



Why WiMax?

A new metropolitan-area wireless standard will change the economics of Internet access—again. **BY WADE ROUSH**

IT'S HARD TO BUY A LAPTOP computer today that doesn't come with a Wi-Fi chip: a built-in radio that lets users surf the Web wirelessly from the boardroom, the bedroom, or the coffee bar. People love Wi-Fi because a single base station—a box with a

wired connection to the Internet, such as a DSL, cable, or T1 line—can broadcast to multiple users across distances as great as 100 meters indoors and 400 meters outdoors. But there's a new technology standard on the way that will make Wi-Fi look feeble. It's called WiMax, and it provides wireless broadband Internet connections

at speeds similar to Wi-Fi's—but over distances of up to 50 kilometers from a central tower.

“Metropolitan area” wireless networking at broadband speeds isn't new, but the specialized equipment that receives the broadband signals has typically been too expensive for everyone but large businesses. Now that U.S. computing and communications firms are gradually reaching consensus on the details of the WiMax standard, however, those prices could come down significantly. Industry agreement on details such as how to encrypt WiMax signals, which frequencies to use, and how to provide multiple users with access to

IN THIS SECTION

22

At NASA, robots gain a finer sense of movement and learn how to improvise.

24

Ultrasound exams go up against mammograms for breast cancer screening.

25

Coming soon to an amusement park near you: RFID tags for your kids.

those frequencies will finally allow companies like Intel to manufacture mass quantities of WiMax-enabled chips for use in broadband wireless equipment. And that's expected to eventually bring WiMax receivers into the \$50 to \$100 price range of today's DSL and cable modems, meaning that millions of users could eventually drop their current Internet service providers—often local phone or cable companies—and simply access

It was Intel's announcement of a major push into WiMax technology in January 2004 that helped the standard emerge into the spotlight. The company's Centrino initiative had already put Wi-Fi chips into millions of laptops. "After we did that, we began looking at whether you can cover full cities with Wi-Fi," explains Scott Richardson, manager of Intel's broadband wireless group. While it would be relatively simple to blanket an entire

provider of extrafast DSL connections to hard-core online gamers and technical professionals who work at home. But because DSL works over phone lines, it has an inherent limitation: about 30 percent of residences in the cities Speakeasy serves are too far away from phone network central offices to get a usable signal. "That's a lot of people to turn away," says Speakeasy CEO Bruce Chatterley. "That's why we started to look for alternatives, and that's why WiMax is so strategic to our business." Speakeasy will begin technical trials of WiMax equipment using Intel's chips by the end of this year and hopes to offer broadband wireless connections to business and residential customers by the middle of 2005.

But while the emergence of WiMax will give consumers, businesses, and people in hard-to-reach areas a powerful new way to connect to the Internet, it won't happen overnight. For one thing, it could take manufacturers some time to reach the economies of scale that would enable consumer-priced WiMax equipment. Then there's the cost of building a network of transmitters. "People tend to think that you can put one WiMax tower on a hillside and beam around the entire city, and that's certainly not the case," says Intel's Richardson. "When you fill up a cell, you use up the capacity"—meaning that providers will still have to add towers as demand grows, just as they do in traditional cell-phone networks.

But TowerStream, a Waltham, MA, company that plans to add WiMax to its existing broadband wireless services, thinks it has that problem licked: it's already tied up what chief operating officer Jeff Thompson calls "beachfront property" atop many of the tallest buildings in Boston, New York City, Chicago, and other cities, and it will simply install the new WiMax-certified gear alongside its existing transmitters. "When WiMax comes out," Thompson says, "our speed of deployment will be very quick. We'll have a wireless backbone in the sky." Which sounds great—as long as it really does cost less to use than our earthbound skein of wires, fibers, and cables. ■

Millions of home broadband users could drop their DSL or cable providers and simply access the Internet by antenna.

the Internet over rooftop antennas at the other end of town.

WiMax's first appearance, however, will take place in more public venues. Equipment meeting the standard will allow a new wave of small and medium-sized businesses to go wireless, abandoning the expensive T1 lines they currently rent from local or regional phone companies. New Wi-Fi base stations designed to connect to the Internet via WiMax could also create mobile-computing hot spots in places without phone lines—think the Great Lawn in Central Park. And WiMax networks could extend broadband Internet access to poor regions that currently have none.

WiMax—an acronym for Worldwide Interoperability for Microwave Access—is little more than a long list of technical specifications intended to ensure that wireless equipment from different vendors can interoperate at high speeds. Also known as 802.16, the specifications have been under development since the 1990s as an alternative to technologies such as Ethernet and Wi-Fi. A single WiMax transmitter will transmit voice, video, and data signals across distances of up to 50 kilometers (assuming an unobstructed line of sight) at rates as high as 70 megabits per second—enough to support about 60 businesses at T1 speeds, or hundreds of homes at DSL speeds.

city with Wi-Fi hot spots, the company decided, such a patchwork would be difficult to administer and would operate over too narrow a frequency range to deliver sufficient amounts of data for future needs. "We came to the conclusion that Wi-Fi needed to evolve into more of a 'carrier' technology, deployed by a service provider, and needed to exploit a lot more spectrum options," says Richardson. WiMax, which operates at greater distances and over a greater range of frequencies, turned out to be ideal.

The company began designing communications processors to exploit these frequencies—from roughly two to 11 gigahertz, a range used mainly by Wi-Fi, microwave ovens, and certain types of radar—and had delivered the first sample chips to manufacturers by September. Meanwhile, it began promoting an industry association called the WiMax Forum to certify equipment from vendors as WiMax compliant. And through Intel Capital, the company's venture wing, it has begun to make strategic investments in a few companies that plan to demonstrate how WiMax can be put to profitable use.

Seattle-based Speakeasy is one of those companies—and a prime example of the economics driving WiMax's rollout. Founded in 1994 as an Internet café, Speakeasy has evolved into the leading

Engineers are giving Robonaut a keener sense of its own movements.



ROBOTICS

Adroit Droids

AFTER 50 YEARS OF RESEARCH, scientists have yet to build a robot that can learn to manipulate new objects as proficiently as a one-year-old child. Robots don't react well to new situations; most of their movements must be programmed in advance. Some use sensors to fine-tune their movements in real time, but they generally don't retain and interpret the sensor data. So while they might navigate a room without bumping into things, they can't stop to help rearrange the furniture.

But now advances in sensors, software, and computer architecture are beginning to give robots a sense of their "bodies" and of what sorts of actions are safe and useful in their environments. The results could eventually include more effective robotic assistants for the elderly and autonomous bots for exploring battlefields and space.

This summer, one of the world's most advanced robots passed an important test at NASA's Johnson Space Center in Houston, TX. The dexterous humanoid robot learned to use tools to tighten bolts on a wheel. Rather than having to be separately programmed for

each of several possible situations, the robot showed it could recover if a tool slipped from its grasp or was moved around—and that it was flexible enough in its routine to tighten the bolts in any order requested. "Now, within limits, the robot can adjust to changes in its environment," says Vanderbilt University electrical-engineering professor Alan Peters, one of the project leaders.

The key advance: a new framework for robot learning. Peters's software gives the NASA robot, called Robonaut, a short-term memory that lets it keep track of where it is and what it's doing. By correlating actions like reaching for and grasping a tool with information from its 250 sensors—visual, tactile, auditory—the robot gets a feel for which movements achieve what kinds of goals. It can then apply that information to the acquisition of new skills, such as using a different tool. Maja Mataric, codirector of the University of Southern California's Robotics Research Lab, calls Peters's work "important for bringing together research on sensory-motor learning and applying it to real-world, highly complex robots."

Gregory T. Huang

MEDICINE

Modular Drugs

Over the past decade, biotech companies have introduced a string of protein-based antibody drugs, which mimic the action of the body's own immune system to combat conditions like cancer and arthritis. Antibody drugs can zero in precisely on misbehaving cells and often enlist the aid of our own antibodies to force a disease into retreat. But there's a price for their effectiveness. Antibody drugs are based on large molecules, so they have a hard time getting into the bloodstream and into cells.

Over the past year, however, researchers have begun to test a new class of genetically engineered protein drugs that act like antibody drugs but are more easily absorbed into the body. They're called small modular immunopharmaceuticals, or SMIPs, and their main proponent is Seattle-based Trubion Pharmaceuticals. "The basic idea was, 'How do we make these molecules smaller' without diminishing their effects?" says Daniel Burge, Trubion's senior vice president of clinical development.

The drugs Trubion's researchers eventually devised are one-third to two-thirds the size of conventional antibody drugs. They can also be adapted to the needs of specific patients: sections of the molecules can be added or removed to hit offending cells with larger or smaller payloads, depending on the treatment required.

Trubion's most advanced drug, which will enter safety trials in humans early in 2005, attacks white blood cells called B cells, which can cause diseases like lymphoma and leukemia when they become malignant. One end of the drug molecule binds specifically to B cells, while the other end carries a module that invites other immune cells to attack the B cells. Nancy Haigwood, viral-vaccines program director at the Seattle Biomedical Research Institute, says that based on the data she has seen on Trubion's drugs, "It's possible that for particular applications they might even replace [current antibody drugs] because they are smaller, nimbler, and better at getting to the cells. It looks like it has terrific potential." **Karen Epper Hoffman**

COURTESY OF NASA JOHNSON SPACE CENTER

IMAGING

Deeper Vision

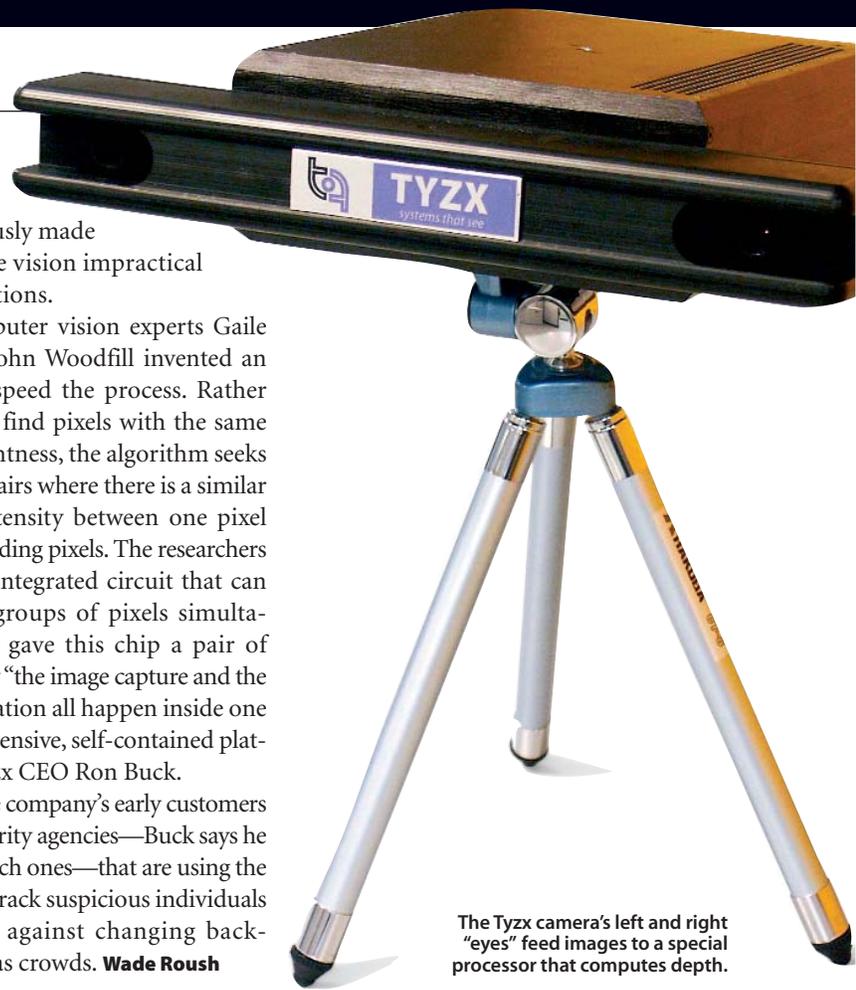
RESearchers are making big strides toward low-cost systems that mimic human vision to give machines three-dimensional information about their environments. By building hardware that analyzes corresponding chunks of paired live images in parallel—as the human brain is thought to do—Tyzx, a startup in Menlo Park, CA, is making computerized depth perception fast enough that surveillance devices and robotic vehicles can incorporate it.

Creatures with two forward-facing eyes can perceive depth because their left and right eyes see from slightly different perspectives, in which the displacement of nearby objects is greater than that of distant objects. Using this apparent difference, called parallax, the brain swiftly determines the distance to an object. While a machine equipped with a pair of cameras can also use parallax to see in three dimensions, the amount of computation required to find matching pix-

els had previously made stereo machine vision impractical for most situations.

Tyzx computer vision experts Gaile Gordon and John Woodfill invented an algorithm to speed the process. Rather than trying to find pixels with the same color and brightness, the algorithm seeks out left-right pairs where there is a similar contrast in intensity between one pixel and its surrounding pixels. The researchers then built an integrated circuit that can search many groups of pixels simultaneously. They gave this chip a pair of “eyes,” and now “the image capture and the stereo computation all happen inside one relatively inexpensive, self-contained platform,” says Tyzx CEO Ron Buck.

Among the company’s early customers are federal security agencies—Buck says he can’t reveal which ones—that are using the technology to track suspicious individuals as they move against changing backgrounds such as crowds. **Wade Roush**



The Tyzx camera’s left and right “eyes” feed images to a special processor that computes depth.

MEDICINE

Screening with Sound

There’s a well-established medical technology that many physicians believe could help catch undiagnosed breast tumors in one-third to one-half of women—yet it’s not being used routinely. It’s ultrasound imaging, a longtime fixture of obstetricians’ offices. Some doctors use ultrasound along with traditional x-ray mammography in breast exams, but the majority have been waiting for clearer evidence of its benefits. And that’s exactly what a key clinical trial now under way in the United States could provide.

At least half of women under 50 and about a third of older women have naturally dense breast tissue, making it harder to distinguish between healthy tissue and questionable masses in mammograms. Ultrasound can get around that problem because the dif-

ferent types of tissue reflect sound waves differently, says Wendie Berg, the leader of the trial and an independent breast-imaging consultant in Lutherville, MD. “Ultrasound is widely available and relatively inexpensive,” she says. “It’s reasonable to consider it for routine screening.”



Ultrasound can reveal tumors missed by mammograms.

In past studies involving thousands of women, ultrasound did detect dozens of dangerous cancers missed by mammograms. But the studies didn’t adequately measure the reverse: the number of cancers detected by mammograms but missed by ultrasound.

The new trial will assess 2,808 women at 20 different U.S. and Canadian locations over three years and is designed to count “false negatives” accurately. All participants will get ultrasound exams in addition to their annual mammograms. A final verdict on the two technologies’ effectiveness isn’t expected until 2008.

Oncologists say ultrasound would only be a supplement, not a replacement, for x-ray mammography, since both methods sometimes miss tumors and misidentify healthy tissues as cancerous. But the two together, says Berg, could catch more cancers than mammography alone. **Corie Lok**

COURTESY OF CISP (SCREENING); COURTESY OF TYZX (VISION)

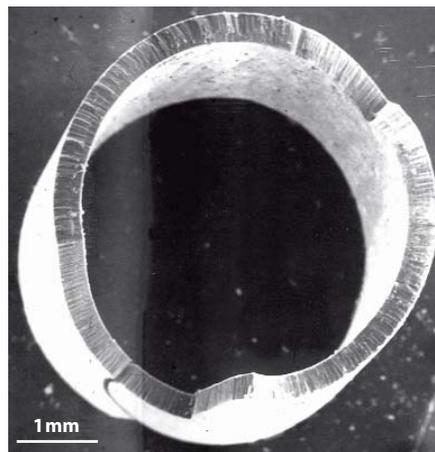
NANOTECHNOLOGY

Nanofilters

Every day, an estimated 3,000 to 6,000 people worldwide die from diseases caused by contaminated water. Filtration can reduce the risks, but traditional bacterial and viral filters trap pathogens inside granular carbon or porous ceramic or polymer materials, many of which are difficult to clean and must be changed frequently.

Now scientists are turning to carbon nanotubes. A team from Rensselaer Polytechnic Institute in Troy, NY, and the Banaras Hindu University in Varanasi, India, has devised a way to get millions of the large carbon molecules to collect on the inside surface of a quartz tube about a centimeter across. The resulting tube-inside-a-tube consists of radially oriented nanotubes, packed as tightly as a fistful of spaghetti and bonded together; this structure can be detached from the quartz and extracted whole. With one of its ends capped and water pumped in through the other, such a cylinder acts as a filter. Water molecules can squeeze out through nanometer-sized gaps in the walls, but bacteria like *E. coli* and viruses like the 25-nanometer-wide poliovirus get stuck.

The structures are heat resistant and strong enough that they can be cleaned repeatedly using autoclaves or ultrasound devices like those at medical clinics and hospitals, making them reusable many times, says Pulickel M. Ajayan, the professor of materials engineering at Rensselaer who led the work. **David Cotriss**



Tightly packed nanotubes form a cylinder.

COURTESY OF PULICKEL M. AJAYAN (NANOFILTERS); COURTESY OF PARAMOUNT'S GREAT AMERICA (TAGS)



At Paramount's Great America, a network of receivers tracks kids wearing radio frequency ID tags.

WIRELESS

Wrist Radio Tags

CONSUMERS ARE GETTING USED to the idea that nearly all products, packages, or pallets of merchandise will soon bear radio frequency ID tags to help manufacturers and retailers manage inventory. But sooner than most people realize, they may be wearing such tags themselves: a few amusement parks, hospitals, and even schools are pressing ahead with projects to put RFID tags into wristbands to keep track of patrons, patients, and students.

The technology makes medical care safer and more efficient. Staff at the 30-bed general surgery unit at the Jacobi Medical Center in New York, NY, for instance, are outfitting patients with RFID wristbands that record their names, genders, dates of birth, and chart numbers—the codes for their electronic medical records. Doctors and nurses use tablet PCs equipped with RFID readers to upload this data from a patient's wristband, and the computers then retrieve the patient's record wirelessly from the hospital database. "We're hoping we will eliminate the potential danger of giving the wrong medication to the wrong patient," says Robert Sidlow, associate medical director for the North Bronx

Health Care Network. Sidlow hopes to install the RFID system in Jacobi's new 500-bed building, opening later this year.

RFID has also found a place in amusement parks. At Paramount's Great America in Santa Clara, CA, \$5 will get a parkgoer an RFID bracelet encoded with his or her first name. One of 65 antennas scattered throughout the park—which ever is closest to the person at any given moment—reads the bracelet information and sends it to the park's central servers. Parents who lose their children can go to any of several kiosks, wave their own bracelets in front of the kiosks' readers, and bring up maps showing their kids' locations.

Not everyone is amused by such applications. While tracking and identifying people has obvious benefits, slapping RFID tags on people could infringe on their privacy if the technology is misused, warns Kenneth Farrall of the Electronic Privacy Information Center in Washington, DC. Though Farrall admits that the early applications of RFID tagging seem to do more good than harm, he cautions that as the technology grows more sophisticated, "it could become more difficult to control the data." **Corie Lok**

milestone

The **European Commission** has given the green light for farmers throughout the European Union to buy and plant 17 varieties of genetically modified corn—the first time biotech crops have received such EU-wide authorization. All food made with the corn varieties, which St. Louis agricultural-products company Monsanto engineered to resist a pest called the corn borer, will be labeled as genetically modified.

ipo

Seattle's **Corus Pharma** has filed preliminary papers with the U.S. Securities and Exchange Commission for an initial public offering. Backed in part by Cascade Investment, Bill Gates's private fund, Corus is testing inhaled treatments for asthma and cystic fibrosis in humans.

Biotech

acquisition

Palo Alto, CA's **Agilent Technologies** announced an agreement to acquire software firm Silicon Genetics of Redwood City, CA. The acquisition reflects an effort by Agilent—a leading maker of life-sciences and chemical-research equipment—to strengthen its position in bioinformatics.

regulations

Danvers, MA-based **Abiomed** has sought approval from the U.S. Food and Drug Administration to market its AbioCor artificial heart under a humanitarian-device exemption. Such an exemption would allow doctors to implant the heart, which has been tested on just 14 people so far, in not more than 4,000 patients suffering from end-stage heart failure.

advance

Researchers at **King's College London** have created human embryonic stem cells that carry a mutation that causes cystic fibrosis. The cells could offer new opportunities for scientists to study the devastating genetic disorder and develop new treatments for it.

ethics

As genetics researchers continue to home in on genes that affect behavior and contribute to neurological conditions such as schizophrenia and autism, Stanford University is launching a center to study the ethical consequences of such research. One project planned for the new **Center for Integration of Research on Genetics and Ethics**: a Web-based ethics consultation service for geneticists.



COURTESY OF ABIOMED

milestone

Insects such as water striders can walk on water—and now robots can too. Metin Sitti, an engineering professor who heads **Carnegie Mellon University's Nano-Robotics Lab**, has built an eight-legged mechanical creature that's so light—about one gram—that it can stand on water and propel itself forward without breaking the water's surface. Equipped with tiny sensors, Sitti says, future water-striding robots could be used to monitor water quality or snoop on enemies.



advance

Traditional cell phones have so few keys that typing text messages is a hassle, but PDAs with full Qwerty keyboards have so many keys that each one is tiny.

The latest smart phone from Waterloo, Ontario, handheld manufacturer **Research in Motion**, the Blackberry 7100t, splits the difference with a 20-key keyboard. Most of the keys have two letters, and the phone's software guesses which one the user intends by reading previous letters and searching a 30,000-word internal dictionary. The software uses corrections, word frequency, and the user's address book to improve its predictions over time.

setback

Longhorn, Microsoft's successor to its three-year-old Windows XP operating system, won't be ready for launch until 2006, the company said in August. That's more than a year later than originally projected, and it means rival operating systems such as Linux will have more time to get footholds before Microsoft upgrades its flagship product. At the same time, Microsoft said one much vaunted feature of Longhorn—a storage system called WinFS that will let programs such as Outlook, Word, and Excel share data more easily—won't be included in the operating system's first release after all.

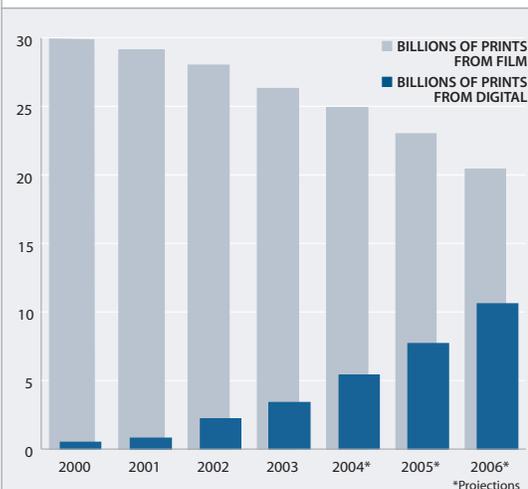
Infote

record

Most Wi-Fi hot spots are no larger than your neighborhood Starbucks. But in the state of Washington, **Columbia Energy**, a subsidiary of one of the state's oldest rural electric cooperatives, is using the wireless technology to bring high-speed Internet service to underserved rural areas. It's creating what could be the world's largest area with continuous Wi-Fi coverage: a 9,600-square-kilometer area spreading across parts of Walla Walla, Columbia, and Umatilla Counties.

acquisition

Qualcomm, the San Diego-based maker of communications chips for cell phones, has agreed to pay \$170 million to acquire **Iridigm**, a San Francisco company developing microelectromechanical displays for mobile devices that work on the same principle as the iridescence of a butterfly's wing. Qualcomm says it hopes to speed up commercialization of Iridigm's displays, which should cost less to manufacture than the conventional liquid-crystal displays found in most cell phones and PDAs.



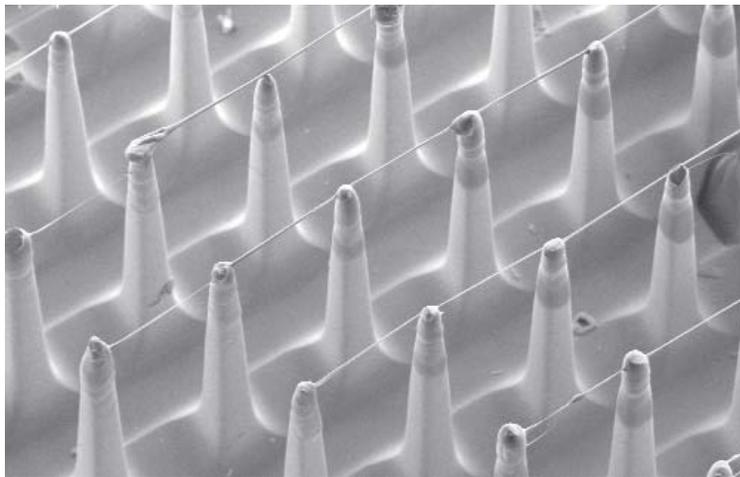
«metric

With a digital camera, you don't have to get film developed to see how your pictures came out. Nonetheless, a growing number of U.S. amateur photographers are ordering prints of their digital photos—meaning steady business for photofinishers despite a big drop-off in sales of traditional film.

SOURCE: PHOTO MARKETING ASSOCIATION (METRIC); COURTESY OF METIN SITTI (MILESTONE)

follow-up

Recent breakthroughs in materials science have sparked considerable excitement about the commercial feasibility of polymer-based solar cells that would be cheap and easy to make (see "Solar-Cell Rollout," TR July/August 2004). In a move that will combine two of the leading research groups in the field, **Konarka Technologies**, a Lowell, MA-based startup, has acquired Siemens's organic-photovoltaics business; Siemens's solar-cell researchers will also join Konarka. Last year, Siemens's scientists reported making polymer solar cells with record-setting efficiencies in converting sunlight to electricity.



research

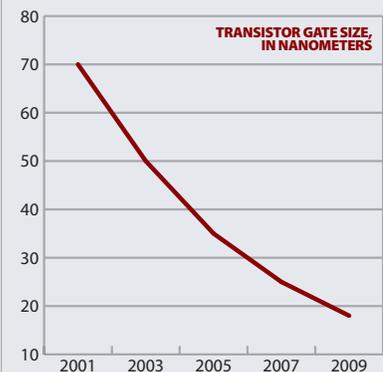
Scientists at the **University of Louisville** in Kentucky have developed a novel technique that could make it possible to more easily and directly form 3-D networks of nanostructures. The researchers use tiny tips to suspend fibers on micro- and nanostructures, providing a potential fabrication tool for microfluidic and microoptical devices.

advance

IBM scientists have measured the energy it takes to "flip" the magnetic orientation of a single atom. This measurement of one of the fundamental magnetic properties of materials is a significant step in developing nanometer-scale magnetic structures for ultradense data storage, quantum computing, and other advanced applications.

milestone»

Intel says that, in its effort to uphold Moore's Law, it has made a fully functional memory chip with more than a half-billion transistors, each measuring only 35 nanometers across. Intel expects to begin shipping commercial versions of the chip next year. Intel predicts it will be able to continue to shrink its chip technology through at least 2009 (see chart).



Nano

funding

The **National Cancer Institute** has announced a \$144.3 million, five-year initiative in nanotechnology. The research project will look to use recent advances in nanotech to improve the diagnosis and treatment of cancer.

manufacturing

One of the most intriguing properties of carbon nanotubes, large molecules that could prove a basic building block for nanotech, is their potential to form superstrong materials. Fibers made of nanotubes are potentially 10 times stronger than the strongest existing commercial fibers. Now researchers at **Rice University** say they have improved methods for manufacturing fibers made of single-walled carbon nanotubes. The improved manufacturing methods could potentially make large-scale production of the superstrong fibers commercially viable.