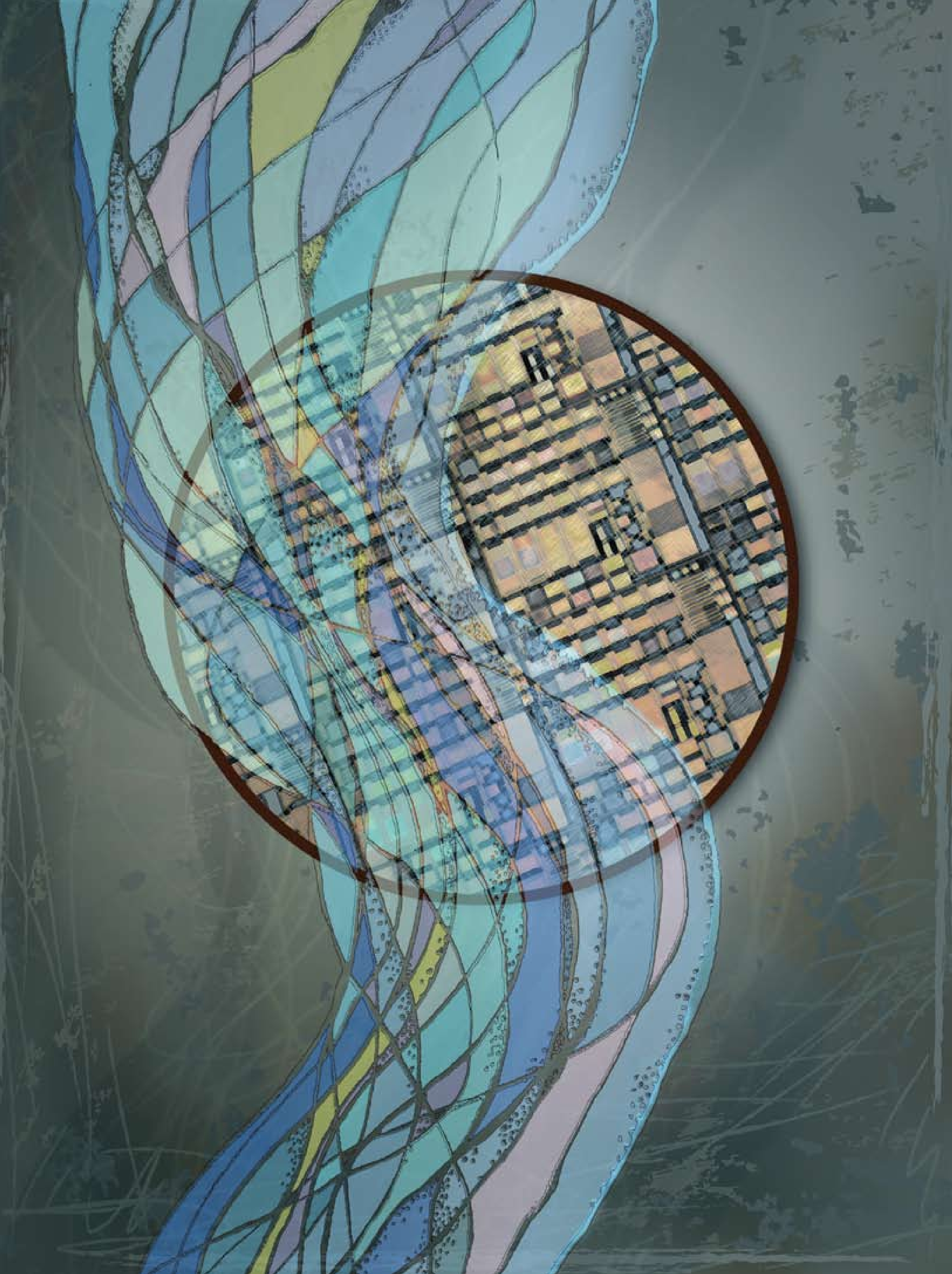

Smooth Sailing

By John M. Dunn

Sinmat's wafer polishing technology promises smaller, more-powerful semiconductor chips

Nearly a decade ago when Energizer Power Systems in Alachua closed its doors, Deepika Singh couldn't have imagined it would open so many other doors for her.

But when the rechargeable battery manufacturer left the Gainesville area, Singh took her entrepreneurial spirit and a background in materials science and went looking for an opportunity.

Her search led her back to the people and the science she knew best.

Based on research conducted by her husband, UF materials science and engineering Professor Rajiv Singh, the two founded Sinmat to develop solutions for the semiconductor industry.

Deepika Singh is the company's president, while Rajiv Singh serves as vice president and chief technology officer.

"We both have our own innovative accomplishments, expertise and industrial experience which we bring to Sinmat," says Deepika Singh.

During his nearly 20 years at the University of Florida, Rajiv Singh has become a world leader in the semiconductor processing field, earning 16 patents and authoring two popular industry software programs, 10 books and more than 400 publications. He is also a principal in another company called Nanotherapeutics that is developing ways of using nanotechnology in the pharmaceutical field.

At Sinmat, the company's wafer polishing technology promises to make it cheaper and easier to build smaller, ever-more-powerful semiconductor chips, which are at the heart of countless new industries.

And that's the reason Deepika Singh was invited to a White House conference on emerging industries in March. There, President Barack Obama singled out her company for praise, noting that it helped to address the energy crisis by "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."

"The way he said what the company does, I could not have said it better," says Rajiv Singh. "It was very exciting to see he had captured the essence of what we do in clean energy."

President Obama isn't the only one to notice Sinmat. In 2004, 2005 and 2008, *R&D Magazine* recognized Sinmat for creating one of that year's 100 most technologically significant products.

Illustration by K.D. Kinsley-Momberger

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David Blankenship

During that time, Sinmat has grown from four employees to 16 and last year the company reported a significant growth in revenues.

Making a computer chip is a long, complex process carried out at the microscopic level.

Chip makers begin with a silicon wafer, then "grow" a layer of silicon dioxide on it by exposing the wafer to extreme heat and gas. A "mask" or stencil, representing a computer circuit, is placed on top of the wafer and then the whole wafer is bathed in ultraviolet light. Exposed wafer material becomes gooey and is washed away, leaving behind microscopic "etched" trenches, which are then filled with a metal, such as copper, that conducts electricity and connects hundreds of millions of transistors.

The unexposed "ridges" of the wafer are leveled by a process called chemical-mechanical planarization, or CMP, and this is where Sinmat comes in.

To smooth the wafer, manufacturers apply a slurry of chemicals and microscopic particles that first dissolve and then scrub unwanted material from the surface of the wafer. Next, a machine-controlled polishing pad applies pressure to the treated wafer to polish or plane away the ridges until they are level enough to meet precise industry standards. This layering-and-etching process must be repeated as many as 20 times to create a modern, integrated chip. Finally, the wafer is cut into hundreds of identical microprocessors.

Based on her own experience in material science and her husband's longtime involvement in the field, Deepika Singh understood early on that changes were coming to the semiconductor industry and that opportunity awaited those who could improve on the CMP process.

"The continued miniaturization of transistors provides new opportunities in development of more defect-free planarization techniques, especially for new materials that are being introduced in the semiconductor industry," she says.

So one of Sinmat's first steps was to license CMP technology developed by Rajiv Singh from UF.

Over the past decade, Rajiv Singh has been working to refine the CMP process by chemically manipulating atoms in the materials.

Among the proprietary products developed so far by Sinmat and a UF research team are "smart" slurries.

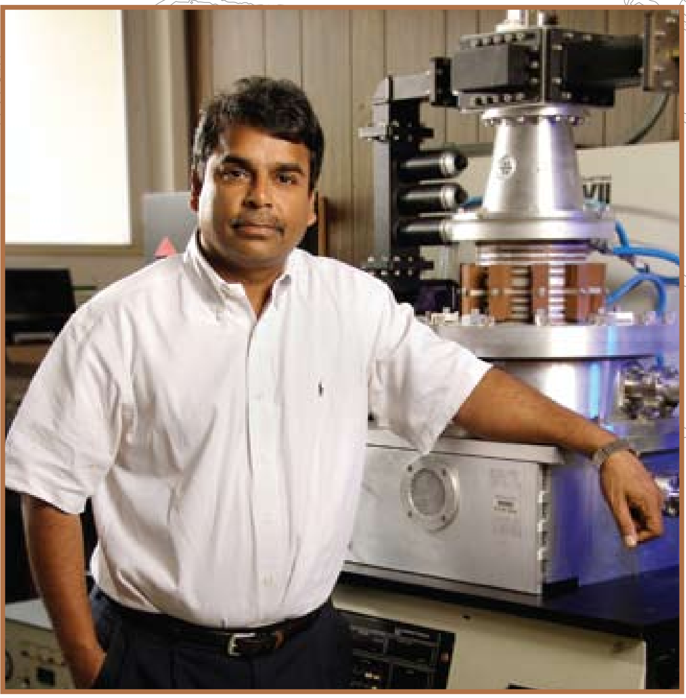
"If you have large particles in the slurry and apply pressure, you can end up with scratches," says Deepika Singh. "So, you have to use smaller nano-derived particles and chemistry."

Such nano-particles are at the heart of Sinmat's current top product, the "Ultra-Rapid Polishing Slurry for Wide Band-Gap Semiconductors." The slurry is used in a process that softens the hard material so that it can be quickly removed. Its tiny nano-particles also render a finer polishing effect and are less likely to leave blemishes on substrates.

Sinmat has also come up with elastic "nano-sponges" that compress without sticking to surfaces and then "bounce back" to their original shape once pressure is removed from the polishing pads.

"The nano-sponges are useful when you have especially hard particles and a very soft material like copper or a dielectric," says Deepika Singh. "Our slurry is also very selective in nature; it will polish some materials, but not others."

Sinmat's smart slurries are expected to be invaluable as the semiconductor industry adds more micro-components



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"WE ARE VERY EXCITED ABOUT THESE ENERGY-RELATED APPLICATIONS. THE GROWTH POTENTIAL IS IMMENSE, WHILE AT THE SAME TIME WE ARE ACHIEVING ENERGY SUSTAINABILITY."

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onto wafers to boost computing power. To make room for these new components, micro-transistors are being engineered closer together, causing the silicon dioxide insulators to become thinner. But, as more components are crammed together, the potential for harmful electrical interference grows.

In response, the semiconductor industry has begun replacing silicon dioxide with another material, known as ultra-low-k dielectric, or ULK. It's the same thickness as silicon dioxide, but less prone to electrical interference. ULK also allows faster switching speeds and gives off less heat.

But there's a downside. ULK is easy to scratch and break so Sinmat's soft sponge properties are "ideal," says Deepika Singh.

Another industry challenge is that multiple, costly steps are involved in using CMP. The process is time consuming, too. It can take tens of hours to polish a wafer.

But Sinmat has found a way to speed things up. It's a digital-based approach that increases the precision of the polishing process over large wafers.

"What used to take days," says Deepika Singh, "now takes hours."

This speed will be even more important, she says, as the size of industrial wafers increases in response to demand for more chips at lower prices.

Not long ago, the standard industrial wafer size was about eight inches in diameter. Now in response to market pressures to bring down semiconductor manufacturing prices, they've grown in size and may soon reach half a meter in diameter.

But the larger wafers are hard to polish uniformly.

"With the old, analog approach to material removal, you can polish too much, or not enough," says Deepika Singh. "A digital approach, however, let's you apply the exact amount of polishing in a precise, uniform manner."

A faster, more efficient process, of course, also means savings for manufacturers. Sinmat estimates that its digital CMP process could cut manufacturing costs up to 80 percent, saving the industry $4 billion annually.

A $2 million grant from the Advanced Technology Program of the National Institute for Standards and Technology will help fund Sinmat's next generation CMP and the company has won grants from the National Science Foundation and the Department of Defense.

Currently, the young company is interested in forging strategic relationships with other companies in the microprocessor industry to help test digital CMP and to assist in the manufacturing and marketing of Sinmat's technologies.

In addition to its research activities, Sinmat provides wafer polishing services to companies and universities all over the world that are conducting research and development in the compound semiconductor field.

Sinmat is leveraging its CMP technology into new clean energy applications including solid state lighting, where 5-watt lamps can supply the brightness of 100-watt incandescent lamps, and manufacturing of ultra-thin, highly efficient solar cells.

"We are very excited about these energy-related applications. The growth potential is immense, while at the same time we are achieving energy sustainability," says Rajiv Singh.

Sinmat is located at the Gainesville Technology Enterprise Center (GTEC) incubator. But, if the business continues to grow, company officials anticipate leaving the incubator in a year or two for a larger facility.

"We were born at the University of Florida," says David Massias, the company's chief corporate development officer. "We're the child that's grown up, and we can walk now."