


RED HERRING
NEWSLETTERS
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NANOTECHNOLOGY FOCUS

You Say You Want a Revolution?

HOW ABOUT SOLUTIONS INSTEAD? MATERIALS SCIENCE MAY NOT CHANGE THE WORLD OVERNIGHT BUT IT WILL PROVIDE ANSWERS FOR A WIDE RANGE OF CHALLENGES IN OTHER MARKETS.

Materials define history. Stone, bronze, silicon – humans' capacity to use them in tools has charted the course of our evolution.

But our steady, materials-based progress is on the verge of sharp acceleration. Recent developments in nanotechnology mean researchers are no longer limited to the elements at hand – they now have the potential to start at the molecular level and fashion exactly the materials they need to solve whatever problems they want to tackle.

Of course, potential can be a curse as well as a blessing, and recently nanotechnology has been criticized for not delivering on its promise right away. Speaking at the MIT-Stanford-Berkeley Nanotechnology Forum at Stanford last May, VC Vinod Khosla warned that “sometime in the next few years we will go through with nanotechnology the same kind of bubble we went through with the dotcom boom.” (See Viewpoint, page 13.)

That remains to be seen. So far, VCs seem to be approaching nanotech with more measure. Venture funding for nano startups fell from \$386 million in 2002 to just \$75 million in the first half of 2004 (see Nanotechnology, page 6).

WELCOME TO ICC REPORT

Three forces drive the world economy: innovation, capitalization and commercialization. ICC Report brings them together in a newsletter that is current, candid and independent. ICC Report goes inside university labs, corporate research centers and early-stage startups around the world to tell readers what's new, why it matters and what it's worth. Each month, ICC Report offers business analysis of developments in seven key sectors: biomedicine, communications, defense and security, electronics, energy, nanotechnology and software. ICC Report explores promising technologies in each sector and gives a clear picture of each technology's market, financing and competitive edge.

In each of these sectors we have selected intriguing young technologies that show market promise. These technologies are in various stages of development: some are already funded and in product stage; some are looking for capital; some are just out of the lab; none of them is a “science project.” All have the potential to significantly alter the dynamics of their respective markets. ●

“The first thing to recognize is that the average gestation time from the first patent to product is a bit more than 10 years.”

Investors with a long-term view are affirming their belief in the sector. Worldwide government, corporate and venture spending on nanotech R&D will total \$8.6 billion in 2004 (see Metrics, page 3).

The big investors have identified many fields in which nanotechnology, and especially materials science, will fuel significant progress, perhaps not next year but in the years ahead.

“The first thing to recognize is that the average gestation time from the first patent to product is a bit more than 10 years,” says

Peter Dobson, professor of engineering science at Oxford University and academic director of the Begbroke Science Park in Cambridge. “There is not a huge number of things that will revolutionize the world. Rather, there are solutions to existing problems.”

Granted, solutions are less exciting than revolutions. But funding for materials-science research is showing traction because investors with vision recognize that today's

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Red Herring, Inc.

1931 Old Middlefield Way, Suite F
Mountain View, CA 94043

phone: (650) 428-2900
email: ICReport@redherring.com
web: www.redherring.com

editors: **Lee Bruno**
Tim Devaney

contributing editors: **Tom Stein**
Maryann Thompson

contributing writers: **Niall McKay**
Will Wade

design & production: **Annette Leong**

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ABOUT ICC RATINGS

Each ICC Report technology profile includes an ICC Rating of that technology's innovation, capitalization and market opportunity. The editors of ICC Report determine the ICC Rating by looking at each technology's fundamentals and potential. Innovation is a measure of the degree to which a new technology is different from existing technologies in its field. Capitalization is an appraisal of a startup's funding progress toward a marketable product. Market opportunity is an estimate of that product's market potential.

COMING UP IN ICC REPORT

SEPTEMBER: **Electronics**
OCTOBER: **Communications**
NOVEMBER: **Defense & Security**
DECEMBER: **Biomedicine**

materials innovations will generate tomorrow's innovations in a wide array of industries, from electronics to photonics to sensing to biotech to energy.

Already, the first wave of nano-inspired innovations is showing up in the market, as materials advancements born in labs over the past several years make their way into commercial products.

South San Francisco-based startup Optiva, for instance, has created a nanoengineered material that can be applied like ink to plastic or glass to create optical films. It's currently used by Sony Magnetic Products of America in that company's LCD manufacturing equipment.

Other examples of consumer products now making use of materials-science innovations include: sunscreens that incorporate nanoscale powders developed by Advanced Nano Technologies to refract UV light; and nanofibers developed by Nano-Tex that are used in stain-repellent pants. Sunscreens and trousers may not conjure images of a brave new world but these innovations are the concrete success stories that other materials startups will lean on when they look for funding.

Materials developments that are showing promise in the long term include work by researchers at the University of Durham in England, who have announced the creation of a weak (but functioning) plastic magnet that works at room temperature. Previous plastic magnets worked only at very cold temperatures. The Durham researchers' magnetic polymer holds promise for a new generation of motors and electronic parts made of plastics.

This summer, researchers working with North Carolina State University and the National Science Foundation's Center for Advanced Materials and Smart Structures announced they'd found a way to coax materials to self-assemble into orderly arrays of nanodots.

The researchers are already working with industry partner Kopin Corp. to apply their discovery to the development of far more efficient LEDs. Down the road, the new technique could power research into superdense computer memory, enabling the storage of 10 terabits of data on a 1-inch nanodot chip.

In the display industry, advances in polymer light-emitting diodes are perhaps the most exciting innovation in the past 15 years. PLEDs offer significant improvement over liquid-crystal technology. They could mean lower-power, brighter displays. They are flexible enough to be manufactured onto glass or plastic and don't require costly backlights, filters and polarizers. The PLED work was started in the Cavendish Laboratory at Cambridge University in 1989 and is the basis of startup Cambridge Display Technology.

Researchers at Palo Alto Research Center have also been making strides in the field of polymer electronics. PARC is working with plastic semiconductors, which are especially useful in the design and construction of large, inexpensive displays. PARC's polymers can be dissolved in liquid to form a sort of semiconductor ink. Like traditional ink, it can be printed on materials via technology similar to that used in jet printers. This is much less expensive than traditional photolithography and PARC scientists have effectively used their polymer to create jet-printed semiconductors.

But research in materials science offers to do more than make better displays for consumer devices. Researchers working in the field of molecular electronics are engineering molecules to perform electronic-circuitry functions now done by semiconductor-based devices. That could mean molecular-size transistors, which would help the chip industry keep up with Moore's Law.

Nanoengineered materials will inevitably provide the building blocks for next-generation technologies that will break limits and open new opportunities. But the rewards will emerge in the space of years. Not a revolution but a materials evolution. ●

Funding for materials-science research is showing traction because investors with vision recognize that today's materials innovations will generate tomorrow's innovations in a wide array of industries.

METRICS

Nanotechnology has taken its lumps lately. The IPO market for nanotech startups, once so rosy, has withered in the face of skepticism, much of it directed at Nanosys, which ended up pulling the plug on its public offering. That said, it must be noted that only about 4 percent of worldwide nano funding is supplied by venture capitalists, by one researcher's estimate. The vast majority of spending is by governments and corporations. The U.S. government alone plans to put

nearly \$1 billion into nanotechnology research next year.

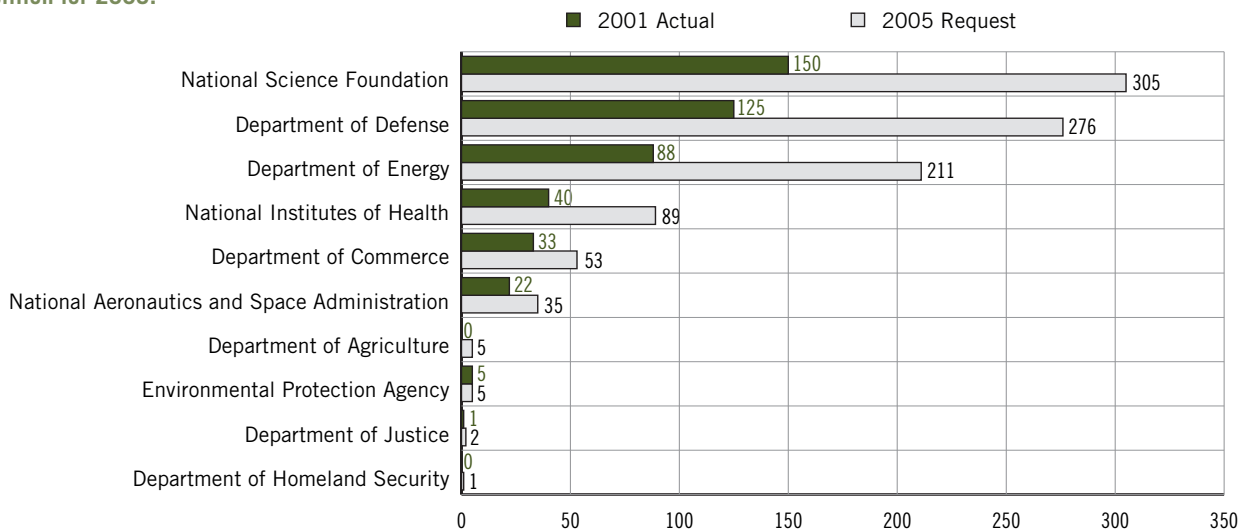
"The sea change in the past year has been the increase in corporate investments," says Bill Rus, president of research company Venture Analytics. "Corporations are doubling down on their investments and are in it for the long haul." According to Lux Research, 63 percent of the 30 companies in the Dow Jones Industrial Index are now investing in nanotechnology R&D. Another impressive trend: global com-

mitment. Lux estimates governments, corporations and VCs worldwide will spend \$8.6 billion on nanotech research and development in 2004.

Where is the money going? Today's hot sector is tools and equipment. The firms attracting attention are those that can do contract R&D work for major multinationals as they work on developing their own intellectual property. It's the 21st-century equivalent of selling picks and shovels to the 49ers. ●

U.S. NATIONAL NANOTECHNOLOGY INITIATIVE FUNDING TREND

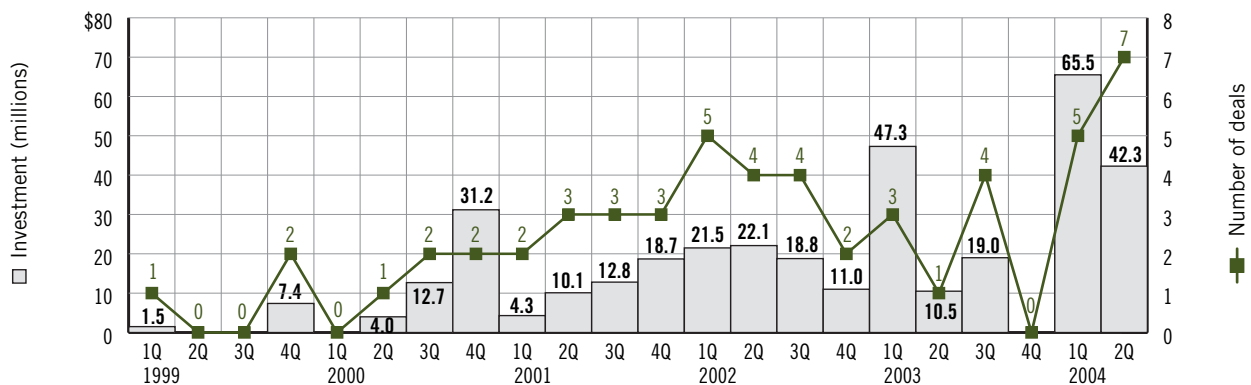
Governments continue to provide nearly half of all global nano investment and the U.S. is no exception, budgeting nearly \$1 billion for 2005.



In millions. SOURCE: The Nanotechnology Report 2004, Lux Research

NANOTECHNOLOGY VENTURE CAPITAL INVESTMENT TREND

A record seven venture deals with "nanotechnology" in their company description were logged during the second quarter.



SOURCE: PricewaterhouseCoopers, Thomson Venture Economics, National Venture Capital Assoc. MoneyTree Survey

ELECTRONICS

SECTOR OVERVIEW Holographic technologies are starting to catch on with investors. InPhase Technologies, a maker of holographic storage devices, closed a \$15 million round of venture financing earlier this year. More such investments will likely follow, because holographic storage hits close to the heart of the torrid consumer-electronics market, allowing next-generation CDs and DVDs to store 300 times as much data as optical drives. Holographic technology is also being applied to optical networking and to test and measurement devices. For more on this, see the profile of Headwall Photonics below.

HEADWALL PHOTONICS

Holographic Diffraction Gratings
Fitchburg, Massachusetts
www.headwallphotonics.com

ICC RATING (scale 1–10)	
INNOVATION	7
CAPITALIZATION	8
MARKET OPPTY	7

Sometimes, when the bottom falls out there's an upside. Case in point: Headwall Photonics.

Though the company places its foundation in May 2003, it actually dates back to 1976, when it was known as American Holographic and focused on holographic diffraction grating

Headwall received industry acclaim when it won an R&D 100 Award, handed out by *R&D* magazine to recognize the most technologically significant products introduced to the marketplace each year.

technologies. In 2000, American Holographic was acquired by Agilent Technologies, which employed the diffraction gratings – used to finely aim beams of light – as a critical component in its optical-networking subsystems.

But when the telecom market crashed in 2002, demand for networking gratings slipped as well. So division managers bought the business from Agilent and started an independent company: Headwall Photonics.

Headwall still makes holographic diffraction gratings but has turned its attention from networking and refocused the technology on other markets with more immediate growth potential.

David Bannon, a Headwall cofounder and its vice president for sales and marketing, says the core capability of holographic gratings is precisely aiming, measuring and manipulating beams of light. That's a key component of optical networking systems but it's just as valuable in test and measurement applications. Bannon says Headwall's custom-tooled devices are the fruit of

the company's extensive background in precision optics, which enables it to craft some of the most high-performance photonic subsystems currently available. With almost three decades of experience, he says Headwall has a track record that's unmatched.

Headwall's technology has applications in the medical, life sciences, and test and measurement markets. One immediate application is reflective optics – measuring the absorption and reflection levels of different wavelengths of light. Companies in fields as diverse as the pulp and paper industry and automobiles are interested in using the technology to measure colors as part of their quality-control programs. Headwall technology would be used in systems that precisely measure the wavelength of a beam of light bounced off a product to determine its color.

Bannon says the same technology could be used one day to measure skin tone in diabetics to determine blood-sugar level. The noninvasive technique would evaluate skin tone by measuring the wavelength of a beam of light reflected off the skin to determine the glucose content of the bloodstream.

Although this application is years off, there is a large potential market consisting of people who now must evaluate their blood-sugar level several times daily by pricking their skin and testing their blood.

Headwall's initial funding was \$8 million to \$10 million in physical assets and cash, including a clean-room manufacturing facility. Agilent and Applied Spectral Partners are among the backers. Headwall is currently generating revenue and is profitable, with about 35 percent of sales in legacy telecom designs and the rest in test and measurement systems, especially those of the federal government. Several defense agencies are exploiting Headwall's wavelength-evaluation capability in security applications. The U.S. Air Force uses Headwall components in an infrared-imaging system aboard its Predator drone.

Though other companies offer test and measurement systems based on differing technologies, Bannon says no other firm is working on refractive optics in this field and that the Headwall method offers more accurate measurement techniques.

Bannon says Headwall is now pursuing additional funding, which it will use to ramp up marketing efforts.

ANALYSIS: Headwall received major industry acclaim this year when its holographic technology won an R&D 100 Award. The awards are handed out by *R&D* magazine to recognize the most technologically significant products introduced to the marketplace each year. Though the award is certainly no guarantee of future success, analysts say it should help Headwall close any credibility gap as it goes out to raise a new round of venture funding. ●