

## Top 10 Nanotech Products of 2004

Our third annual Nanotech Product Guide reveals some interesting trends. The overwhelming majority of commercially available nanotech products on the market today are in sports. Last year (see “2003 Nanotech Product Guide”, July 2003), we featured Nanogate/Holmenkol’s Cerax Nanotech Ski Wax, Babolat Tennis Racquets using nanotubes and longer lasting nanoparticle tennis balls from Inmat/Wilson. Even products such as Nano-Tex’s Nano-Care water repellent and stain resistant coatings had appeared in ski jackets from Germany-based Ziener. In 2004, sports led the way for nanotechnology commercialization yet again. From golf balls to footwarmers, athlete skin care to new tennis racquets (from Wilson), consumer demand for better exercise equipment and materials is still driving nanotech revenues. With the help of our affiliated institutional research firm, Lux Research, we’ve listed the top 10 nanotech products of 2004.

### Shock Doctor Aerogel Hotbeds (Footwarmers)

Northborough, Massachusetts-based Aspen Aerogels launched a nanotechnology-based footwarmer in March of 2004. It’s used by the 2004 winner of the North Pole Marathon, the Canadian Ski Team and U.S. Military’s Elite Special Forces.

Aspen’s Pyrogel AR5401 utilizes highly insulative nanoporous aerogel technology, providing 3-20 times more thermal performance at a given thickness when compared to existing materials. It also resists compression, and does not require loft to deliver this benefit. In the case of the Elite Special Forces boots, just a 2mm thick layer of Pyrogel 5401 was needed to provide a significant improvement in field performance.

Plymouth, Minnesota-based Shock Doctor has developed a product called Hotbeds being used in military boots for improving the level of comfort in cold weather operations. Since Pyrogel AR5401 is so efficient, the Hotbeds are only 2.5mm thick. Cost: \$19.99 for one pair of Hotbeds.

### Washable Bed Mattress

In October, Simmons Bedding Company, one of the world’s largest mattress manufacturers, unveiled its latest innovation, the HealthSmart Bed, featuring a zip-off mattress top that may be laundered or dry cleaned. The top is available on all Simmons Beautyrest and BackCare mattresses targeted to sell at price points of \$1,399 and above. Its coolmax channeled fibers wick away sweat

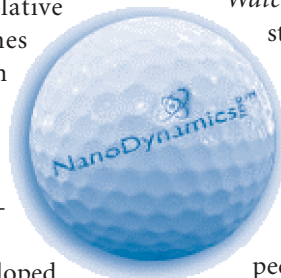
and moisture as you sleep and allow fabric to dry quickly in the laundry. In the second layer, Nano-Tex creates a semi-impervious layer that traps fluids and particles so they can be washed away. The third layer is Terry cloth treated with Teflon fabric protector that provides an extra level of protection.

### Golf Balls & The “Nano” Driver

Tokyo-based Maruman & Co. has adopted fullerenes from Honjo Chemical for use in golf club heads. New titanium fullerene materials are being used in their top of the line “New Majesty” driver, which went on sale on July 5 of this year. Compared to conventional titanium, the new driver resists bending 12% better, has a hardness 3.6% better than titanium, a 20% more resilient head (based on robot testing), and flight distance has increased 15 yards (compared to their old 360cc class driver). Since it was released, Maruman has been overwhelmed with orders, to the point where the Maruman homepage displayed an apology from the company for the two-week delay for shipments of the driver.



Buffalo, New York-based NanoDynamics (see *Companies to Watch*, September 2004) might have a nice accompanying stocking stuffer. NanoDynamics has come up with a golf ball that can correct its own flight path so it flies straighter than conventional balls. The ball won’t shift 45 degrees in midair, but the design of the ball—and the undisclosed nanomaterials it’s made of—serve to better channel the energy received from the club head and thus correct a wobble or slight drift. The ball is expected to hit stores in the spring of 2005. A sleeve of three



balls is \$24.99 and a dozen balls are \$89.99

### Personalized Skin Care

As most of us already know, marketing and more specifically packaging are what sells make -

## INSIDE

Top 10 Nanotech Products of 2004.....	1
Top 5 Nanotech Breakthroughs of 2004. . .	4
Thinking Small: Michael Knapp .....	5
Companies to Watch .....	6
Follow the Money .....	7
The Nanosphere/Word on the Street .....	8

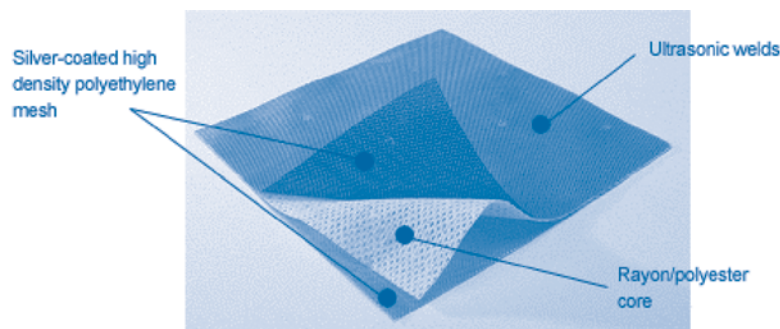
up. Nowadays technology sells, so it is no surprise that Madison Avenue has latched onto nanotechnology for selling cosmetics. Recent visitors to Barney's New York will notice Bionova's skin care booth. With "nano skin tech" prominently displayed on the walls,



this New York-based cosmetics company is based on 25 years of scientific research conducted by Russian scientist Dr. Michael Danielov, CEO and founder of Bionova. Bionova offers "personalized skin care" and says approximately 50% of their sales come from their customized products. Through a series of online or in person interview questions, Bionova scientists tailor face, hand, and body creams based on a person's sex, age, race, skin type, and lifestyle habits like levels of exercise. As an example, in August Bionova introduced a Tennis Skin Care line. The Bionova Grand Slam skin care line claims to provide skin protection for the climatic conditions of all four major tennis tournaments: the skin scalding sun of the Australian Open; the gritty grime of Roland Garros' red clay that can assault skin with abrasions; the wet Wimbledon weather combined with the potential allergic reactions to grass. And for NYC's U.S. Open, the stuff is supposed to protect against the oppressive humidity and pollution that can cause calluses and blisters. A 1-ounce vial of Tennis Player Sun & Wind Protection - Dry Skin cream costs \$60.

### Nanosilver Wound Dressing for Burn Victims

Nucryst Pharmaceuticals, a division of



Canadian-based Westaim Corporation [WEDX], develops and manufactures dressings for serious burns and chronic wounds. Silver has long been known to kill bacteria. Nucryst's nanosized silver particles increase surface area improving its antibacterial effectiveness against 150 types of microbes, including drug-resistant bacteria. Nucryst reports that its nanosilver product Acticoat kills bacteria in as little as 30 minutes, and acts continuously over several days. While the product has been on the market since 1999, Nucryst partner Smith & Nephew [SNN] paid a \$5 million fee to Nucryst for reaching one of its sales and regulatory milestones in the first quarter of 2004. Just how well have their dressings done? Sales has increased from \$3 million in 1999 to \$16 million in 2003 and Acticoat is used today in more than 100 of the 120 major burn hospitals in North America.

### Military-grade Disinfectants

Used on Navy submarines, cruise ships, aircrafts and healthcare facilities, San Jose, CA-based EnviroSystems' EcoTrue nanoemulsive disinfectant cleaner cleans and disinfects in one step. In the post SARS virus scares of 2003, Boeing [BA] recommended EcoTru for use in airplanes. The recommendation helped EnviroSystems attract 30 airlines as customers, up from four, since the SARS scare began. Currently EcoTrue is the only EPA-registered Tox Category IV disinfectant product in the U.S.



This means there are no harmful dermal (skin), ocular (eyes), inhalation (breathing), or ingestion (swallowing) effects when using

## The Insider

As I write this, CNBC has just wrapped up a full week of nanotech coverage. Sure some of it wasn't nanotech, but only loyal subscribers will know the products and companies we've previously called out as nano-pretenders opportunistically trying to cash in. We also saw stocks like NANX, ALTI and TINY surge on the coverage as the classical Keynesian "beauty contest" played itself out. For more analysis on some of Nanosphere stocks be sure to read this month's "Word on the Street." If you can get some late holiday shopping done, take advantage of our exclusive annual feature with this year's all new top 10 Nanotech Product Guide. And be sure to read this month's Thinking Small with Mike Knapp. He's a polished exec running a company and technology that I'm so convinced could change the world that my partners and I have put our money behind it.

Here's wishing you and your family nothing but the best in the new year! Write to me as always at nanotech@forbes.com. Here's to thinking big about thinking small!...

EcoTru. Just how does it work? Conventional disinfectants must be dissolved in a solvent such as water or alcohol and made to flood – in effect "drown" – the host organism with a toxic chemical. This method of infection control requires a tradeoff. To ensure microorganisms are killed, the toxic chemical must be present at levels that cre-

## Nano in the News

### Nanopretender? Artwork & Beyond Inc Changes Name to Advance Nanotech, Inc

Former seller of framed artwork online as well as online charity art auctions, Artwork & Beyond changed the name of the company to Advance Nanotech Inc. on November 14, and began trading under that name with the new ticker symbol [AVNA.OB]. Started in 1980 as Colorado Gold & Silver, Inc., the company ceased mining operations in 1999 and then acquired BankNet Kft and LM Hungary Parts Supply and Distribution Co., two companies organized under the laws of Hungary. Needless to say: Caveat emptor.

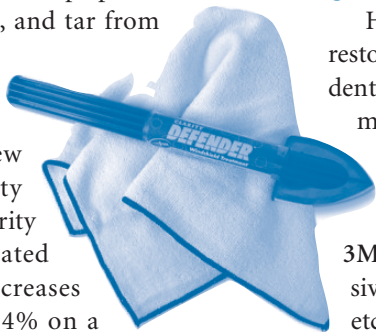
ate health and contamination risks. EcoTru's nanoemulsion formulation works very differently. Nanospheres of oil droplets are suspended in water to create a nanoemulsion requiring only miniscule amounts of EcoTru's active ingredient, PCMX. The nanospheres carry surface charges that efficiently penetrate the surface charges on microorganisms' membranes, much like breaking through an electric fence.

### BASF's Superhydrophobic Spray

BASF [BF] is now wielding its nanotech muscle in the building material industry, especially in concrete, brick facings, limestone, and plasters. In the near future, your home may be coated with Mincor, an additive to improve the hydrophobic effect of building materials. Its extreme water repellence minimizes contact and adhesion among water drops and surfaces. Rain water pearls up immediately. In addition to extremely hydrophobic polymer constituents, Mincor also contains nanoparticles. This reduces the adhesion of water and particulate soiling to a minimum. Dirt particles are simply rinsed away by rain water. Pre-marketing started in 2003 and product introduction to end-user markets is on the way, says Ruediger Iden, Senior Vice President of Polymer Physics at BASF. Currently the fluid formulations of Mincor are delivered in 20 kg and 170 kg barrels and sold through BASF Future Business. BASF is currently looking for distributors.

### Clarity Defender Automotive Glass Treatment

It's an invisible barrier for windshields. It repels rain and helps prevent snow, ice, bugs, and tar from sticking. It's Valley View, Ohio-based Nanofilm's new product, Clarity Defender. A Clarity Defender treated windshield increases driver vision 34% on a



rainy night, which can add about 1 second to driver response time. At 60 mph that's an extra 88 feet of pavement. Clarity Defender, for sale on Amazon.com, is the first of an automotive product line being launched in 2005 by Nano-film, which we featured last December for their coating technologies in sunglasses. Nanofilm deposits coating layers of 150 nanometers and 20 microns thick, respectively. Then it uses chemical self-assembly to form a polymer coating, 3-10 nanometers thin, on the outer layer of the anti-reflective lenses.

### Flex Power Joint & Muscle Pain Cream

Recently featured on CNBC, Berkeley, California-based Flex-Power may give BenGay (owned by Pfizer [PFE]) and Mineral Ice (Bristol-Myers Squibb [BMY]) a run for their money. Started in 1999 by ex-UC Berkeley soccer player and pro-athlete money manager Bijan Esmaili and Rasheen Smith, Flex Power claims to use 90 nanometer liposomes produced with an undisclosed partner "in the healthcare sector" to soothe aching muscles. With an army of 20 pro athletes as investors, including Jason Kidd and Hakeem Olajuwon, Flex-Power said it's not necessarily nanotech patents or a scientific breakthrough driving the product, but the litany of high profile users and sports teams using the \$20/jar creams. Will the early guidance they received from Power Bar founder Brian Maxwell help turn this into another celebrity-endorsed success story like the George Forman Grill?



### 3M Dental Adhesive

Having a porcelain veneer, tooth restoration, or root canal work soon? Your dentist just may put nanoparticles in your mouth to help your new crown stick better. As we featured in our September story "3M: Practicing Nanotechnology Without the Hype", 3M ESPE, a 3M [MMM] subsidiary in dental adhesives, announced a new option in total-etch dental adhesives: Adper Single Bond

Plus Adhesive. The new adhesive incorporates a silica nanofiller technology that forms a stronger bond to tooth enamel and does not need to be shaken by dentists prior to using to prevent clustering of the particles which can decrease the performance. Dental care is one area to keep an eye on as companies from 3M to BASF to Colgate Palmolive [CL] are working on advancements in toothpaste using nanohydroxyapatite (see "Nanohydroxyapatite in Your Smile, May 2003), a material which is increasingly being looked at for bone regeneration in periodontal surgery.

### 2005 Outlook

What's in the pipeline for 2005? You guessed it, more sports. In September, State College, Pennsylvania-based NanoHorizons said it began selling a line of metallic nanoparticles that are compatible with standard polymer manufacturing process. Silver, gold and other metals that kill bacteria and odor-causing microbes can be incorporated into shoes, athletic equipment and other plastic or nylon products. "We're working with a company that does socks right now and should have a sock on the market within the year," says Dan Hayes, director of operations for NanoHorizons. Richardson, Texas-based Zyvex also announced they're working with a sporting company, Easton Sports. Easton's Bicycle Division will incorporate Zyvex's Carbon NanoTube (CNT) additive, NanoSolve, into many of its 2005 line of bicycle components.

We also expect to see more nano-enabled drugs from companies like Elan [ELN], which have developed sophisticated nanomilling and nanoparticle reformulation technologies. While there are already a few drugs on the market developed using nanotechnology (an anti-nausea medication for chemotherapy patients called Rapamune by Wyeth [WYE] and Novavax's [NVAX] Estrasorb transdermal lotion for estrogen replacement therapy), many more such as Starpharma's [ASX: SPL] topical microbicide VivaGel are in clinical trials. **N**

#### Semiconductor Industry Association (SIA) Launches Nanoelectronics Research Initiative

The SIA announced earlier this month it launched a Nanoelectronics Research Initiative (NRI), an effort designed to integrate research from universities, the federal government, and the U.S. semiconductor industry. NRI research areas include materials, device structures, and assembly methods for microelectronic devices with feature sizes smaller than 10 nm, the range at which most existing semiconductor technologies, materials, and production processes cease to work.

# Top 5 Nanotech Breakthroughs of 2004

**N**anotech has been growing in sophistication and recognition with each passing year. According to the National Nanotechnology Initiative (NNI), federal funding for U.S. nanotech research and development reached an estimated \$961 million in 2004. The most notable areas in which nanotech took hold this year was biomedicine and semiconductors, with advancements in new drug delivery methods and instrumentation, a few of which we've listed below.

## 1) Infineon Produces World's Smallest Transistor

**Researchers:** R. Seidel, A. Graham, J. Kretz, B. Rajasekharan, G. Duesberg, M. Liebau, E. Unger, F. Kreupl, and W. Hoenlein

In December, Infineon [IFX] researchers led by Franz Kreupl constructed the world's smallest nanotube transistor, with a channel length of only 18 nm. The most advanced transistors currently in production are almost four times this size. To build their nanotransistor, the researchers grew carbon nanotubes, each one measuring only 0.7 to 1.1 nm in diameter, in a controlled process. According to the researchers, it already performs as well as much larger silicon-based devices. Infineon says this demonstrates that nanotube transistors can fulfill the demands of further scaling until 2018.

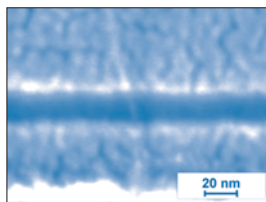


Image showing the individual carbon nanotube forming the world's smallest nanotube transistor. The device has a channel of just 18 nm. Credit: Infineon

## 2) Sensing Single Electron Spin

**Researchers:** Dan Rugar, John Mamin, Raffi Budakian & Benjamin Chui (IBM's Almaden Research Center in San Jose, CA)

Dan Rugar and team at IBM [IBM] have devised a mechanism capable of reading the spin of a single electron. The magnetic resonance force microscope they built consists of a magnet attached to a 100nm-thick lever, an electron, and a laser beam. The spinning electron creates a tiny magnetic field that causes the lever to oscillate, which in turn interferes with the laser beam, allowing scientists to read the spin. Such an instrument may lead to 3-D imaging of the inner structures of materials. It also marks a significant step toward quantum

computing, in which information can be stored in the spin of a single electron.

## 3) FEI Company Breaks the 1 Angstrom Imaging Barrier

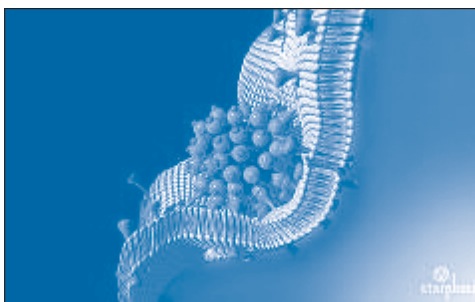
**Researchers:** Rob Fastenau, Max Haider

In March, FEI Company [FEIC] announced they had broken the one angstrom image resolution barrier with their 200kV transmission electron microscope, FEI's Tecnai F20 ST and advanced electron optics capabilities developed by FEI and by its partner, CEOS Company. FEI said that this is the first time images could be directly viewed with a resolution of less than one angstrom using commercially available technologies. This means they can achieve resolutions one-tenth of a nanometer in size, possibly in 3-D. This is considered a significant milestone in electron microscopy.

## 4) Human Trials with Dendrimers

**Researchers:** George Holan, Guy Krippner, Tom McCarthy, Jeremy Paull, Tim Grogan

Melbourne, Australia-based Starpharma's [ASX: SPL] product VivaGel, a dendrimer-based topical microbicide that prevents HIV and other STDs, showed positive results in Phase I human trials. VivaGel is the first drug product in the world based upon nanoscale dendrimers to enter human trials. Not only does VivaGel represent a new form of HIV prevention, but it is also early hope that nanoscale dendrimers—if approved by the FDA after phase III trials—may be a new drug delivery platform. In October, Starpharma (see *Companies to Watch, December 2002*) announced it would lead a consortium to develop a second generation microbicide for the prevention of infection by HIV and other sexually transmitted diseases. This consortium is being funded by a US\$5.4 million (A\$7.5 million) grant from the U.S. National Institutes of Health (NIH).



## 5) Clothing the Toxicity of Fullerenes

**Researchers:** Vicki Colvin, Christie Sayes, John Fortner, Wenh Guo, Delina Lyon, Adina Boyd, Kevin Ausman, Yizhi Tao, Balaji Sitharaman, Lon Wilson, Joseph Hughes & Jennifer West (Rice University & Georgia Institute of Technology)

After a March report by Eva Oberdorster of Southern Methodist University in Texas showed that fullerenes cause brain damage in fish, concern regarding the toxicity of nanoparticles was on the rise. And recently, a team led by Rice University chemist Vicki Colvin showed that fullerenes also kill human liver and skin cells, though they are non-carcinogenic. However, the team realized that the toxicity was a result of aggregations of naked nanoparticles, and found that when the fullerenes were clothed in other chemicals they no longer clumped together and lost their toxicity. The finding is a major step toward ensuring the safety of such particles in mass production and inside the human body in drug delivery systems.

## Looking Ahead to 2005

Next year will see an increase in federal funding of nanotech, with nearly \$1 billion allocated to the NNI. Here's a preview of what we see coming.

Solar energy is one of the fastest growing industries, and next year solar cells will hit the market for use in mobile devices. This past summer, Nanosolar Inc. and Nanosys [Full disclosure: My venture firm is an investor in Nanosys] received R&D contracts worth up to \$10.3 million and \$14 million respectively from DARPA for their work on solar cells. Massachusetts-based Konarka received \$6.1 million, and its inexpensive, lightweight, flexible solar strips look headed straight for consumer products.

Next year there will also be continued advancements in biomedicine, as more and more nanotechnology enters human trials and safety concerns are improved. This year already set the tone with progress in fullerene detox, and positive results from the first dendrimer trials in humans. Nanosensors, lab-on-a-chip diagnostics, real-time patient monitors, and smart drug delivery systems will be next year's major players. Cancer research specifically will benefit from nanotech in 2005; the National Cancer Institute has already announced a \$144.3 million initiative for nanotech research. **N**

# Thinking Small: Michael Knapp

**Y**ou can imagine the very rare breed of experienced executive sought out by a bunch of demanding VC's to run a new startup—Cambrios—which spanned seemingly unrelated disciplines like genetics, biotechnology and semiconductors—all under one roof. Michael Knapp, PhD is a trained scientist and a proven entrepreneur. He founded Caliper [CALP], built out the company's microfluidic technology, signed key biotech and big pharma partnerships. Dr. Knapp co-founded Amphora Discovery Corp., a chemical genomics company spun out of Caliper, Molecular Tool, Inc., a genetics company and was Scientific Director of Genetica SARL, an affiliate of Rhone Poulenc SA in Paris, France. [Full Disclosure My venture firm, Lux Capital is an investor in Cambrios]

## In layman's terms, how does Cambrios' technology work?

Our founders, Angela Belcher and Evelyn Hu, created an amazing framework of technology and how it could be used. Dr. Belcher's instincts in materials science and her research work into how animals incorporate inorganic materials into their bodies was the starting point for the company. We use the biotechnology method known as peptide display which is like "evolution in the laboratory" to find proteins that bind to commercially important inorganic materials. This is widely used technology: you create a large library of random genetic modifications to an organism like a virus or yeast which can be easily grown in the laboratory. You put these small genes into a protein that is expressed on the outside of the organism, so that when the organism grows, it has a new protein piece in its exterior, free to interact with things in its environment. This library is so large, one to ten billion different variants, that you are likely to find a small number of proteins capable of physically attaching to a material.

## How do you select the ones you want?

You wash away the ones that don't bind and grow up the ones that do. Then you can read the DNA sequence of what you have in-

serted and you end up knowing the protein sequence responsible for this molecular affinity. Cambrios is interested in getting binding agents to the materials that make us solid state electronic devices. Dr. Belcher's lab has done an amazing job of characterizing the range of binding specificities which can be achieved with this method: to metals, oxides, semiconductors, magnetic materials, etc. Once you have these proteins and the genes that code for them, you can begin to construct nanostructures out of these materials in a process that is directed by the properties of molecular affinity. For example, Dr. Belcher has cloned the gene for proteins that bind important semiconductors like cadmium sulfide into the bacteriophage M13. When this gets expressed along this virus' coat, it can cause the synthesis of cadmium sulfide nanocrystals all up and down the virus. Simple heating makes these crystals fuse into a nanowire made of that material. Because they are made biologically, they are all exactly the same size and shape.

## What industries could be most impacted and how might the economics of manufacturing be changed?

People have talked about being able to use binding agents for inorganic materials to address advanced therapeutic needs, provide actively functional fabrics, make novel paints, catalysts for the chemical industry, industrial coatings and many others. At Cambrios, we're focusing on the electronics industry and in making novel manufacturing processes to create solid state devices.

## Could you give me a specific example?

Sure. Adding a material specifically to a micro-pattern is done lithographically. The new material is deposited over the entire surface. Then the substrate is coated with a photoresist and re-exposed in the original pattern. In one form of this process, the photoresist is developed to remove the un-exposed region. The material is etched away everywhere except where the new patterning has happened. Then the exposed photoresist is removed, revealing the new layer. With

Cambrios technology, we expect it will be possible to accomplish the same effect with one step. This is sometimes called site-specific deposition. With biochemistry, you can engineer such an agent at the genetic or protein level in a very short time. So we could eliminate a lot of steps. But also, this is a wet process which would eliminate the need for large vacuum tools which are extremely costly, especially for breakthrough fabrication areas like displays. Biochemistry is also intrinsically a room-temperature process which might eliminate the high temperatures required in a lot of processes and enable the use of plastic substrates. Any one of these value propositions could change things dramatically in the electronics world; all of them would be a really big thing.



## What are the next steps for Cambrios?

We've picked some early applications in building new processes for LCD manufacturing and we need to deliver some great proof-of-concept results. That should allow us to get some commercial partners, both R&D partners and distribution partners. Then we have to engage in collaborative product development and launch a few good products in less than five years. Along the way, we need to attract some research support from the government which is very interested in what Dr. Belcher has done.

## People need easy comparisons to fit their mental models. How should people value Cambrios in the future?

We think our first products will look like those sold as "electronic materials"; things like photoresist or materials for CMP (chemical mechanical polishing). Shipley, now called Rohm & Haas [ROH] Electronic Materials, or ATMI [ATMI] are good examples of what we would like to be with respect to our novel processes. As I said earlier, we are likely to, at least initially, partner with companies like that so the products can be delivered to the skeptical market through a trusted vendor. **N**

### Vietnam To Launch Nanotech Center

Thanks to a loan from the World Bank, Ho Chi Minh City National University will build a \$4.3 million nanotechnology lab. The construction of the lab is expected to start in June 2005. Dr Dang Mau Chien, director of the laboratory, said this will be the first nanotechnology lab in the country. The lab will train people in microelectronics and nanotechnology as well as work closely with industry.

# Companies to Watch

## Arrowhead Research Corp.

[Public: ARWR]

www.arrowres.com

626-792-5549

Pasadena, California

Chief Executive: R. Bruce Stewart

What it does: Builds diverse subsidiaries, sponsors research, acquires IP.

Publicly-traded Arrowhead Research is like a microcosm of nanotechnology itself: wide-ranging, promising yet unproven, a menagerie of work in progress. Arrowhead offers investors the potential for long-term gains: it's a public company with three subsidiaries and the potential for more to emerge from research the company sponsors at CalTech.

Arrowhead's most mature asset may be chief executive Bruce Stewart, who previously founded Acacia Research on a similar multiplex business model. **Acacia Technologies** [ACTG] and **CombiMatrix** [CBMX] are two of Acacia's classes of common stock.

Stewart, with 19 startups to his credit, came out of retirement in 2003 to launch Arrowhead by sponsoring several research projects at CalTech for \$200,000 per year apiece. In exchange for granting Arrowhead the exclusive rights to commercialize resulting intellectual property, CalTech also receives a piece of equity interest in Arrowhead and the respective subsidiaries.

Today Arrowhead consists of three majority-owned subsidiaries — **Aonex Technologies** (semiconductor nanomaterials), **Insert Therapeutics** (drug delivery) and **Nanotechnica** (nanosensors, microfluidics, integrated nanosystems) — as well as sponsored research projects on biomolecular tools, ferroelectric and piezoelectric materials for MEMS, and nanoelectronics.

Insert Therapeutics will be pursuing a Phase I human trial of its drug delivery platform, perhaps within a year. The technology, based on a family of cup-like polymer molecules called cyclodextrins, shows promise for transporting cancer agents, genes and other molecules with high precision, effectiveness and low toxicity.

Nanotechnica is now working on integrated microfluidic devices for separating out particular biomolecules such as proteins from a human sample. An improved probe tip for atomic force microscopes is another niche product a year away.

Finally, Aonex, which is developing methods for incorporating semiconductor nanomaterials such as gallium nitride (used in LED lighting) on low-cost substrates, is focusing on bringing very thin and lightweight solar cells for satellites to market in two to three years.

Arrowhead's relationship with its companies is more direct and operational than **Harris & Harris Group's** [TINY] — Arrowhead provides them and the sponsored scientists with legal services, accounting, budgeting and other core business functions. Right now, the company is pushing a study it commissioned from CHI Research, a New Jersey firm specializing in IP analysis, which reviewed Arrowhead's library of 33 issued patents and claims that "among its main competitors [conveniently unnamed], Arrowhead has the most diversified portfolio of patents in the nanotechnology space." The press release on the IP analysis sent ARWR's stock soaring 57% higher in one day. Of course, such an upbeat assessment, paid for by Arrowhead, will undoubtedly be met with some skepticism—a healthy cross-section of IP is, after all, no guarantee of specific market success. The real challenge for Arrowhead over the coming months and years will be building real businesses around the patents and generating revenues through development partnerships or product customers. Stay tuned.

## CTI Molecular Imaging

[Public:CTMI]

www.ctimi.com

865-218-2000

Knoxville, Tennessee

Chief Executive: Ronald Nutt

What it does: Makes hardware and biomarkers for PET imaging.

Magnetic Resonance Imaging, the most popular form of medical imaging, uses radiofrequency waves and a strong magnetic field rather than x-rays to provide clear and detailed pictures of internal organs and tissues. Yet a growing technology emerging out of Knoxville, Tennessee-based **CTI Molecular Imaging** [CTMI], called PET (Positron Emission Tomography), soon might begin to eat into MRI's dominance.

CTI's PET scanner has an advantage over traditional imaging technologies (MRI, X-ray, ultrasound) because it can identify changes at the molecular level before anatomic changes are visible. A PET scan begins with the administration of an imaging agent, or biomarker, to the patient. The biomarker is a mildly radioactive compound that emits tiny particles called positrons. A non-invasive scanner then detects the radioactive signal that the biomarker emits from within the patient's body. These signals are amplified and turned into a 3-D image of the patient where the physician can view the patient's metabolic activities.

Currently, PET accounts for just 1% of all diagnostic imaging procedures. According to Biotech Systems, a Nevada-based healthcare market research provider, the total number of PET procedures grew to 650,000 in 2003, an increase of 48% from the previous year. The discovery of new biomarkers for different applications is an important factor in increasing the utilization of PET. CTI is the largest provider of molecular biomarkers for PET imaging in the US and owns more than 50% of the market's most commonly used cancer detecting radiopharmaceutical — FDG. Another biomarker in the pipeline, FDDNP, determines the location and quantification of the precursors that characterize Alzheimer's disease.

The company's goal is to make molecular imaging a standard clinical and research tool by delivering biomarkers that can be "tagged" to various compounds in the human body. In efforts to expand the company's capabilities to serve the research and pharmaceutical markets, CTI recently acquired small animal imaging companies **Concorde Microsystems** (\$41 million in cash and unregistered stock) and **ImTek** (\$3.75 million cash plus incentive payments). Small animal PET imaging is a growing research market (roughly \$100 million), and will be essential in the development of future human biomarkers. Concorde has 80% of the market and is increasing its edge over **General Electric's** [GE] **Amersham**.

Net Revenues for CTI in 2004 were \$401.7 million, a 10.9% increase over net revenues of \$362.3 million in 2003. Management expects revenues in the \$420 - \$430 million range for 2005. The company earned \$0.40 per share in the fiscal year ended September 30, 2004. The PET machines themselves are manufactured by its CPS Innovations unit, a joint venture between CTI and **Siemens Medical Solutions** [SI] both of which distribute its products. Driving revenue growth is a sales agreement inked with Siemens in May 2004, providing access into Siemens medical clients and improved competitive sales position domestically. CTI has also partnered with **Toshiba** and **Hitachi** [HIT] to help drive international sales, which comprise 36% of the company's total revenue. With blue chip industry partners, CTI should continue to increase its geographic reach and market penetration of PET throughout 2005. Definitely a company to watch. **N**

# Follow the Money

A monthly look at who in nanospace is getting funding and who's giving it.

## Venture Capital

### Arrayx

[www.arrayx.com](http://www.arrayx.com)

**Location:** Chicago, Illinois

**Lead Scientist/CEO:** David Grier/Lewis Gruber

**Funding Announced:** 12/14/04

**Investors:** Draper Fisher Jurvetson, Nanostart AG, LCMH Technology Investments and Ventures Midwest, LaSalle Investments President Robert Geras

**Funding Amount:** \$10 million (Series D)

**Notes:** Arrayx has raised approximately \$17 million in total VC funding since its 2000 inception. Other shareholders include Fahnestock Venture Capital Fund, ARCH Development Corp. and Arrayx-MDGP Investment GP. Arrayx has developed a system called BioRyx which can be used to collect specified types of cells from a mixed suspension, manipulate cells for enhanced viewing, measure cell-cell interactions and cell-object interactions, and extract nuclear material from specific cells (e.g., chromosomes or DNA). Arrayx's system uses focused light to form optical traps that function like microscopic "tractor beams" to collect and manipulate the relevant cells.

**Outlook:** In this difficult venture funding environment, Arrayx turned to Northbrook, Illinois-based LaSalle Securities to help raise this 4th round of financing through a private placement. This financing will help go toward Arrayx's next product, a cell-sorting device called the CelRyx system. Arrayx has undisclosed partners for two product applications of the CelRyx system; a deal with the world's largest provider of semen for artificial insemination of cattle who will sell CelRyx system gender-sorted sperm worldwide, and a deal with a leader in the human and veterinary blood collection industry for development of a CelRyx product. Arrayx has attracted Braintree, Massachusetts-based Haemonetics [HAE], a worldwide maker of automated blood processing systems. Haemonetics will make an equity investment of \$5 million in Arrayx. Additionally, under a separate licensing agreement Haemonetics will make milestone payments to Arrayx if Arrayx reaches certain proof of concept, development and regulatory deliverables. The potential milestone payments total \$12.5 million. If milestones are met, and the Company makes commercial sales of products that incorporate the technology, Haemonetics would make royalty payments to Arrayx

## Government Funding

### Government of Canada

**Funding:** NanoQuebec

**Funding Announced:** 12/13/04

**Funding Amount:** \$724,500

**Notes:** NanoQuebec, an organization devoted to promoting the development of nanotechnology in Quebec was pledged \$724,500 CDN from the Minister of Canada Economic Development. On December 14, NanoQuebec announced that four Quebec-based companies that will each receive \$100,000. The four companies: American Dye Source (secure coatings and inks to combat counterfeiting), Atomistix North America (nanoelectronic components), BioSyntech (repair of orthopaedic tissues) and IatroQuest (*see Companies to Watch, June 2003*) were selected from 40 companies working in nanotechnology in Quebec. NanoQuebec works closely with eight university institutions in Quebec - Concordia, Laval, McGill, Montreal, Sherbrooke, INRS, Ecole Polytechnique, and Ecole de technologie supérieure.

### U.S. Department of Energy (DOE)

**Funding:** Altair Nanotechnologies [ALTI], Hydrogen Solar, subsidiary of Hydrogen Solar Ltd. UK. Academic partners include University of Nevada, Las Vegas' Research Foundation and Center for Energy Research.

**Funding Announced:** 12/13/04

**Funding Amount:** \$3 million

**Notes:** The DOE grant will go toward developing Hydrogen Solar's Tandem Cell, which converts light and water directly into hydrogen fuel. Hydrogen Solar has developed photocatalytic nanocrystalline thin films for the Tandem Cell which absorbs high energy (ultraviolet and blue) light helping generate hydrogen. Altair plans to use its nanomaterial synthesis technology to lower the costs and boost the performance of Tandem Cell's thin films. Through shared research collaborations. The project's ultimate goal is to rapidly commercialize alternative energy vehicles throughout Nevada, and ultimately the rest of the United States.

## Corporate Funding

### Nanogen Inc. [NGEN]

**Funding:** Michael Heller, University of California, San Diego

**Funding Announced:** 12/1/04

**Funding Amount:** \$300,000

**Notes:** The two-year funding will go towards Heller's work using electric field-based technology for nanofabrication and assembly

of nanostructures, as well as for integrating nanostructures with other devices. Nanogen's portfolio includes more than 40 U.S. patents or patent applications based on Heller's intellectual property, 10 of which are related to nanofabrication work he conducted while employed by the company. Nanogen will have a priority position to obtain any IP rights developed under the deal.

# The Nanosphere

Company [symbol]	Technology	Coverage Initiated	Current Price	52 Week Range	Market Cap (\$mil)	Buy/ Hold/Sell
<b>Intellectual Property Incumbents</b> <i>Leading researchers in nanotech, with big potential for spin-offs and revolutionary breakthroughs.</i>						
IBM [IBM]	Nanoscale storage and nanotube transistors	3/02	\$96.20	\$81.90 - \$100.43	\$160,140.00	Buy
Hewlett-Packard [HPQ]	Molecular transistors and switches	3/02	20.96	16.08 - 26.28	63,300.00	Buy
<b>Instrumentation</b> <i>Tools that allow researchers to view and manipulate nanoscale matter.</i>						
Veeco [VECO]	Atomic Force Microscopes	3/02	20.53	17.45 - 34.40	610.40	Buy
FEI [FEIC]	Focused Ion and Electron Beam Microscopes	1/03	21.73	16.66 - 28.50	723.30	Buy
<b>Materials</b> <i>Companies producing nanoscale materials with novel properties that have applications across a wide range of industries.</i>						
Symyx [SMMX]	Novel materials discovery	3/02	29.85	16.51 - 32.20	960.04	Buy
<b>Modeling</b> <i>Companies developing software to visualize, model and simulate matter and activity at the nanoscale.</i>						
Accelrys [ACCL]	Molecular rendering and analysis software	3/02	7.77	5.49 - 23.25	205.97	Buy
<b>Platform Technologies</b> <i>Companies that have corralled key intellectual property that will be the foundation of future developments.</i>						
Nanosys [private]	Nanowires and nanostructure-enabled devices	3/02	n/a	n/a	n/a	n/a
NVE Corporation [NVEC]	Spintronics-based MRAM	7/03	27.35	25.62 - 69.69	123.10	Buy
<b>Investment Firms</b> <i>Companies that are investing in promising early-stage nanotechnology startups.</i>						
Harris & Harris Group [TINY]	Non-volatile RAM, drug delivery, nano-optics	5/02	14.47	7.07 - 23.60	249.59	Hold
<b>Nanobiotechnology</b> <i>Companies that are working at the intersection of nano- and bio-technology.</i>						
SkyePharma [SKYE]	Nanoparticle solubilization for drug delivery	8/02	13.00	8.91 - 14.50	808.91	Buy
Flamel Technologies [FLML]	Nano-encapsulation for drug delivery	8/02	18.01	13.67 - 32.10	386.26	Hold
Immunicon [IMMC]	Nanoparticles for medical diagnostics	5/04	7.80	6.92 - 10.61	180.18	Buy

## Word on the Street

**IBM:** Big Blue announced it was selling its entire PC division to China's Lenovo for \$1.75 billion. The move should not affect the company's nanotech strategy.

**HPQ:** CEO Carly Fiorina disclosed that the board had decided against breaking up HP three times in the past year. Merrill Lynch analyst Steve Milunovich contends that spinning off of HP's printing division could boost the stock price to \$25-\$30 per share.

**VECO:** Punk Ziegel initiated coverage on shares of Veeco with a Buy rating and a \$25 price target.

**FEIC:** FEI announced that it has been selected by the TEAM project to build the highest resolution scanning/transmission electron microscope in the world: 0.5 angstrom -- approximately 1/3 the size of a carbon atom.

**SMMX:** Symyx's market capitalization briefly broke the \$1 billion mark following the announcement of a 5-year alliance with Dow Chemical [DOW] worth approximately \$120 million. The deal represents another significant validation of Symyx's technologies, which Dow has used to discover nanoscale catalysts to manufacture its VERSIFY plastomers and elastomers. Japan's JSR Corporation also began sales of new electronic materials containing polymers made under a license from Symyx. Symyx expects to earn royalties in the first quarter of 2005. This marks the third successful commercialization from Symyx's materials pipeline. We reiterate our Buy.

**ACCL:** ACCL shares jumped close to 15% this month, thanks in part to the public launch of the Accelrys Nanotechnology Consortium, intended to accelerate the development of software tools that enable the design of

nanomaterials and nanodevices. Charter members include Corning [GLW], Fujitsu and e2v Technologies.

**NVEC:** NVEC fell more than 20% following a Motley-Fool.com story critical of the company's prospects. The website first covered NVE in a story called "MRAM: The Holy Grail of Memory" on August 18 where it profiled the company as a "hidden gem." On November 22, Motley Fool flip-flopped, contradicting its prior stance, and published a piece called "NVE's Nanotrap Only Snares Speculators." The story contained no third-party interviews or new research. It was an opinion piece by a writer with unlisted credentials or affiliation. NVEC has been long under attack by controversial short-seller Manuel Asensio who wages press release campaigns that successfully shake investor confidence. On October 14, Asensio released an attack on NVEC. The Motley Fool article published on November 22 used language from Asensio's press release down to the misspelling of "transistor"; incorrectly spelled "transitor". The article contends that NVE backed away from its claim that it would be due royalties if Motorola commercialized the MRAM described in its technical papers. This is wholly inaccurate. NVE did not back away from its claims relating to Motorola. In fact, the company became even bolder in its claims of MRAM patent value in the most recent SEC filing: "We know of no practical alternative design being pursued by potential MRAM suppliers that could be sold in commercial quantities in the foreseeable future." Contrary to the Motley Fool article, NVE's "watershed" patents ('411 and '053) apply, but are not limited to, one transistor per bit reading, and they do specifically relate

to MRAM. Many of the other issues the author brings up were directly addressed in our most recent November issue, including the Freescale [FSL] spin-off and NVE's relationship with Cypress [CY]. While Cypress' MRAM program has experienced unexpected delays, it has publicly reported progress on their designs and yields. Uncertainty still lingers. And that means long or short, this stock will remain volatile. In the absence of any material news, we stand by our contention that NVE's IP is valuable and reiterate our Buy rating.

**TINY:** Harris & Harris advanced nearly 10% on a series of favorable nanotechnology segments on CNBC.

**SKYE:** Shares moved more than 21% higher after partner Endo Pharmaceuticals [ENDP] began the commercial sales of DepoDur in the U.S. market. DepoDur is the first single-dose extended-release formulation of morphine approved by the U.S. FDA for the treatment of pain following major surgery. This is SKYE's most important pipeline product and the company expects that DepoDur revenues will be a critical piece to replacing milestone payments as its major source of income.

**FLML:** After Bristol-Myers Squibb's [BMY] surprising decision to abort the development of Basulin long-lasting insulin using Flamel's Medusa nano-delivery platform, FLML has been busy trying to prove Medusa's value with a pair of Phase I/II studies. FLML remains a Hold as we await the results from BMY's Basulin studies.

**IMMC:** Insider sales continued to pile up. IMMC's Chief Counsel followed its CEO, CFO and R&D chief in adopting a Rule 10b5-1 trading plan to sell portions of company stock over time. \*Stock prices as of Dec. 17, 2004

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