



# Nanotechnology Newsletter

## February 2011 Edition

### SUMMARY

- **The momentum of nanotechnology development continues domestically and overseas.** Besides making continued vast financial commitment to nanotechnology research, the U.S. plans to place more emphasis on transferring new processes and materials from basic research discoveries to commercial products to benefit the local economy and the society as a whole. In overseas, many countries are taking steps to strengthen their competitive edge on nanotechnology as well. For example, (a) China more than tripled its nanotechnology research and development (R&D) spending in the last five years ending 2010 than the prior five-year period; (b) India will have their first nano park in 2011; (c) Singapore has collaborated with Israel to develop new nanomaterials for the enhancement of existing energy and water management technologies and; (d) Saudi Arabia will have the King Abdullah Institute for Nanotechnology launched by this year-end.
- **On the research front, discoveries continue to be abundant, led by laboratories at universities.** Interesting projects include (a) the development of “killer paper” on which silver nanoparticles are deposited to kill bacteria so as to extend the shelf life of food and (b) nanoparticles containing a metal that finds the location of a clot in a blood vessel and makes the clot visible to a special type of CT scanner can be used to confirm if a patient had a heart attack or not.
- **The recent nanotechnology IPO is well received and nanotechnology M&A activities have been active thus far in 2011.** NeoPhotonics Corporation (NPTN) listed in the New York Stock Exchange has performed very well, up 20.5% in the first day of trading on February 2, 2011 and posting an absolute return of roughly 65% between the date for its debut and February 25, 2011. There were at least two M&A deals involving nanotechnology companies (BioVex Group and Unidym Inc.) in January 2011 alone, reflecting the thirst for IP and technology. Harris & Harris Group (TINY) is an investor of NeoPhotonics and BioVex while Arrowhead Research Corporation (ARWR) is an investor of Unidym. Both Harris & Harris Group and Arrowhead Research are constituents of both the Cedrus Nanotechnology Index – Diversified (CNID) and Cedrus Nanotechnology Index – Pure (CNIP).

### LATEST DEVELOPMENTS IN THE NANOTECHNOLOGY INDUSTRY

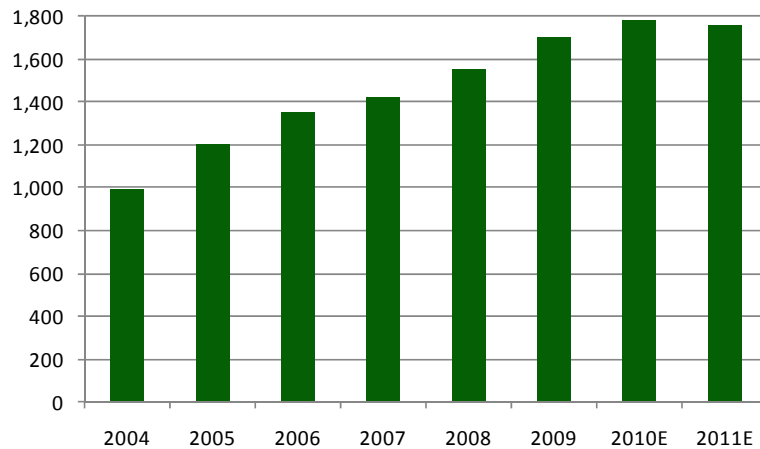
- National Nanotechnology Initiative (NNI) of the U.S. with \$1.76 billion budget proposed for fiscal year 2011 has outlined its strategy beyond 2010. One of the goals is to foster technology transfer from research discoveries for the benefit of the U.S. economy and society. To achieve this target, nano-manufacturing R&D will be doubled while increasing the focus on nanotechnology-based commercialization and related support for public-private partnership. NNI also plans to accelerate nanotechnology development in support of the President’s priorities and innovation strategy through close and targeted program-level interagency collaboration on the following initiatives. These actions are further evidence that the U.S. is committed to maintaining its leadership position in nanotechnology.



## NANOTECHNOLOGY NEWSLETTER

- **Nanoelectronics for 2020 and beyond** (\$55 million funding committed) – The goal is to speed up the discovery and use of innovative nanoscale fabrication process and novel concepts to produce revolutionary materials, devices, systems and architectures to advance the field of nanoelectronics.
- **Sustainable nano-manufacturing** (\$23 million funding committed) – To accelerate the development of industrial-scale methods for manufacturing of functional systems with relatively limited complexity based on manufactured nanoparticles with designed properties.
- **Nanotechnology for solar energy** (\$51 million funding committed) – New innovations and fundamental breakthroughs in addition to solar technology performance improvement are pursued to attain the target of generating 10% of electricity in the U.S. from renewable sources by 2012 and 25% by 2025.

**U. S. National Nanotechnology Initiative Investments (FY2004-2011E and in \$ million)**



Source: NNI and Cedrus Investments Ltd.

- In the corporate world, nanotechnology R&D investment in the logic foundry space is expected to increase meaningfully as competition intensifies. While the mainstream process technology in semiconductor manufacturing is switching to 40nm in logic devices, the leaders in this arena whether integrated device manufacturers (IDMs) such as Intel (INTC) or foundries like TSMC (TSM) and GlobalFoundries are pushing the technology envelop hard to sustain Moore’s Law by developing the 20nm process currently. A recent report also indicated that Samsung, which is aggressively pursuing the opportunity as a foundry, has just joined this elite league. Samsung will continue to use 193nm immersion lithography tools for the 20nm process with the help of double patterning and other tricks. Reportedly, Samsung’s 20nm process design kits will be available in February 2011 with risk production scheduled for 2H 2012 and early production in 1Q 2013.



# NANOTECHNOLOGY NEWSLETTER

## GLOBAL DEVELOPMENT (OTHER THAN ASIA)

### Saudi Arabia

- In October 2010, Prince Muqrin Bin Abdulaziz of Saudi Arabia laid the foundation stone of the King Abdullah Institute for Nanotechnology (KAIN) in King Saud University. In the ceremony, according to the General Intelligence Presidency of Kingdom of Saudi Arabia, the Prince said **“Through close monitoring of the international scene and trends of modern technology in the advanced countries, it was noticed that there is great attention and huge financing being provided to the field of nanotechnology because the one who will have the greater share in nanotechnology will rule the world economy in the 21st century.”** Aside from developing nanotechnology research and technology, KAIN has the vision of fostering the partnership between academic and major industrial and commercial institutions such as SABIK and Saudi ARAMCO. According to Okaz/Saudi Gazette Sunday, the King Abdullah Institute for Nanotechnology will be launched on November 11, 2011 at a cost of SR97 million (or ~\$26 million).
- King Abdullah Institute for Nanotechnology is the third entity in Saudi Arabia devoted to nanotechnology after the Center of Nanotechnology and Center of Research Excellence in Nanotechnology. Center of Nanotechnology was established in 2006 at King Abdulaziz University for the implementation and technology transfer of nanotechnology between Saudi Arabia and the Arabic region while the Center of Research Excellence in Nanotechnology is the platform through which King Fahd University of Petroleum and Mineral develops a program for scientists and faculty members to carry out research.

## ASIA DEVELOPMENT

### China

- According to the announcement made in January 2011 by the national nanotechnology co-ordination committee co-established in 2001 by the Ministry of Science and Technology, the Chinese Academy of Science (CAS) and the National Natural Science Foundation, China invested over 5 billion yuan (approximately \$760 million) on nanotechnology research and development between 2006 and 2010, more than triple the 1.5 billion yuan spent in the prior five years (between 2001 and 2005). In addition, the number of patent applications related to nanotechnology in China became the second largest worldwide by 2009, increasing from 4,600 in 2005 to 12,000 in 2009. The amount spent and the dramatic increase in the number of patent applications evidenced the commitment of China and the fruition of the spending in nanotechnology.

### India

- India will have its first nano park in 2011. The park is located in North Bangalore and will house several nano science and nanotechnology-related industries. An Indian government official said that an all-out effort has been made so that Bangalore will be the nanotechnology hub of India just like it is in information technology. Actually, India just held its third edition of Bangalore Nano 2010 (Department of IT, Biotechnology and Science & Technology, Government of Karnataka was the host of the event) last December in an effort to attract local young scientists to nano-related research works.
- Although nanotechnology has largely been an initiative driven by the government in India, participation from the private sector is on the rise. The Indian Society of Nanoscience and Nanotechnology, a non-profit organization with the goal of promoting scientific research and business development of nanoscience and nanotechnology,



## NANOTECHNOLOGY NEWSLETTER

will host the Nanotech India 2011 in conjunction with Ag Nanotech Impex India Private Ltd. in December 2011 to promote the awareness and acceptance of nanotechnology.

### Israel and Singapore

- Under a Singapore government sponsored program, the academicians in Israel and Singapore announced in December 2010 the establishment of a 5-year collaboration for the development of new nanomaterials by synthesizing inorganic materials such as carbon, gold and silver to enhance the efficiency of existing energy and water management technologies, including water cleaning and monitoring as well as energy harvesting and conservation. The partnership would patent and market energy and water nanotechnology resulting from this technological collaboration.
- Separately, in October 2010, the Singapore Institute of Manufacturing Technology (SIMTech), a research institute of the Agency for Science, Technology and Research (A\*STAR) launched the Nanotechnology in Manufacturing Initiative (NiMI) to explore nanomaterials for industry applications and address the challenges in nano-manufacturing.

## DEVELOPMENT IN NANOTECHNOLOGY BY SECTORS

### Manufacturing

#### UC Berkeley Researchers Identify New Way for Growing Nanolasers on Silicon

February 7, 2011

Researchers at UC Berkeley was able to find a way to grow nanopillars made of indium gallium arsenide (a III-V material) onto a silicon surface using metal-organic chemical vapor deposition (MOCVD), a technology commonly used in today's commercial production of thin-film solar cells and light-emitting diodes (LEDs). This innovation could result in highly efficient silicon photonics for engineering on-chip nanophotonic devices such as lasers, photodetectors, modulators and solar cells. Silicon, the building block for modern electronics, is extremely deficient at generating light so that silicon photonics are made to exploit the inherent ability of light particles of being able to carry more data than electrical signals can.

<http://www.azonano.com/news.asp?newsID=21505>

#### University of Maryland Researchers Have Made a Breakthrough in the Use of Visible Light for Making Tiny Integrated Circuits

February 4, 2011

Professor John Fourkas and his team recently introduced a technique called RAPID lithography which would make visible light possible to attain (and potentially even surpass) lithographic resolution currently obtained with shorter wavelength radiation. Because visible light does not require the use of high vacuum conditions as current short wavelength technologies do, it is far more inexpensive to generate. Hence, it has the potential of substantially lowering the production costs.

<http://www.azonano.com/news.asp?newsID=21475>

#### New Transistors – An Alternative to Silicon and Better Than Graphene

January 31, 2011

EPFL's Laboratory of Nanoscale Electronics and Structures (LANES) publishes a study showing that molybdenite, a mineral that is abundant in nature and usually used in making steel alloy or as an additive in lubricants, has distinct advantages over traditional silicon or graphene and can be used to make smaller and more energy-efficient electronic



## NANOTECHNOLOGY NEWSLETTER

chips. Molybdenite is a two-dimensional material versus the three-dimension silicon so that the former is less voluminous, and molybdenite consumes 100,000x less energy in standby mode than a traditional silicon transistor. Hence, molybdenite has the prospects of making very small transistors, LEDs (light-emitting diodes) and solar cells.

<http://www.sciencedaily.com/releases/2011/01/110130194145.htm>

### **Growing Carbon Nanotubes on Chips at the Post CMOS Wafer Stage**

November 15, 2010

To compete with the state-of-the-art CMOS (Complementary Metal Oxide Semiconductor) technology, carbon nanotube-based sensors must be produced with a low-cost, reliable and large-scale reproducible carbon nanotube deposition process on the wafer level. Given the difficulties that scientists have encountered so far, they believe that a hybrid approach – to grow and integrate carbon nanotubes on CMOS wafers and use these carbon nanotubes to improve the performance of existing CMOS technology – could be a more realistic approach.

<http://www.nanowerk.com/spotlight/spotid=19000.php>

### **Electronics**

#### **Atomically Thin ‘Switch’ Makes for Smarter ICT Devices in the Future**

January 31, 2011

Researchers at the University of Southampton have developed a new graphene transistor with record-high switching performance (1,000x higher on/off switching ratio), overcoming one of the drawbacks of graphene – difficult to turn off the current flow due to its intrinsic physical properties. With this enhancement, graphene can potentially make consumer electronics more functional and with higher performance. Graphene, a material made from a single atomic layer of carbon arranged in a two-dimensional honeycomb structure, could likely replace or at least be used alongside with silicon integrations, according to Dr. Muktadir at the university, as CMOS’ (Complementary Metal Oxide Semiconductor) downscaling is reaching its limits.

<http://www.nanotechwire.com/news.asp?nid=11512&ntid=&pg=3>

#### **Touchscreens Made of Carbon**

January 27, 2011

Touchscreens that contain carbon nanotubes have developed by researchers at Fraunhofer as the deposits of indium, by which indium-tin-oxide is made to form the wafer-thin electrode underneath the glass surface of a display, are limited. Carbon is low cost, available around the globe and is a renewable resource. This new material, comprising of carbon nanotubes and low-cost polymers, not only has similar efficiency as indium-tin-oxide but also is much cheaper. Moreover, electrode foil made by this new material is flexible and could be used as photovoltaic foils to line corrugated roofs or other uneven structures.

<http://www.nanotechwire.com/news.asp?nid=11490&ntid=&pg=5>

#### **Brightest Nanoparticles Shun Quantum**

January 19, 2011

Researchers at Clarkson University in Potsdam, New York claimed that the mesoporous silicon-dioxide (silica) nanoparticles have proven to be 34x brighter than the brightest quantum dots and hence took the crown of being the brightest nanoparticles of the world. According to Professor Igor Sokolov at the university, these nanoparticles have potential applications in medicine, biology, materials science and environment protection because they allow much finer detection of environmental pollutants, biosensors and homeland defense detectors.

<http://www.eetimes.com/electronics-news/4212302/Brightest-nanoparticles-shun-quantum>



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# NANOTECHNOLOGY NEWSLETTER

## **Nanoelectronics Make Devices Affordable**

December 9, 2010

Mr. Suraj Rengarajan, Engineering Manager, Applied Materials (AMAT), said, "Using the concepts of general large scale manufacturing, nano materials can be developed. Electronics industry can bring down the costs of many electronic devices using nanotechnology. Cost per function is going down via innovation in nano manufacturing." He added that what he said was true for semiconductor LCD TVs and solar panels.

[http://www.nanotech-now.com/news.cgi?story\\_id=41099](http://www.nanotech-now.com/news.cgi?story_id=41099)

## **Energy**

### **New Nanomaterials Unlock New Electronic and Energy Technologies**

February 3, 2011

Scientists participating in the collaborative international research led by the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College Dublin, Ireland, and the University of Oxford have invented a low-cost and very-high-yield method with very large throughput to create atom-thin "nanosheets" from a range of materials using common solvents, ultrasound and devices similar to those used to clean jewellery. These nanosheets can be used as thermoelectric materials, enabling devices to generate electricity from waste heat. Efficient thermoelectric devices could recycle cheaply and easily part of the energy lost as waste heat from power plants (50-70% of the energy produced by gas-fired power plants as well as coal and oil plants is lost as waste heat).

<http://www.sciencedaily.com/releases/2011/02/110203141818.htm>

### **Nanomaterials: Peapod Power**

February 2, 2011

Yu Wang and his colleagues have created a composite material with a peapod structure, consisting of cobalt oxide nanoparticles embedded in carbon fibers. Cobalt oxide is a favorable material for anodes in lithium ion batteries because of its higher capacity for holding ions than other conventional materials like tin. Electrodes built using the peapod composite had enhanced lithium storage and capacity retention – delivering 91% of total possible capacity after 50 charge-discharge cycles. Lithium ion batteries can be found in a number of consumer electronics such as cameras and calculators, but the repeated process of lithium ions being incorporated into and extracted from the electrodes by alloy formation or chemical conversion has caused the degradation of electrodes and subsequently the performance of the batteries.

<http://www.nanotechwire.com/news.asp?nid=11532>

### **New Technology and Partnership Creates Less Expensive, More Efficient Hydrogen Fuel Cells**

February 2, 2011

Dr. Jim P. Zheng at the Florida A&M University-Florida State University College of Engineering has designed a thin material (membrane) known as "buckypaper," which is a form of carbon that is extremely light and can conduct heat or electricity easily. With this new material, the amount of the expensive platinum used in current fuel cells will be reduced. Another advantage of using this thinner and lighter material is that the fuel cells will be smaller but with the same amount of power. The bottom line is greater than 40% performance improvements and 25% durability improvements amidst lower cost of production, which has been the roadblock for the mass production and deployment for fuel cells.

[http://www.nanotech-now.com/news.cgi?story\\_id=41574](http://www.nanotech-now.com/news.cgi?story_id=41574)

## NANOTECHNOLOGY NEWSLETTER

### **A Dash of Disorder Yields a Very Efficient Photocatalyst**

January 28, 2011

Scientists from the U.S. Department of Energy's Lawrence Berkeley National Laboratory found that by engineering disorder into the ordinarily perfect atom-by-atom lattice structure of the surface layer of titanium dioxide nanocrystals (a semiconductor photocatalyst) in addition to adding impurities, 24% of the sunlight absorbed by the photocatalyst could be converted into hydrogen, a production rate of approximately 100x higher than most other semiconductor photocatalysts. Moreover, these photocatalysts showed no signs of degradation during a 22-day test period, revealing that they are potentially durable enough for producing hydrogen in a pollution-free way for use as an energy carrier in fuel cells, which could replace combustion engines in vehicles.

<http://www.nanotechwire.com/news.asp?nid=11496&ntid=&pg=4>

### **Nanotech Can Increase Energy Production Efficiency**

December 9, 2010

Nanotechnology can benefit the energy sector in many ways whether it is nano-optimized fuel cells or efficient solar cells. In energy storage, nanotechnology can play a vital role in the reduction of transmission losses and consumption. Cost reduction in the production of renewable energies is another thrust area for nanotechnology.

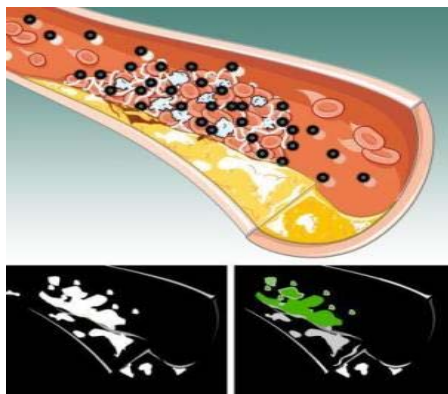
[http://www.nanotech-now.com/news.cgi?story\\_id=41098](http://www.nanotech-now.com/news.cgi?story_id=41098)

## Life Science

### **New Nanoparticles Make Blood Clots Visible**

February 2, 2011

Researchers at Washington University School of Medicine in St. Louis have designed nanoparticles containing enough bismuth (a metal) that can find the location of a clot in a blood vessel and make them visible to a new kind of X-ray technology (spectral CT). With the use of a special type of CT scanner that is capable of "seeing" metals in color, medical staff can confirm whether a patient is having a heart attack or not in a matter of hours. Most people's heart attacks or strokes are from moderate-grade disease that breaks off and blocks an artery suddenly. These nanoparticles allow doctors to see ruptured plaque even when the blood vessel is not very narrow.



A blood vessel (top) with ruptured atherosclerotic plaque (shown in yellow) is developing a blood clot. The nanoparticles, shown in blue and black, are targeted to a protein in the blood clot called fibrin, shown in light blue. A traditional CT image, bottom left, shows no difference between the blood clot and the calcium in the plaque. A spectral CT image, bottom right, "sees" the bismuth nanoparticles targeted to fibrin in green, differentiating it from calcium (still shown in white) in the plaque. (Credit: Wiley-VCH Verlag GmbH & Co. KGaA.)

<http://www.sciencedaily.com/releases/2011/02/110202143802.htm>





## NANOTECHNOLOGY NEWSLETTER

### **“Cornell Dots” – Brightly Glowing Nanoparticles – may Soon be Used to Light up Cancer Cells to Aid in Diagnosing and Treating Cancer**

February 1, 2011

The U.S. Food and Drug Administration (FDA) has approved the first clinical trial in five melanoma (a type of skin cancer) patients with the use of an inorganic material in the same fashion as a drug. The trial will try to verify whether the Cornell dots (silica spheres less than 8 nanometers in diameter that enclose several dye molecules) are safe and effective in humans. Organic molecules that bind to tumor surfaces or even specific locations within tumors can be attached to the silica shell, which is essentially glass and is small enough to pass through the body and out in the urine. These dots fluoresce when exposed to near-infrared light so that researchers can monitor the activities of tumor cells. The Cornell dots could also be used in other applications like displays, optical computing, sensors and such microarrays as DNA chips.

<http://www.azonano.com/news.asp?newsID=21423>

### **Growth-Factor-Containing Nanoparticles Accelerate Healing of Chronic Wounds**

January 26, 2011

Investigators at Massachusetts General Hospital have fabricated nanospheres containing keratinocyte growth factor (KGF), a protein for wound healing, fused with elastin-like peptides that could improve the healing of chronic wounds such as pressure sores and diabetic foot ulcers. Using KGF alone can help heal wounds, but it is applied only to the surface of the wound and required repeat applications, limiting its benefits for deep skin wounds and making the therapy extremely expensive. The fused KGF and elastin rapidly and efficiently self-assemble into nanoparticles as temperature increases, and the nanoparticles accelerate healing by stimulating the formation of both surface epithelial tissue and thick fibrous connective tissue.

<http://www.nanotechwire.com/news.asp?nid=11480&ntid=&pg=5>

### **Researchers Seek Silicon Nanowire Sensors**

December 13, 2010

The Institute of Microelectronics in Singapore will collaborate with the University of Illinois to explore new ways to design and make nanowire sensors for their ultimate deployment in point-of-care test systems to detect proteins that signals cancers. Researchers believe that silicon nanowire sensors could power rapid, low-cost and high through-put biological tests. Point-of-care diagnostic systems are one of the fastest-growing areas in healthcare, and some estimates projected the market could grow to \$22.5 billion in 2013.

<http://www.eetimes.com/electronics-news/4211446/Researchers-pursue-silicon-nanowire-sensors>

### **Another Nanotechnology Step towards 'Fantastic Voyage'**

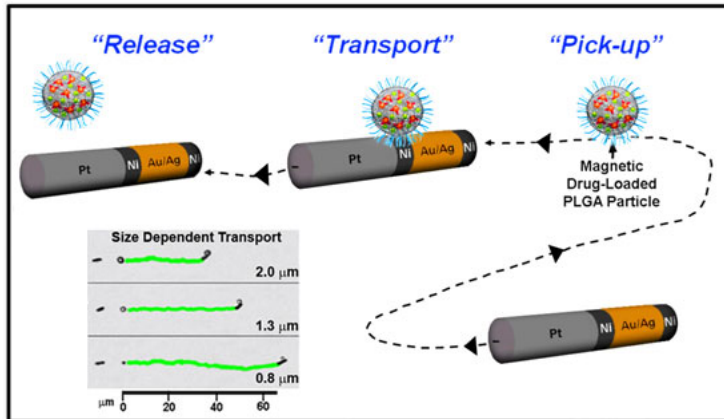
December 10, 2010

Catalytic nanoshuttles can pickup common biocompatible and biodegradable drug-loaded poly(lactic-co-glycolic acid) [PLGA] particles and liposomes and transport them over predefined routes to predetermined destination. The strong propelling force provided by the nanoshuttles can potentially facilitate the tissue penetration of drug carriers. Additionally, this nanomotor-guided nanoparticle drug delivery can also minimize the undesirable off-target effects of the current nanoparticle drug delivery systems."





## NANOTECHNOLOGY NEWSLETTER



Translocation of model drug carriers by catalytic nanowire motors. (Image: Joseph Wang, UCSD)  
<http://www.nanowerk.com/spotlight/spotid=19378.php>

### Environment

#### Tuning Graphene Film So It Sheds Water

February 2, 2011

James Dickerson and his colleagues have been able to make a film of graphene oxide and alter the roughness of its surface by changing the pH (a measure of acidity or alkalinity) of the liquid medium and the electric voltage used in the process so that it either causes water to bead up and run off or spreads it out in a thin layer. Potential applications for this discovery include self-cleaning glasses and clothes, antifogging surfaces, corrosion protection, and snow-load protection on buildings.

<http://www.sciencedaily.com/releases/2011/02/110201155628.htm>

#### Killer Paper for Next-Generation Food Packaging

January 26, 2011

“Killer paper,” containing a coating of silver nanoparticles, has been developed and could be used as a new packaging material to preserve foods from spoilage by fighting bacteria, thus allowing longer shelf life. The coated paper showed potent antibacterial activity against *E. coli* and *S. aureus*. Silver nanoparticles have a longer-lasting effect than larger silver particles and can help to overcome the growing problem of antibiotic resistance, in which bacteria develop the ability to shrug-off existing antibiotics. The deposition of silver nanoparticles on the surface of a paper involves the usage of ultrasound or the use of high frequency sound waves.

<http://www.nanotechwire.com/news.asp?nid=11481&ntid=&pg=5>

#### Nanotechnology in the Automotive Industry

November 12, 2010

By powering electric vehicles with higher performance and longer lifetime lithium ion batteries or future generations of hydrogen-powered cars with improving fuel cell performance, nanotechnology help protect the environment from damage arising from carbon dioxide. Currently, it seems there is agreement that the ideal battery type for electric cars is lithium ion, but no consensus yet with regard to which lithium ion chemistry to use. Nanotechnology can potentially enhance the energy and power density, shorten the recharge time as well as decreasing the size and weight of batteries while improving their stability and safety. Proton exchange membrane (PEM) fuel cell is one of the leading fuel cell technologies particularly for transportation applications. With the deployment of nanotechnology, we can



## NANOTECHNOLOGY NEWSLETTER

expect the availability of cheaper bipolar materials using nanocomposites, more efficient non-platinum electrocatalysts and thermally stable and more durable membranes.

<http://www.nanowerk.com/spotlight/spotid=18972.php>

### Water Desalination with Graphene

October 6, 2010

Nanotechnology could have an impact on water treatment and remediation, sensing and detection, and pollution prevention. Besides ion concentration polarization, capacitive deionization (CDI) technology is another relatively new method of purifying brackish water. The advantages of CDI are that it has no secondary pollution, is cost-effective and energy efficient. The reason for CDI to be energy efficient is that it aims to remove only the salt ions, which are a small percentage of the feed solution, as opposed to most other technologies that aim to separate water, which accounts for 90% of the feed solution.

<http://www.nanowerk.com/spotlight/spotid=18696.php>

### Carbon Dioxide Capture with Nanometric Thin-Film Membranes

September 21, 2010

It is estimated that one third of the world's total carbon dioxide emissions come from the burning of fossil fuels like coal and oil in the process of producing energy in power plants. Efforts have been made to capture carbon dioxide before it hits the atmosphere. However, carbon dioxide has to be separated from other waste gases, and this filtration process is expensive and requires the use of chemicals. Membranes currently in use are not competitive for large-scale applications because their permeance (flux) for carbon dioxide is not high enough. By combining a carbon dioxide-philic polymer design with controlled nanofabrication conditions, researchers in Germany have achieved defect-free selective layers much thinner than 100nm and with unmatched high carbon dioxide permeance as well as high selectivity and stability. This membrane-based process can decrease the separation costs to lower than 30 Euro/tonne versus the 30-50 Euro/tonne for the conventional process.

<http://www.nanowerk.com/spotlight/spotid=18139.php>

## FINANCING IN NANOTECHNOLOGY

### Public

- **The recent nanotechnology IPO generated significant return for investors so far.** NeoPhotonics Corporation (NPTN) is the very recent nanotechnology IPO listed in the New York Stock Exchange. 7.5 million shares were sold (500,000 shares more than originally planned) at \$11 a share (the high-end of the price range between \$9 and \$11). This stock finished 20.5% higher than its offering price on the first day of trading (February 2, 2011); based on the closing price as of February 25, NeoPhotonics has appreciated approximately 65% since its debut. Harris & Harris Group (TINY), the publicly-held venture capital firm focusing on nanotechnology and others and a constituent of the Cedrus Nanotechnology Indices (both CNID and CNIP), is an investor of NeoPhotonics.

### Private

- **IP and technology possessed by nanotechnology companies are attractive assets** as witnessed by the recent M&A activities. On January 24, Amgen Inc. (AMGN) announced the acquisition of BioVex Group, a private company with an experimental cancer vaccine in late-stage development that may represent a new approach to treating melanoma (a type of skin cancer) and head and neck cancer. The deal could cost Amgen up to \$1 billion, comprising of \$425 million in cash at closing and as much as \$575 million in additional payments upon the



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## NANOTECHNOLOGY NEWSLETTER

achievement of certain regulatory and sales milestones. Harris & Harris Group is also an investor of BioVex Group.

- Unidym Inc., a holder of 90 issued patents on carbon nanotubes and a subsidiary of the publicly traded Arrowhead Research Corporation (ARWR) [also a member of the Cedrus Nanotechnology Indices, CNID and CNIP], announced its acquisition on January 18, 2011 by Wisepower Company Limited, an electronics company listed in Korea. The purchase price includes \$5 million upfront in stock and convertible bonds plus up to \$140 million cash earned-out payments based on cumulative sales and licensing milestones. In addition, Unidym's shareholders will be paid 40% of licensing revenue from a set of the company's patents.



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# NANOTECHNOLOGY NEWSLETTER

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