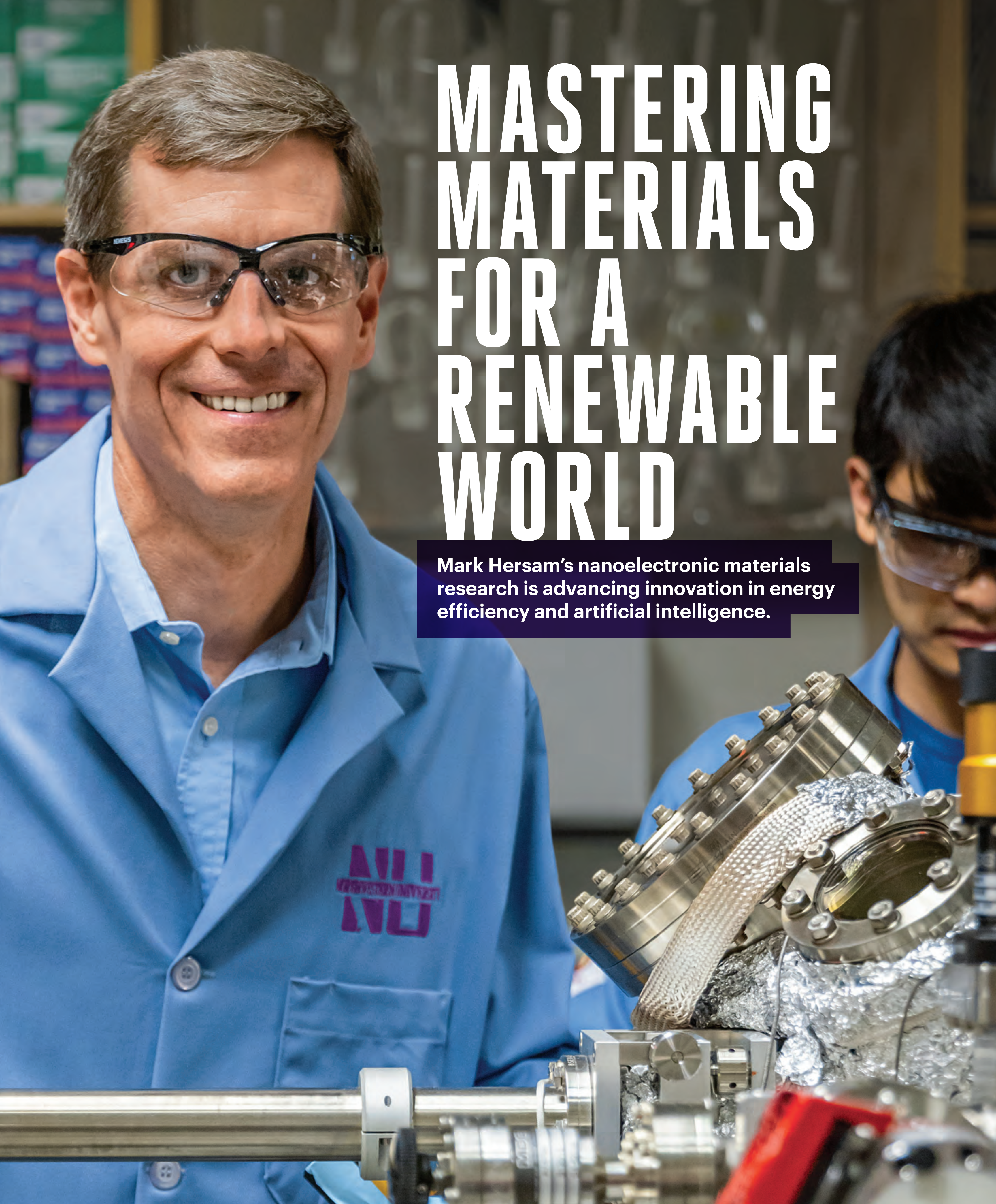
MASTERING MATERIALS FOR A RENEWABLE WORLD

Mark Hersam's nanoelectronic materials research is advancing innovation in energy efficiency and artificial intelligence.



As an electrical engineering undergraduate student in the 1990s, Mark Hersam knew the future of electronics was tied to the future of materials.

At the time, the field was focused on making the transistor ever smaller. Before nanotechnology became a popular area of research, Hersam understood there were going to be significant challenges to scaling below one micron.

"Many fundamental limits would be reached, some of which would be related to the fact that the physics would change at the nanometer scale," says Hersam, Walter P. Murphy Professor of Materials Science and Engineering. "The underlying principles would transition from classical physics to quantum mechanics, and consequently, there would need to be new materials to get past those barriers."

This realization prompted Hersam to shift toward materials science, where he became a pioneer in the field of low-dimensional nano-electronic materials. His groundbreaking research helped drive Northwestern's leadership in materials science while contributing to advances in renewable energy and computing.

His work includes the synthesis of borophene. Stronger, lighter, and more flexible than graphene, borophene has the potential to revolutionize batteries, electronics, sensors, solar cells, and quantum computing.

Today, Hersam is an elected member of the National Academy of Engineering and chairs Northwestern Engineering's Department of Materials Science and Engineering. He also serves as professor (by courtesy) of electrical and computer engineering and chemistry. In addition to leading high-impact research, he trains the next generation of graduate and undergraduate students, who are pushing the boundaries of materials science.

A BROAD VIEW OF NANOELECTRONIC MATERIALS

Hersam joined Northwestern in 2000 after earning his PhD from the University of Illinois Urbana-Champaign. He says Northwestern's interdisciplinary culture was a major draw, but the fact that the school was ahead of the curve on nanotechnology made the decision easy.

It didn't take long for Hersam's research group to make waves in the materials science field. One of the lab's specialties is understanding and controlling the surface chemistry of nanoelectronic materials, which can have a decisive impact on properties.

"We work on multiple next-generation technologies, including neuromorphic computing and quantum computing," Hersam says. "But what you realize is that surfaces and interfaces are critical in other areas, like energy technologies such as solar cells and batteries. Once you have mastered the surface chemistry of nanoelectronic materials, you can apply that knowledge to many other technologies."

A FOCUS ON ENERGY

With energy consumption growing worldwide, minimizing energy use and finding sources of energy are important areas of focus for Hersam.

"I think energy is the most significant challenge facing humanity," he says. "We would like to produce and use energy in a way that does not have collateral damage, and it is fair to say that renewable forms of energy have the least amount of collateral damage. Solar cells are about as renewable and clean as you can get, so making a more efficient solar cell is a high priority for us."

But even the world's best solar cell can't take over the energy grid without storage for use in darkness or cloudy conditions. "Another target for us is batteries as an enabler for renewable energy," Hersam says. "We already use batteries for other applications, including portable electronics and electric vehicles, but the dream would be to do it at the grid level. Once you solve that problem, then you can imagine a world where all energy is renewable."

One particularly problematic area for energy consumption is artificial intelligence. AI requires a tremendous amount of energy to handle large volumes of data and uses huge quantities of water for cooling. Hersam's lab is working on projects to address this issue, including developing a new transistor modeled on the brain, which mimics human intelligence by simultaneously processing and storing information to perform energy-efficient associative learning at room temperature.

"In neuromorphic computing, you no longer have a separate memory and microprocessor," he explains. "Instead, memory and data processing are colocated, which minimizes the need to move data, thus giving you massive reductions in power consumption for data-intensive tasks like artificial intelligence."

MULTIPLYING IMPACT BY TRAINING THE NEXT GENERATION

The Department of Materials Science and Engineering is undergoing a generational change, Hersam says. He sees this as a moment to improve the experience of students, postdoctoral fellows, faculty, and staff. As he works to hire the next generation of faculty, Hersam "wants to create an environment where junior faculty can thrive. They will each be leading their own research groups, where the next generation of students will be trained to maximize their impact on society."

Educating students is what Hersam enjoys most about his role. "All professors believe that their research is important and can result in impactful technologies," he says. "But at the end of the day, research is a means of training students, and watching what they accomplish in their careers is where I get the most joy from this job. I know that the accumulated impact of the alumni from my laboratory will easily exceed what I will ever achieve myself."

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Photo by Matthew Allen