Iman Roqan builds spectroscopy lab in Saudi Arabia

Prachi Patel

The King Abdullah University of Science and Technology (KAUST) sits on a sprawling desert campus 80 kilometers north of the port city of Jeddah in Saudi Arabia. The graduate-level research university has a multi-billion-dollar endowment and a lofty mission: build a force of graduates with globally competitive technical expertise in order to diversify the country's economy beyond petroleum.

Iman Roqan, an assistant professor of materials science and engineering, is proud to be part of KAUST's mission. Roqan, a petite woman with a determined look who chooses to wear her abaya and headscarf despite the University's liberal policies, is one of five female faculty members at the university out of a total of nearly 90, and the only Saudi woman.

She is busy setting up her state-of-the-art laboratory, the first one in the country devoted to the spectroscopic studies of semiconductors. Her curiosity and interest in semiconductor spectroscopy has driven her academic progress over the years. As a PhD student in physics at the University of Strathclyde in Scotland, Roqan investigated the optical and structural properties of group-III nitride semiconductors—indium nitride, gallium nitride, and aluminum nitride—which are used for high-intensity light-emitting diodes (LEDs). Her goal is to improve the quality of grown films of these materials, so they can lead to more efficient solar cells and LEDs.

High-efficiency solar cells could have large implications for her country, Roqan said. Saudi Arabia, which holds one-fifth of the world's crude oil reserves, currently meets nearly all of its energy needs from fossil fuels. The country plans to spend $100 billion to venture out into solar and nuclear power to meet increasing energy demands with a more sustainable mix of sources. "Solar cells will be very important for Saudi Arabia," Roqan said. "Solar power is the second biggest topic of interest for energy after oil."

One of Roqan's projects focuses on indium gallium nitride (InGaN). The material is used in today's blue and green LEDs, but scientists started exploring it for solar cells in 2003.

"You can engineer the bandgap of indium gallium nitride to cover a large range and can capture the entire solar spectrum from near-UV to infrared," Roqan said. "So far, silicon-based solar cells have shown better light-to-electricity conversion efficiency, but this material was proven theoretically to be much more efficient."

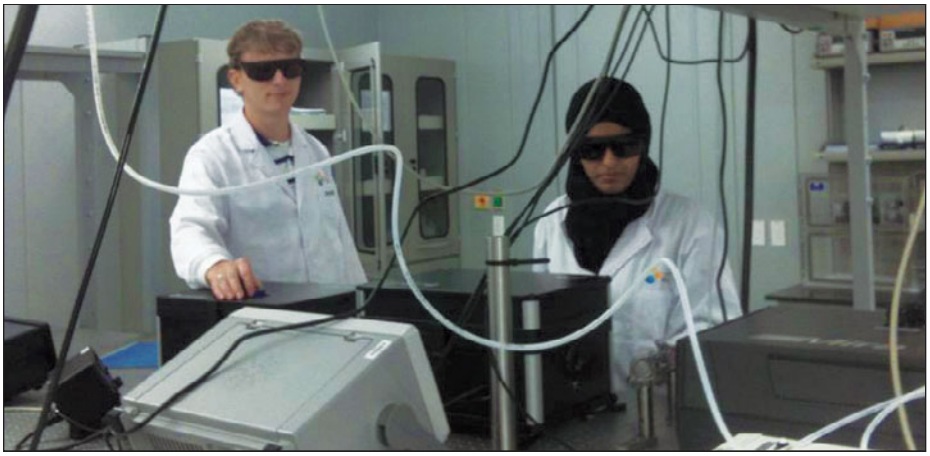
The theoretical limit for the conversion efficiency of silicon solar cells is 29%. With InGaN, it could be possible to grow multiple layers with different bandgaps and make cells that are over 50% efficient. However, growing high-quality films has proven difficult, and scientists have made devices that are 3% efficient at best.

The problem is that indium atoms tend to form clusters when the material is grown with high indium content. In a solar cell, electrons and positively charged holes recombine at these clusters, reducing efficiency. Using photoluminescence and time-resolved spectroscopy, Roqan said she hopes to shed light on how and why the clusters form, which should allow her to fabricate better quality films and improve solar cell efficiency.

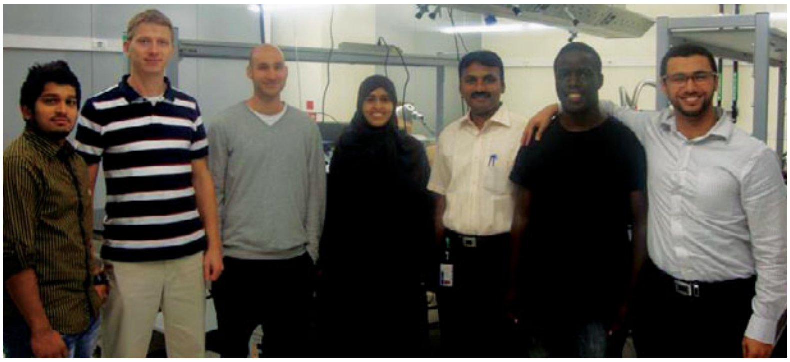
She also intends to similarly investigate III-nitrides such as aluminum gallium nitride, which is used for UV LEDs and laser diodes, devices with applications in water and air purification.

Roqan cannot wait to get going, but first she needs to get all her laboratory equipment in place. The challenge of setting up her advanced lab has been part of being a large, brand new university. It took a year after KAUST opened in 2009 to finish construction of her lab. Then it took a few more months to obtain the lasers, electron microscopes, detectors, analyzers, and a myriad of other tools she needs. With the generous budget KAUST allots to each researcher, buying what she wants was not the problem, she said, but the process has been slow because shipping to Saudi Arabia takes time.

Right now, Roqan is most eagerly anticipating a streak camera, an important detector for many of her spectroscopy techniques. Coincidentally, the camera is also useful for nuclear weapon development, so she has had to wade through a maze of paperwork to prove that it will only be used for education and research. "Hopefully by the end of the year it should all be done and my lab should be in 100 percent working condition," she said.



https://doi.org/10.1557/mrs.2011.242 Published online by Cambridge University Press



Iman Roqan (*center*) is surrounded by her international research group at KAUST (*left to right*) **Fukruddin Mahmood** from India, **Vasily Melnikov** from Russia, **Ioannis Bantounas** from Greece, **Venkatesh Singaravelu** from India, **Fred P.M. Jjunju** from Uganda, and **Abdulaziz Baras** from Saudi Arabia.

While her laboratory was being set up, Roqan and her students had to rely on KAUST's core laboratory facilities. They also traveled frequently to laboratories in the United Kingdom with whom she has close collaborations, including Imperial College London, and the University of Strathclyde and St. Andrews University in Scotland. She regularly hosts people from other institutions as well. This fall, Roqan will have visiting researchers from Imperial College and City University in London.

Since February, Roqan has been collaborating with researchers at Imperial College to study gadolinium-doped zinc oxide. The material could find use in spintronics, an emerging technology that could lead to a new class of electronic devices by exploiting the intrinsic spin of electrons, and could also find use in LEDs. Roqan's goal, again, is to be able to grow higher quality films of this relatively new material than has been possible so far.

"We have a technique to grow the material, so I synthesize the material," she said. "We do the magnetic and optical characterization at KAUST and then some structural and electrical characterization at Imperial College."

When Roqan is not in her lab observing the properties of rare-earth-doped semiconductors, she teaches a semiconductor properties class and an optoelectronics devices class. She hopes to instill in her students the same curiosity, passion for scientific inquiry, and principles of hard work that she said she grew up with. She credits her parents for instilling these principles in her and encouraging her to go for higher education in a society where this is not the norm for women. "My family was unique with regards to giving me full support to pursue my career and to be independent despite being from a conservative society," she said.

After receiving her bachelor's degree in physics and education from Umm Al-Qura University in Mecca, Saudi Arabia in 1998, Roqan obtained a master's degree in photonics and optoelectronics devices at Heriot-Watt University and St. Andrews University in Scotland. She then went to the University of Strathclyde to pursue her doctorate, and planned to continue her research in a postdoctorate position after earning her PhD degree in 2008. But fate had something else in store. KAUST was hiring faculty and Roqan's PhD supervisors persuaded her to apply. She was one of the first academic appointees at KAUST.

Being one of the university's few women professors has been a unique experience. "Many times people are surprised when they find out I'm a faculty member," she said. "People assume I am a student or a post-doc."

She hopes that this perception might change soon, and is certainly doing her part in supporting women to be involved in physics and engineering at KAUST. Roqan had a female postdoctoral fellow for a year, and is now looking to recruit female students from Saudi Arabia and worldwide. The challenge, she added, is the notion of a lack of freedom for women in Saudi Arabia. Once students get there, they are surprised at the open, liberal nature of the campus. A third of KAUST's student body now comprises females.

Roqan's six-person laboratory is all male, but the striking diversity exemplifies the university's international student body. She has one master's student from Saudi Arabia, a PhD student each from India and Uganda, and a postdoctoral researcher each from Greece, India, and Russia. It is a talented team that she has chosen with great care and she is excited to work with them.

Underneath Roqan's calm voice is a palpable energy derived from pursuing her scientific dream in her home country. "This will give me an opportunity to… serve my country with new technology, building new industry, and improving the research culture. KAUST's vision is to be one of the best research institutes in the world and this is what I hope for." □

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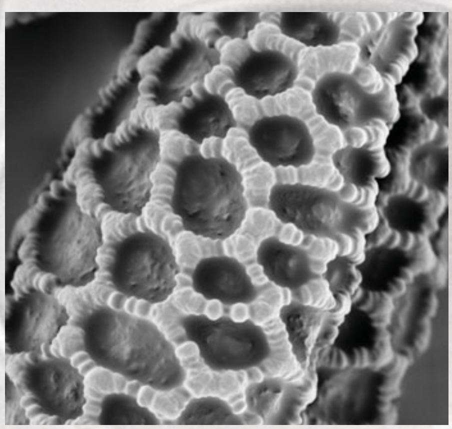
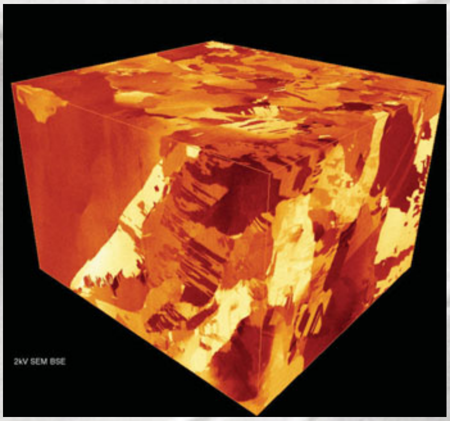
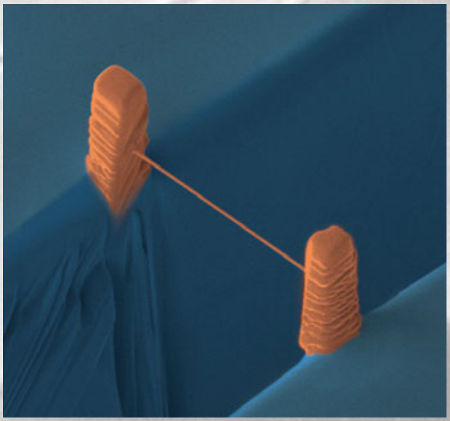


Surface of uncoated pollen, imaged using SEM at very low kV (50 V).

The horizontal field width is 51 µm. *Courtesy of FEI NanoPort.*



Austenic-ferritic duplex steel, 16 x 12 x 18 µm³ volume acquired with the AutoSlice and View™ application. A series of top-down high energy, high angle SEM-BSE images were collected automatically. The distance between each slice is 30 nm. *Courtesy of FEI NanoPort.*



Platinum nanowire deposited and milled to about 50 nm diameter for use as a gas sensor *Courtesy of Peter Heard, Bristol University, United Kingdom.*

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