



Photo by Jim Stroup

Working with electrical and materials science engineers, Rachel Umbel monitors the crystal growing in a 1000-degree Celsius environment.

Growing crystals and minds

By Lindsey Haugh

Semiconductors are one of the nation's top exports and are a strategically important industry for the economy and national security. In 2012, the Semiconductor Industry Association (SIA) reported semiconductors were primarily responsible for the global trillion-dollar electronics industry. In the U.S. alone, semiconductor companies generated \$146 billion in sales.

The fabrication of semiconductor materials is essential to the field of power electronics and necessary for the following applications: energy efficiency, energy storage, energy distribution, communication, and computer systems.

Rachel Umbel, a doctoral student in the materials science and engineering program at Virginia Tech, is working with gallium nitride to grow crystals. The chemi-

cal compound has properties superior to silicon, the dominant platform in building semiconductors and ultimately, power electronics.

Prior to her research in Blacksburg, Umbel obtained her bachelor's degree in physics and was enrolled in the honors college at the Indiana University of Pennsylvania. On an internship in 2010, Umbel had the opportunity to study under Nobel laureate, Eric Cornell at the University of Colorado-Boulder. During another National Science Foundation-sponsored program, she collaborated with an international panel of researchers in the quest for gravitational waves at the University of Glasgow, Scotland.

Umbel works with a group of students advised by Lou Guido, an associate professor jointly appointed in both materials

science and engineering and electrical and computer engineering. Guido's research group is made up of nine electrical engineering and materials science and engineering master and doctoral students.

"The combination of different educational backgrounds is perfect for interdisciplinary research," said Umbel, the lone female on the team. "What can be learned, not only in the lab, but over coffee and discussing our findings, is pretty exciting."

Together, they "bake out" the MOCVD reactor chamber using what Umbel compares to a self-cleaning oven. The slow process takes approximately two and a half hours in order to prevent flaking of the growing crystals. The second phase is the growth phase. Using a two-inch diameter wafer, the crystals grow at an incredibly

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hot temperature – 1,000 degrees Celsius. The crystal films are a couple microns thick -- thinner than a human hair.

The group constantly monitors the system, taking every safety precaution, because it uses toxic gases such as arsine. The gases are passed over a substrate and then break down, decomposing, creating the crystal. The system is maintained through a scrubber system, cleaning the exhaust

gases before they are released, ridding it of toxic gases.

From beginning to end, the total growth time of a crystal is four hours.

Growing gallium nitride on silicon, otherwise known as crystals, will enable the manufacturing of integrated circuits and therefore, lower the cost of semiconductor device fabrication and further enhance the field of power electronics.

The young doctoral student is hopeful about the research and inspired to stay in the field after completing the doctoral program in 2015.

“And maybe after I defend, I will obtain an industry job with one of the world’s largest semiconductor chip makers...like Intel,” said Umbel with a grin. “Or maybe a travel adventure abroad before settling into my first real job.”

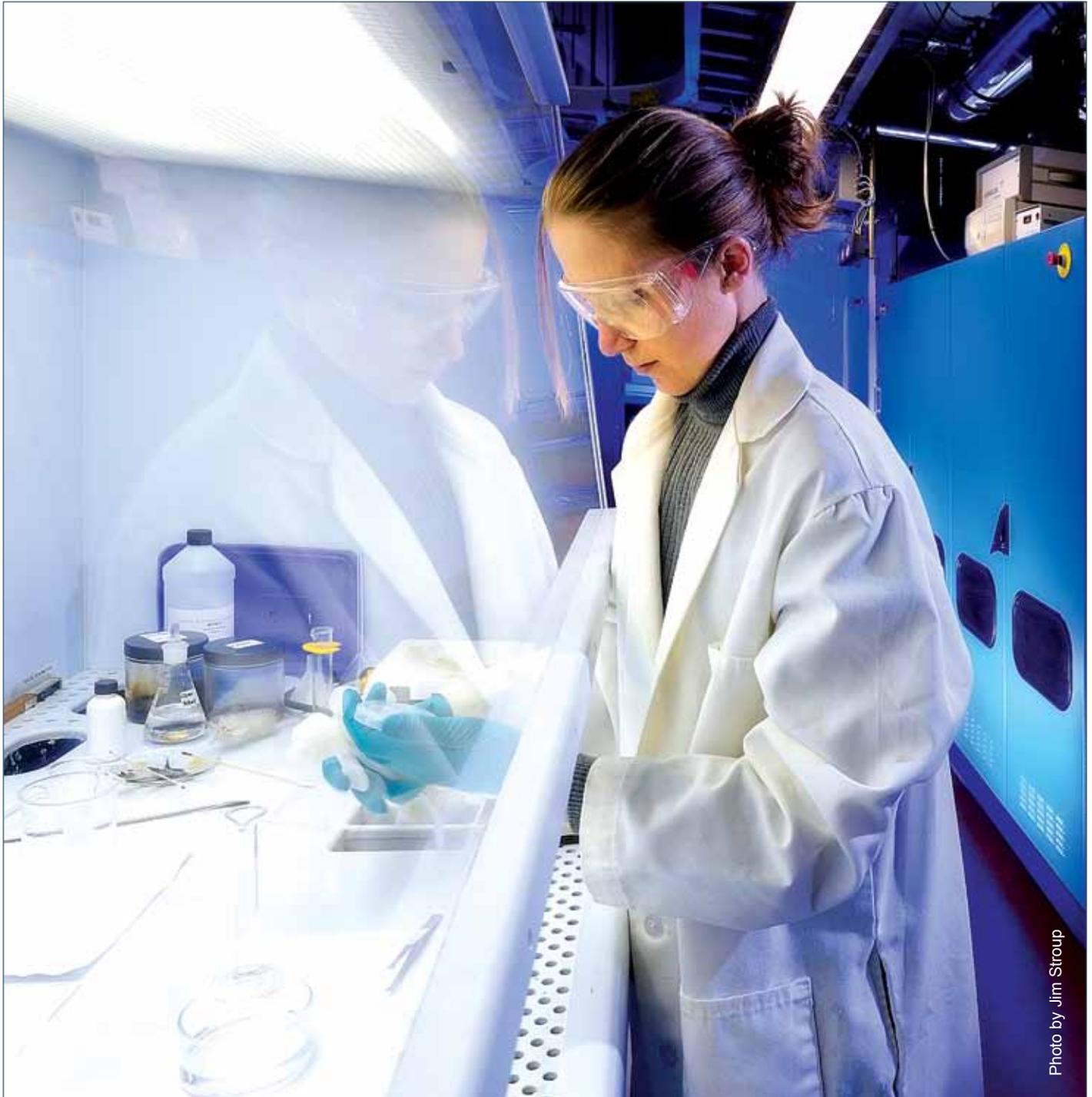


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Rachel Umbel examines the growing gallium nitride on silicon, otherwise known as crystals.