# POWER WASH

## Polishing the microchips that power clean-energy technology

As Earth's population grows, the global demand for energy is predicted to rise, and with no immediate end in sight. By 2040, the world's energy consumption will increase by 56 percent, according to a 2013 report by the U.S. Energy Information Administration.

To meet these demands, clean-energy technologies like solar cells, wind turbines, electric vehicles, and light-emitting diodes (LEDs) have come forward as viable alternatives to fossil fuels. Worldwide adoption continues to increase as the technologies become cheaper and more efficient.

A key contributor to the development of improved clean energy technology is Gainsville, Florida, based Sinmat, Inc. The company, founded in 2000 by a husband and wife team, specializes in polishing slurries that transform the rough surfaces of extremely hard materials into flawless façades. Sinmat's products contain a unique mix of nanoparticles and chemicals that help produce the smooth, defect-free surfaces essential for making high-performance, high-efficiency semiconductor chips. Many of those chips find a home in clean energy devices, as well as in consumer electronics such as smartphones and wearables.

"Normally these material surfaces have a lot of defects like scratches and other things which can

negatively affect the quality of the device," said Sinmat co-founder Rajiv Singh. "That is why the polishing process is so important—it serves as the final touch-up for the surface."

Over the last two decades, Sinmat has been well-recognized and awarded for its efforts. The company and its co-founder, Deepika Singh, were praised by then-President Barack Obama at a 2009 clean energy event in Washington, D.C. "Sinmat is developing new ways to manufacture microchips that can help power smarter energy systems, from more fuel-efficient hybrid cars to more responsive, efficient lighting for homes and businesses," said Obama.

The R&D 100 Awards—known as the "Oscars of Innovation"—recognized the company in 2004, 2005, 2008, and 2009 for developing one of the top 100 technology products in each of those years. More recently, Sinmat won the 2017 Manufacturing Business of the Year at the Gainesville Area Chamber of Commerce Business Awards.

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Rajiv and Deepika Singh leveraged their research backgrounds in materials science and engineering into commercial success with Sinmat. The company has profited each year since it has been in business, and has been awarded millions of dollars in federal funding, including multiple Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) contracts from the Department of Defense. They credit the SBIR/STTR program for both spurring technology development as well as helping them find commercial partners.

"Had it not been for the SBIR program, we would not have had a successful product because it not only gave us funding, but also it found us an end user who was very willing to work with us," said Rajiv. "We were able to connect with some of the manufacturers who were in need of this technology, which helped us launch our products into the field."

Rajiv Singh

Along with co-founding Sinmat, Rajiv is a professor at the University of Florida in the Department of Materials Science and Engineering. He specialized in a manufacturing process known as chemical-mechanical planarization (CMP), a critical step in semiconductor fabrication which smooths surfaces through a combination of chemical and mechanical forces. It removes unwanted irregularities on a thin slice of material called a wafer—usually made of silicon—to achieve a flawless surface upon which layers of integrated circuitry are built. During CMP, the wafer is pressed against a rotating polishing pad that is flooded with a slurry containing chemicals and particles. It is then cut into individual chips for use in various electronic devices.

Rajiv initially developed slurries for softer materials but soon became interested in polishing ultra-hard materials such as silicon carbide, a compound whose unique properties make it ideal for high-efficiency and high-power applications. In recent years, this synthetically-produced crystalline compound of silicon and carbon has emerged as a viable alternative prized for its advantages over silicon: high operating temperature, low losses, high thermal conductivity, and other attractive features.

But silicon carbide is exceedingly hard, and polishing the material is difficult without creating defects that can affect chip performance. Companies would use aggressive techniques and hard particles like diamond, but they would lead to damage and scratches on the microscopic scale. Rajiv and Deepika predicted that the semiconductor industry would soon demand better ways to polish such ultra-hard materials. They decided to commercialize his CMP research by co-founding Sinmat.

"We wanted to see our innovations reach the market, which is why we co-founded Sinmat," said Deepika. "We combined our expertise and the spirit of

Sinmat was co-founded by Deepika Singh, and is now one of the leading global suppliers of CMP technologies.

innovation to develop chemical-mechanical polishing solutions for the semiconductor industry."

Rajiv designed slurries by including an unexpected ingredient: soft nanoparticles. These soft-surfaced particles have been found to provide a high polishing rate for silicon carbide, up to ten times faster than previous processes. Instead of taking several days to produce an inferior product, Sinmat's slurries can achieve atomically smooth surfaces, with no damage, in hours' time.

Today, Sinmat is a leading global supplier of CMP technologies, and holds over 35 patents. More than half of the silicon carbide wafers manufactured in the world use the company's technology. Its unique polishing slurries have proven valuable not only for silicon carbide but also for materials like gallium nitride, sapphire, and diamond. "Any application where power is being transferred—electric vehicles, hybrid vehicles, transformers, power converters for wind energy or solar energy—these chips are used," said Rajiv. "Also, we expect the demand for these chips to increase in the next several years due to an increase in devices for high-speed communications and radar systems."

**Sinmat, Inc.**
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