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NQPI
OHIO UNIVERSITY

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Hla Receives Patent for Novel Superconductor

Ohio University Professor of Physics and Astronomy and NQPI member Saw-Wai Hla recently received a U.S. patent for the development of an ultra-thin superconductor.

Hla holds the patent with former visiting OHIO Professor Abdelrahim Hassanien and former graduate student Kendal Clark, now an assistant professor of Physics at Central Methodist University. The superconductor is exhibited by $(BETS)_2GaCl_4$, a compound with unique properties.

In superconductors, unlike in metals such as copper or semiconductors such as silicon, electrons move without resistance. As a result, superconductors produce negligible amounts of heat, and currents are not susceptible to energy loss during transmission.

"Nowadays, we are concerned about

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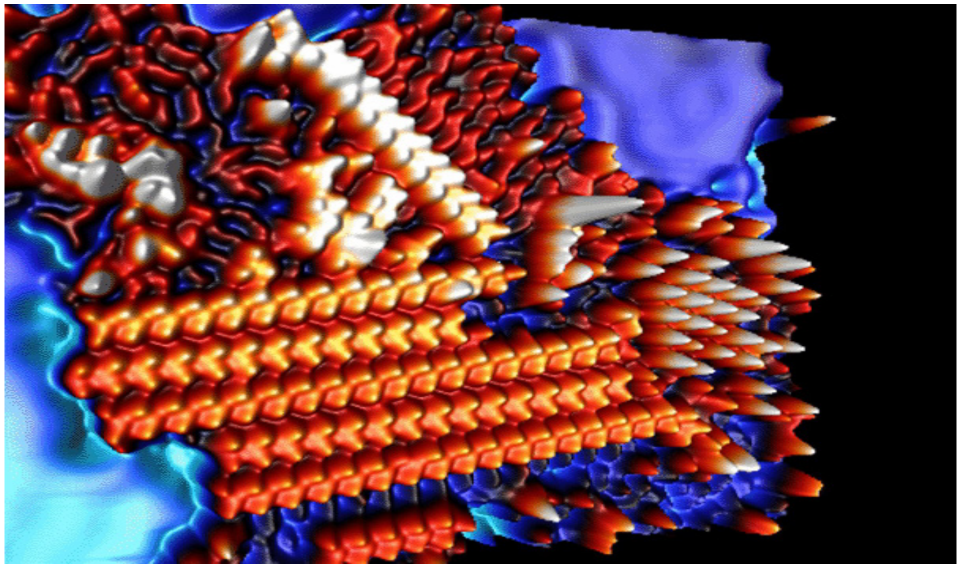

Scanning tunneling microscope image of $(BETS)_2GaCl_4$ chains on a silver crystal surface at 6 K. These molecular chains are one of the tiniest superconductors discovered.

Characterizing Mechanics of Cancer Cell Invasion

Ohio University Professor of Physics and Astronomy and NQPI member David Tees is investigating the mechanical properties of cancer stem cells to elucidate how they propagate throughout the body.

It is well known that tumor cells can enter the blood and form secondary tumors in other tissues. However, the mechanism behind this process is not fully understood. Tees is working with Monica Burdick, an OHIO professor of Chemical and Biomolecular Engineering, to characterize how breast cancer cells travel through vessels. Tees' team includes current and former graduate students Young Eun Choi, Amina Alipour, Aaron Burdette and Pooja Chopra.

During development, stem cells differentiate (mature) into discrete cell types that are normally fixed for the organism's lifetime. However, when cancer cells become mesenchymal, they can dedifferentiate, taking on stem-like properties and often redifferentiating as a secondary tumor.

"Once the cell goes through this transition, its mechanical properties might change," Tees said. "These cells are more aggressive ... and potentially more able to propagate in the body at another site."

Tees hypothesized that mesenchymal cells mimic healthy leukocytes, allowing them to circulate undetected. Metastatic cells are initially large and rigid, but by altering their mechanical properties, they may be able to pass through pulmonary capillaries. Tees' team uses two methods to measure cancer stem cell flow behavior.

In the first method, Tees' team observes the movement of cancer cells into a micropipette under pressure. They have characterized the relationship between stress (pressure) and strain (cell deformation).

The group is developing a second method based on kinematics that utilizes microfluidics to track cell movement. In this system, a cell sample travels through a series of tapered vessels to a channel that is narrower than the cell diameter. They measure the time cells take to deform and enter the narrow section. Although his group monitors flow microscopically, Tees hopes to develop a system with electronic sensors, which would allow clinicians to collect information on a patient's risk of metastasis.

"Watching these cells go by is ... a complex skill and labor-intensive," Tees said. "An electronic measurement that tracks the movement of cells ... would be a more practical device ... that's usable for a non-expert."

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Director's Corner

Dear Colleagues:

Warmest greetings from Athens, Ohio! Welcome to the 16th edition of the NQPI newsletter; I hope you enjoy hearing the latest research and activities being conducted by NQPI members.

First, please join me in congratulating Dr. Alexander Govorov, who was recently named an Ohio University Distinguished Professor, the highest permanent recognition of outstanding scholarly and creative accomplishments attainable by OHIO faculty. Dr. Govorov's internationally recognized work on the optical and thermal properties of nanocrystals and nanomaterials is an example of the exceptional research of our members. NQPI now has four active members who have been recognized as Distinguished Professors!

I would also like to congratulate NQPI member Dr. Saw-Wai Hla on his newly granted U.S. patent on ultra-thin superconductors. You can read about the broad range of interdisciplinary research being done by our members, including Dr. David Tees' work on the properties of cancer cells and Dr. Martin Kordesch's study of thermionic cathode surfaces. You will learn of the interesting work on extending the "shelf life" of transplanted human hearts by Dr. Tadeusz Malinski, who was recently awarded a prestigious award for his work in cardiology.

It's a pleasure to highlight our students' achievements, including 2016 graduates Ramana Thota and Sneha Pandya, who have begun careers at Intel Corporation. We have also started an effort to invite alumni who worked with members of NQPI to visit with current students and researchers. Our first guest, 1997 graduate Dr. Petra Stumm, worked with Dr. David Drabold and has a successful career in the semiconductor industry.

Lastly, NQPI has a website that is updated regularly. Please visit *www.ounqpi.org* to learn about the latest NQPI research, grants, publications, event photos and more.

I wish you a productive rest of 2016.

Eric Stinaff, NQPI Director

Distinguished Professor

Alexander Govorov

NQPI member Alexander Govorov has been named a 2016 Ohio University Distinguished Professor. The title recognizes outstanding scholarly accomplishments and is the highest permanent recognition attainable by OHIO faculty. Govorov, a professor of Physics and Astronomy, is known for his research on the optics of nanostructures. He is credited with starting the field of chiral plasmonics and plasmonic bioassemblies. His research on gold nanoparticles was recently published in *Nature*. Since 2002, Govorov has published more than 150 papers and his work has received more than 9,000 citations. He was also named a fellow by the American Physical Society and in 2015 he won OHIO's Outstanding Faculty Research and Scholarship Award. NQPI member and Physics and Astronomy Professor Martin Kordesch, who nominated Govorov, called him a "Top 1% physicist."

Optimizing FRET

A program developed by Ohio University Professor of Chemistry and Biochemistry and NQPI member Jixin Chen will allow researchers to better visualize molecular interactions using single-molecule Förster resonance energy transfer (smFRET).

The program, which was created in collaboration with Rice University Professors Anatoly Kolomeisky and Christy Landes, and graduate students Joseph Pyle and Kurt Waldo Sy Piecco, will help account for a "blurring effect" due to limitations in frame resolution. The group described the work in an article that was recently published by the *Journal of Physical Chemistry B.*

"It could be that ... you need to further test whether the value you get from your measurement is reliable," Chen said. "The point of this paper is to increase the frame resolution ... so the data after the analysis is more reliable."

See the full article at www.ounqpi.org.

NQPI Editorial Changes

The past year has brought several changes for Ohio University's NQPI newsletter staff. After four years of service, Physics and Astronomy Professor Horacio Castillo stepped down as the newsletter's faculty adviser and editor. We thank Horacio for his excellent work and service. We welcome Castillo's successor, Physics and Astronomy Professor Nancy Sandler, to our team.

The biannual newsletter is created under the direction of Kay Kemerer, who has served as the NQPI business manager and event coordinator since 2013. Two of OHIO's graduate students currently serve as the program's interns. Samantha Peko, a Ph.D. student from the E.W. Scripps School of Journalism, has worked for NQPI since May 2015. Amanda Biederman, a Ph.D. student in the Department of Biological Sciences, joined the staff last January.

Sam studies journalism history. She is a freelance contributor for the local newspaper, *The Athens News*. Her previous experience includes freelance writing for *The Richland Source* and *The Ashland Times-Gazette* in north-eastern Ohio.

Amanda studies the role of biological membranes in cold adaptation. In 2015, she traveled to Palmer Station, Antarctica, to collect physiological data on the Antarctic notothenioid fishes. In addition to her scientific work, Amanda worked as an editor for her undergraduate newspaper, and she has written articles about science through her personal blog.

Amanda joined NQPI because she enjoys meeting with the program's faculty members to discuss their work, and she appreciates the opportunity to learn about the different scientific fields and disciplines that NQPI encompasses.

Sam joined NQPI because she wanted to explore science journalism, and the internship offered the opportunity to do so.

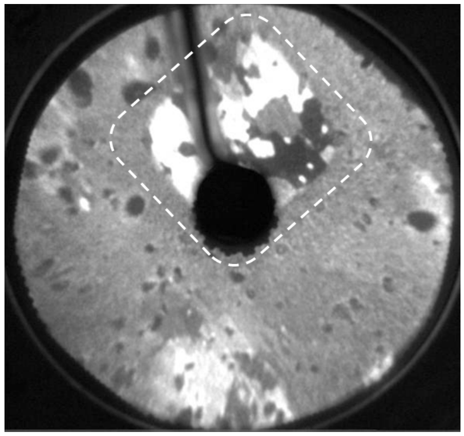
We welcome our new team and look forward to reporting exciting news!

Reexamining the Properties of Surface Coatings

Ohio University Professor of Physics and Astronomy and NQPI member Martin Kordesch recently received a grant from the Defense Advanced Research Projects Agency to study the fundamental properties of surfaces of thermionic cathodes.

Thermionic cathodes are electron sources in high power high frequency amplifiers. They are used in microwave ovens, older tube television sets, and newer technologies such as the 2006 Pluto satellite "New Horizons." Kordesch said it has long been known that the cathodes in such instruments operate at a lower temperature (850 vs. 2000°C), using coatings of barium oxide and scandium oxide on the emitter's tungsten surface. However, researchers do not know why this is the case.

Kordesch said many researchers believe that the compounds form a thick layer over tungsten, while others believe the compounds form a "dipole layer" of approximately one-quarter layer thickness. Kordesch's group examines the molecular interactions in experimental model cathodes, rather than the entire system. This gives him the advantage of viewing the components of the surface directly, which is otherwise difficult at high temperatures.



Thermionic emission electron microscope image of a 200 nm thick, 100 um x 100 um square of Sc_2O_3 deposited on tungsten foil. Imaged at T_B=1191 K.

Kordesch said his work directly contradicts the "layer theory." Viewing images at high temperatures through an electron microscope, Kordesch has observed the formation of "beads" on the tungsten surface, like water droplets on a newly waxed car.

Kordesch's group arranges the two layers of oxide molecules in various shapes on the surface, observing their properties both separately and at points in which they overlap. They have found that when the surface is heated, "empty spaces" develop around the coating. This indicates that the compounds are clustering together. Clustering of the molecules is a phenomenon called "dewetting."

"Wherever (scandium oxide and barium oxide) were touching, they desorb," Kordesch said. "But wherever they weren't touching, they stay intact ... This contradicts everything that anybody knew."

Kordesch hypothesizes that the scandium mediates the dewetting effect. Currently, he is analyzing the behavior of these molecules on single crystal surfaces, to reduce the complexity of the observations. These studies will help him better characterize dewetting among these molecules. Kordesch said his work is addressing an age-old, long abandoned question.

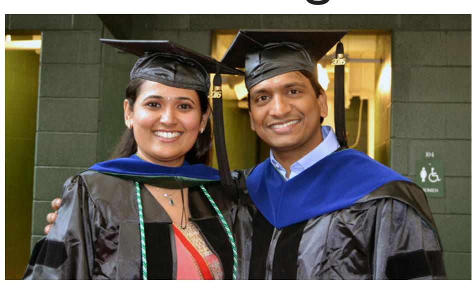
"Sometimes people give up on the really hard problems because they're so tough, and move onto lower-hanging fruit," Kordesch said. "This is a tough problem that's been left over for a long time."

Graduates Working in Industry

For many college students, graduation is the yellow brick road at the end of a long journey. However, after they've crossed it, many may wonder what awaits them next. Some go into academia while others opt to work in other fields. For those interested in industry, it may pay to have connections.

"Bring OUr Alumni Back" is a newly created program started by NQPI. The program was inspired by visits of various alumni to the department in previous years. One such graduate to return to OHIO to share her industry experience was Petra Stumm, who received her doctorate in Physics and Astronomy in 1997 under NQPI member and Distinguished Physics and Astronomy Professor David Drabold's supervision. She is manager of product and platform engineering at Advanced Micro Devices, a semiconductor company. She presented at the CMSS Colloquium Series last year on "Microelectronic Product Development." During the visit, she also met with the Women in Physics group.

Listening to alumni experiences can often inspire current students to explore their options and take on new opportunities.



Sneha Pandya and Ramana Thota at OHIO's 2016 graduation ceremony.

Ramana Thota, a process engineer at Intel Corporation and recent graduate in Physics and Astronomy with a doctoral degree, attended academic conferences where he had the opportunity to meet with people from different venues.

Thota studied photolithography while a doctoral student at OHIO with NQPI member and Physics and Astronomy Professor Eric Stinaff, who is an expert in nanophotonics. Photolithography involves making patterns on a substrate using light, he explained.

From synthesizing nanoparticles to nanophotonics, the understanding of physics allows for the development of many practical applications.

Thota said he is enjoying the new job, which started last January. He is developing the next generation of materials and processes that will advance the scope of applications based on nanotechnology.

Physics and Astronomy doctoral graduate Sneha Pandya said she had aspired to work at Intel since her second year of study. She said she spent a lot of time networking with alumni to help plan her next step.

Now Pandya, who graduated in 2016, works at Intel as a process engineer.

While a graduate student at OHIO, Pandya worked with NQPI member and Physics and Astronomy Professor Martin Kordesch, developing a technique to distribute nanoparticles. The technique was featured in NQPI's fall 2015 newsletter.

Although important, making connections come second to being able to work independently, a trait that Pandya says is indispensable to impress future employers.

"My Ph.D. has not only helped me get the job, but also do the job," Pandya said.

At Intel, she's working at applying her skills by processing semiconductor chips.

Malinski Recognized with Cardiology Award

Distinguished Professor of Chemistry and Biochemistry and NQPI member Tadeusz Malinski was recently honored by the International Academy of Cardiology at the 21st World Congress on Heart Disease in Boston. He received an award titled "The Albrecht Fleckenstein Memorial Award for Distinguished Work in the Field of Basic Research for Cardiology."

This award recognizes Malinski's lifetime work on the application of nanomedical systems for the early diagnosis, treatment and prevention of heart failure, cardiac vasculopathy and vascular diseases. Heart disease is the cause of nearly 25% of deaths in the US – higher than cancer.

Malinski said he was excited to receive the award, which is typically given to individuals with medical degrees.

"It's a very prestigious award. I am probably the only one in the past 25 years who is not a cardiologist," Malinski said.

Malinski has reached many milestones in his career of research and development, and his contributions to the field of cardiology are vast. Nearly three decades ago, Malinski developed a first of its kind nanosensing system and technique that was small enough to be placed in hearts and could successfully measure the release and concentration of several small molecules, like nitric oxide, peroxynitrite and superoxide during a single beat of the heart. This discovery offered a much more complete description of the heart and how the contraction and relaxation forces are regulated in the beating heart.

In serious medical procedures, like heart transplantation, the preservation of these forces is vitally important. Having a better understanding of how the heart actually works made it possible to develop new solutions for storage, which could potentially double the time for the transplantation of a heart graft and improve the success of surgery.

These nanomedical studies have proven to be extremely useful with many practical applications. From his Down Syndrome study (covered by NQPI last spring), to extending the life of a preserved heart, to the recently patented new method of the accelerated healing of the vasculature in wounds, Malinski's contributions to basic research in cardiology are numerous.

Malinski hopes to apply his findings using nitric oxide in the heart to study capillary function in the brain. This could have far-reaching ramifications on the study of diseases like Alzheimer's, Parkinson's, hemorrhagic stroke and aging in general.

Malinski receives lifetime achievement award.

NanoBytes

■ We welcome our newest member, Department of Chemical and Biomolecular Engineering Professor Amir Farnoud.

■ Physics and Astronomy Professor Eric Stinaff was chosen as a plenary speaker for the The Ohio-Region Section of the American Physical Society's fall 2016 meeting.

■ Tomás Rojas-Solorzano, a Physics and Astronomy graduate student, won first place at the Ohio Supercomputer Center's Statewide Users Group meeting.

■ Chemistry and Biochemistry Professor Katherine Cimatu recently gave birth to a baby girl. Congratulations!

Superconductors

Continued from page 1

power and energy," Hla said. "Power plants generate a lot of power, but along the transmission lines to our homes, we've lost the power along the way. The power is wasted, as heat, due to the resistance. So superconductors are very important in technical terms."

Hla said superconductors have become important due to the development of small electronics that are susceptible to current resistance. He compared electron flow in a material to flowing water in a channel; as the channel becomes smaller, water flow is hindered. This, Hla explained, is why laptops are often warm to the touch, while desktop computers generally remain cool.

BETS acts as the superconductor and $GaCl_4$ as the electron acceptor. Hla said that, unlike in metals or semiconductors where single electrons move individually, superconductors transmit electrons in pairs. As a result, the electrons can avoid obstacles and move coherently, facing no resistance.

The superconducting properties of crystalline $(BETS)_2GaCl_4$ were previously known. However, Hla's group has now demonstrated that the material can function as an ultra-thin superconductor. The compound self-assembles to form a long wire that is one molecule thick, about the thickness of a single amino acid. Hla said the single molecule can be synthesized cheaply and efficiently.

Hla said ultra-thin superconductors provide greater resolution and more precise measurements in novel electronic devices, compared to crystalline superconductors. For example, the technology may help improve brain imaging techniques, rendering higher resolution images than those available with current devices.

Additionally, ultra-thin superconductors may be used one day in quantum computers. Quantum computers employ a method known as entanglement to allow for communication between devices, regardless of physical distance.

"It's a little farfetched, but it might be there," Hla said. "People say (the quantum computer) will be the next revolution in technology ... This particle knows what the other particle is doing no matter what distance there is between them. Quantum computers are extremely powerful."

Writing, design, and editing by Samantha Peko and Amanda Biederman. Editing by Dr. Nancy Sandler and Kay Kemerer. Please e-mail nqpi@ohio.edu with comments.