, is a leading researcher in the areas of scanning tunneling microscopy (STM), single molecule manipulation, single molecule spintronics/electronics, molecular switches, and nanomachines on surfaces.



NQPI Member Saw-Wai Hla at work in his lab. Photo by Rob Hardin.

Hla and his team are continuing work in single molecule manipulation. They can control various interactions at the atomic scale.

"In the latest work, we are building very tiny machines. These machines are so tiny they are made of molecules. I can put one million nanomachines in the cross section of a hair. I am continuing to develop more complex nanomachines for information transport in the same tiny scale," he said.

In essence, Hla and his team are learning how to build molecular machines one component at a time. The prior creation of a molecular motor, which uses electrons generated from a STM tip to control rotation of a motor that is one nanometer tall and two nanometers wide, is an important step in this process.

"Motors rotate to produce energy and make things move. At the nanoscale, this tiny motor also rotates. Our goal is simple: we want to develop little machines, and machines have different rotating parts. They have pinions and gears, so this is one of those parts that we are developing. It is essentially a building block in a small nanomachine," he said.

These tiny machines could be powered by installing surface electrodes that would act as an energy source. The potential applications of these nanomachines are promising. In medicine, they could be used to monitor health, dispense medicine, and cure diseases. For example, nanomachines carrying drugs that kill cancer cells could deliver this medicine directly to cancer cells, leaving healthy cells untouched.

"It's not like these little guys are eating away at cancer. These guys attach to the medicine, and then deliver the medicine directly to the cancer cell. Chemotherapy kills all the cells. This is targeted," Hla said. "I am not saying it is happening now, but it is a possibility. It's still a long way to reach there."

Hla's team has also been researching the manipulation of plants at the molecular level to understand how plant molecules produce clean energy and how that process can be replicated.

"We want to understand how plants capture sunlight at the molecular level. We want to image them and then develop artificial plants at the nanoscale level to develop green energy," he said. "My goal is very simple. It has to be green, cheap, and it has to be useful for mankind as medicine or an energy application," Hla said.

NQPI Sponsors Two Post-Doctoral Researchers

A special NQPI grant has funded two post-doctoral researchers during the fall semester.

NQPI Members Jeff Rack, professor of chemistry, and Eric Masson, associate professor of chemistry, have joined the forces of their respective research teams to investigate a new class of materials that exhibit non-random macroscopic deformations when irradiated with light.

"We are trying to use Eric Masson's Cucurbituril macrocycles with our photoisomerizing compounds to make supramolecular materials that exhibit the photochemical features of the photoisomerizing compounds," Rack explained. "When incorporated within this material, enabled by Eric's compounds, we obtain new materials that exhibit properties not exhibited by either of the components."

As explained by Masson, Cucurbiturils are pumpkin-shaped macrocycles which can encapsulate other molecules in their cavity.

A $19,146 grant from NQPI has supported two post-doctoral researchers from the Department of Chemistry and Biochemistry, Yuhuan Jin and Roymon Joseph, to continue this research.

"We are trying to use the Cucurbituril macrocycles to connect the photochromic Ruthenium complexes, and to form new types of supramolecular polymers with photochromic properties. By AFM (Atomic Force Microscopy) experiments, we can screen the shape of the polymer chains, as well as the changes after irradiation and photoisomerization of the photochromic ruthenium complexes," Jin said.

The research completed by the post-docs has produced a number of scholarly outcomes. Jin and Joseph have already presented their research during the Ohio Inorganic Weekend and the Upper Ohio Valley Section of the American Chemical Society in October.

Sandler Brings Nanoscience to Life

One NQPI member's conceptualization of life at the nanolevel has come to life in the form of a claymation video.

Zoom In! The Lotus is an animated educational video designed to introduce kindergarten, first, second, and third graders to the basic concepts of nanoscience. The video follows Gwen Pym, a young nanoscientist who can transform into an extremely miniaturized version of herself to study things at the nanolevel.

Prof. Nancy Sandler presents her claymation video, Zoom In! The Lotus.

Nancy Sandler, an associate professor in the Department of Physics and Astronomy, received a $9,635 grant from the American Physical Society in 2012 to create the educational video.

The animation is being created in a joint effort between the Department of Physics and Astronomy and students from the School of Media Arts and Studies, who are being led by Assistant Professor Kate Raney. Special Project Assistant Jean Andrews served as a liason between the departments.

Between story design, set construction, filming, and post-production work, Raney said it has taken her team over one year of hard work to complete the animation.

In the first video, Gwen flies through the forest on the back of a beetle and learns the secret to keeping her clothes water and dirt free using the leaves of a lotus flower plant, which repel moisture due to their ridged surfaces.

"A lotus leaf has a particular structure. When looked at closely, the surface is made out of bumps that are very close together, so close that the water droplets just roll off the surface. Dirt attaches to the water molecules and leaves with them," Sandler explained.

The animation will be released to schools in Ohio by the end of the year. Sandler is hoping to make a whole series of animations featuring the nanoadventures of Gwen.

The idea for this project actually came when Sandler and her husband, Sergio Ulloa, who is a co-principal investigator in this project, had trouble finding educational science books for their daughter, Julia.

"All this started because we were looking for science books for our daughter. We had no idea how much work it would be," Sandler said.

Ohio University Plans New Interdisciplinary Science Facility

An investigation into renovating Clippinger Laboratories has now suggested it may be cost effective to build a new science building. The Interdisciplinary Science Facility (ISF) was included in a $970 million, six-year capital improvement plan approved by the Ohio University Board of Trustees in November.

"During the conceptual design phase, we discovered that the costs for renovating Clippinger likely exceed the cost of a new facility that better meets the needs of our academic programs," Robert Frank, Dean of the College of Arts and Sciences, said in a September letter to OU faculty.

The next step includes programming and schematic design phases, where programming decisions will be made concerning the design and function of the ISF, followed by the creation of schematics. These phases are expected to be completed by October 2014.

Design input will be sought from departmental committees representing Physics and Astronomy, Chemistry and Biochemistry, and Geological Sciences. This information will then be transmitted to the ISF project committee, which includes an architectural firm and selected faculty representatives.

Smith, from page 1

"Because this is a hybrid system, I had to always keep in mind the good integration between the low temperature scanning tunneling microscopy system and molecular beam epitaxy system in the design. For such a comprehensive system, it is essential to understand each component and carefully select each chamber shape and port specification, so that all components can work together seamlessly," said Lin, who is now a post-doctoral research associate at Oak Ridge National Laboratory.

After Lin graduated in 2011, doctoral students Andrew Foley, Khan Alam, and Perry Corbett have solved several important remaining problems, along with much assistance from the Physics and Astronomy Department machine shop.

The researchers have also been excited to see initial atomic resolution images of the test sample - GaN $(000\bar{1})$ c(6x12) - appear for the first time in September.

"It's important because our microscope is showing some features in this reconstruction that may not have been seen before. Based on images we're getting, we can propose modifications to the current [model] for the reconstruction," Foley said.

Although GaN has been a successful first sample, the next experiments will include magnetic samples grown by MBE, in which case the SP-STM's 4.5 Tesla superconducting magnet will be used to explore atomic-scale magnetic and spintronic effects.

This unique microscope system was initially funded by a DURIP equipment grant from the Office of Naval Research. Its continued development has been supported by the Department of Energy Office of Science, the National Science Foundation, and internal funding from Ohio University.

Writing and design by Angie Faller. Editing by Dr. Horacio Castillo, Kay Kemerer, and Angie Faller. Please email nqpi@ohio.edu with comments.