

Technology Scan

ASIA-PACIFIC

CHINA

Technology for containment of transgenes

Not long ago, a study team, led by Prof. Shen Zhicheng at Zhejiang University School of Agriculture, had invented a simple and reliable containment strategy for transgenes, allowing a signature being printed on transgenic rice.

Researchers have found a novel method for creating selectively terminable transgenic rice. In this method, the gene of interest is tagged with a RNA interference cassette, which specifically suppresses the expression of the bentazon detoxification enzyme, and thus renders a transgenic rice to be sensitive to bentazon, a herbicide used for rice weed control.

They generated transgenic rice plants that were highly sensitive to bentazon but tolerant to glyphosate, which is exactly the opposite in the case of conventional rice. Field trials of these transgenic rice plants further confirmed that they can be selectively killed - with 100 per cent success - by one regular dose spray of bentazon used for conventional rice weed control.

Furthermore, researchers found that the terminable transgenic rice created in this study shows no difference in growth, development and yield compared to its non-transgenic control. Therefore, this method of creating transgenic rice constitutes a novel strategy of transgene containment, which appears simple, reliable and inexpensive for implementation. It also means that the novel technique is able to meet the non-transgenic control needs imposed on food and seeds for export.

<http://www.most.gov.cn>

Plastic optic-fibre transmission system

Xi'an Feixun Photoelectric Co. Ltd. had recently rolled out a 650 nm plastic optic-fibre transmission system. The system that passed a validation check is a novel op-

tic-fibre transmission system equipped with needed functions, enjoying numerous merits, including an increased transmission bandwidth, improved security, enhanced interference resistance, lightning proof, lighter weight, finer flexibility, and less copper use, compared with traditional copper wires.

Even in the context of quartz optic-fibre, the plastic optic-fibre transmission system presents the strength of simple operation, easy interface, inexpensive light source, and lower cost. The new system can find wide applications in public facilities and local networks, especially in short distance high speed data transmission with high confidentiality requirements, including in vehicle (car and boat) based internal telecommunication network, and industrial control network.

<http://www.most.gov.cn>

JAPAN

Gene transduced into human mesenchymal stem cells

Hajime Ohgushi, Principal Research Scientist at the Research Institute for Cell Engineering and Jun Miyake, Director at the National Institute of Advanced Industrial Science and Technology (AIST), in a joint research with Masahiro Go, Chief Research Scientist of Stem Cell Sciences Ltd., transduced a single gene into human mesenchymal stem cells and successfully restored their proliferation and differentiation abilities (osteogenic differentiation).

With the help of an AIST-developed technology, culture-expanded mesenchymal stem cells from the marrow of a patient are being used for regeneration medical therapy for his/her damaged bone or heart. However, the clinical application of this technology is limited, because the proliferation and differentiation abilities of these cells decline drastically within several weeks after the culture. In the joint research, the researchers transduced a gene, *Nanog* or *Sox2*, which is expressed by embryonic stem cells, with the aid of a retrovirus into stem cells with reduced proliferation and differentiation abilities.

The proliferation and differentiation abilities of the cells into which the *Nanog* gene was transduced were either restored to the normal levels or increased in comparison to their initial (right after the primary culture) levels. The proliferation and differentiation abilities were not restored in the cells into which only the *Sox2* gene was transduced; however, they were restored when these cells were cultured with a protein named basic fibroblast growth factor (b-FGF).

Because the cells used in this research were cryo-preserved cells that had already been used for clinical purposes, the research results will soon be applicable to clinical use, and the application of regeneration medicine is expected to expand considerably.

<http://www.aist.go.jp>

Software verification technology

Fujitsu Laboratories Ltd. and Fujitsu Laboratories of America, Inc. announced today their joint development of the world's first core technology for automatic verification of Java-based practical-use web applications. It is used to automatically verify if a web application can operate properly to process specified task transactions - referred to as "business specifications", without the need for manually preparing detailed test procedures or test data.

This new technology has been developed based on verification technology called "model checking", that has been conventionally used for small-scale embedded software. It enables exhaustive and automatic testing that completely covers various scenarios and input data by users, for practical-use web applications such as purchase order systems, and can thereby contribute significantly to the development of high-quality systems.

As Internet technology is becoming more widespread, increasingly more companies are utilizing web applications to create internal mission-critical systems, such as purchase order systems or inventory management systems. Furthermore, in conjunction with the highly dynamic nature of business-

es, enterprise systems are becoming larger and more complex, thus requiring more aggressive lead-times for development and testing. Given these circumstances, there is a need for technology capable of ensuring software quality to satisfy customer requirements.

Technological challenges

In order to assure the quality of web applications, testing is conducted to verify that the developed web application functions properly in accordance with its business specifications. Conventional testing necessitated significant manual effort, as a developer needed to review business specifications and determine which parameters to verify, then create test scenarios and test data in order to test those parameters, and then finally perform rigorous testing. It is generally known that even if such testing is conducted, 0.122 errors per 1,000 steps will remain. This is attributable to the fact that it is highly difficult to avoid errors when depending solely on manual efforts, as it is extremely difficult to thoroughly cover all conceivable test scenarios.

Newly-developed technology

In order to overcome these difficulties, building on formal verification that had been conventionally used for small-scale programmes, Fujitsu Laboratories developed a new technology that enables automatic and exhaustive testing of large, practical-use Java-based web applications to verify their functionality with respect to the transaction specifications.

The key features of this new technology are as follows:

Automatic verification of business specifications for Java programs

A business specification is described using a simple specification language that covers a large number of conceivable test scenarios and test data. Following the specification, an engine, based on this new technology, automatically verifies whether the program operates according to its transaction

specifications. As a result, program developers are freed from the burden of developing detailed test scenarios or test data.

Verification of practical-use web applications

The new technology divides the web application into three parts: screen processing, transaction processing, and database processing; then it extracts just the transaction processing part and verifies it. This enables efficient verification of practical-use web applications, by limiting the scope of verification.

Enables exhaustive verification

By executing tests on variables, without instantiating concrete test data for those variables, the new technology enables exhaustive verification that is equivalent to testing all input variations, thereby making it possible to detect errors that were previously hard to detect through conventional testing methods.

As the world's first, Fujitsu Laboratories applied formal verification to business specifications of practical-use Java-based web applications written. The verification system is based on Java PathFinder, the open source verification tool developed by NASA Ames Research Center. Collaborating with NASA Ames Research Center, Fujitsu Laboratories has enhanced the functionality of Java PathFinder in order to develop this verification system.

Results

In an experiment in which this technology was used, it was verified that over 1,000 test scenarios were exhaustively generated for each function of a web application, compared to just approximately 30 test scenarios that had been created when using conventional manual test methods. It was also confirmed that 30 per cent to 50 per cent of the testing process could be automated. Furthermore, this technology offers consistent and high-quality results for practical-use web applications, as there is no need for programme developers to manually create test scenarios for each function.

<http://www.japancorp.net>

INDIA

Device to detect insects in stored grains

Central Institute of Post Harvest Engineering and Technology (CIPHET), Ludhiana, said it has developed a mechanical device for detection of insects in stored grains. The device is capable of instant detection and a fair quantification of insect infestation in stored foodgrains. It also facilitates detection of live or dead insects besides visualizing egg infestation in grain samples, said a statement from CIPHET, a research institution under the Indian Council of Agricultural Research (ICAR). CIPHET recently patented the device and is ready for its commercial manufacturing through licensing.

"The device is simple in design and fabrication. It is also portable and inexpensive. As a result of its unique movement, the insects hiding in the grain get frightened, wander and are then screened out from the grain sample," said a spokesperson of CIPHET. The official added that the device can be suitably used to detect a variety of insects such as grain borer, rice weevil, red flour beetle, rusty grain beetle and saw-tooth grain beetle in different types of cereals, pulses, oilseeds and other similar commodities that are infested during storage. It is also capable of detecting the carry over infestation from the field harvest.

The instrument will cost Rs 3,500-4,000, and will be useful for storage godowns such as the Food Corporation of India and the Central Ware Housing Corporation, where there is a need to examine the level of infestation caused due to improper storage.

<http://www.hindu.com>

New plan to recycle wastewater

Installation of sewage treatment plant (STP) in requisite numbers in Uttar Pradesh and elsewhere may still be a distant reality. But this has not deterred scientists from coming up with yet another plan to "recycle" wastewater to be used

for domestic purposes. The new plan revolves around the fact that a lot of water is wasted while flushing away human excreta, and that the same water should be recycled while the remaining is used in the manufacture of fertilizers.

The technology has been developed by a team of experts from the environmental division of the civil engineering department of the Indian Institute of Technology, Kanpur (IIT-K). Prof Vinod Tare, team leader of the project said that the technology uses the force of flushing water so that the excreta gets precipitated into a chamber to be used later as a fertilizer, while the water is recycled back to the system.

Prof Tare was in the city to attend a seminar on 'Sanitation: The Challenges Ahead', jointly organized by the Institute of Engineering and Technology (IET) and Indian Water Works association (IWWA). "A lot of water is wasted in washing and flushing off. This water, in fact, finds its way into the water bodies which themselves get polluted heavily," he said. The technology, he said, forms part of the 'ecosan' (ecological sanitation) theory in which ecology forms an integrated part of sanitation.

The experiments to this effect are being done with the help of Research Design and Standard Organisation (RDSO) of Indian Railways in a bid to prevent human excreta from falling on railway tracks, while recycling water back to the flushing system. Another such experiment is being done in Aligarh, where environmentalists from IIT-K are engaged in giving a final shape to the community sanitation project.

<http://timesofindia.indiatimes.com>

REPUBLIC OF KOREA High quality aluminium oxide coating film

Engineers said that they have developed a method to mass produce nanoporous films needed to make high quality aluminium and used in other advanced materials. The technology developed jointly by the Korea Research Institute of Standards and Science

(KRISS) and Germany's Max Planck institute is expected to greatly help improve the characteristics of aluminium and be used to advance nanotechnology. The findings have been published in the latest issue of Nature Nanotechnology journal. Because of its relative lightness and strength, aluminium is used around the world in such products as soda cans, various machinery, automobiles and airplanes.

At present, aluminium is subject to a so-called anodizing process that covers the material with a fine coat of aluminium oxide film. This film provides strength, anti-corrosive protection and excellent electrical insulating properties. The anodizing process, which leaves 10 billion nano-porous holes within a 1-centimeter-square surface of the film, is created by using high voltage electrical currents and sulfuric acid. This procedure is also time-consuming.

"Both hard and mild anodizing processes used to make aluminium leave uneven holes that are not perfectly aligned, have microscopic cracks that affect quality, and require considerable electrical power," said Lee Woo, the KRISS engineer in charge of research for the project. He said the new method called "pulse anodizing" selectively utilizes the pros of both the hard and mild processing to make perfectly even and well aligned nano-porous structure in the coating film. The engineer added that this method uses less power and has a shorter production cycle which is a prerequisite for industrial mass production.

The engineer said the finished aluminium product made with pulse anodizing is stronger and of higher quality. Lee, in addition, said that the aluminium oxide film created in this manner has applications as customized nano-lines and tube structures used in industrial patterning masks, filters and other high-tech products.

<http://www.korea.net>

Nano-patterning technology for ultra small devices

A new nano-patterning method has been developed using electron micro-

scopes and lithograph technology that opens new horizons for the building of ultra small devices of the future, the Republic of Korean scientists said. The team, led by Seoul National University professor Kim Ki-bum, said the Atomic Image Projection Electron-beam Lithography (AIPEL) makes use of natural patterns found in everyday objects at the atomic level, to create so-called quantum dots and lines that can be used on a 10 nanometer scale or smaller.

Engineers have said that with existing technology, circuits in silicon wafers used in high density semiconductor chips cannot be made below 25 nanometers, due to the physical limitations of "sculpturing" dots and lines. A nanometer is one-billionth of a meter. Making smaller circuitry is key to advances in future nano-technology, since such advances could drastically cut down on the size, weight and energy consumption of devices.

"Compared to current lithography techniques used to make circuits on silicon wafers, the new method is 33 times more efficient in terms of ease of production and fine detailing," the materials engineering professor said. "What makes the AIPEL so different is that if a person can see an atomic pattern through an electron microscope, it can be made into a natural mask that can then be carved quickly, cheaply and easily using conventional electron beams and photo resistant materials," the scientist said.

Experimental lithography technology can make small dots and lines that are 1-3 nanometers in size, but since they have to be sculptured individually, such a process will take forever to make any useful device. He said at present, because of limitations in photo-resistant materials, it is impossible, even with the new advances, to make lines and dots that are smaller than 20 nanometers, but once this limit is removed there would effectively be little to stop making devices that are very small. Kim, however, said that while the new technology can help make dots and lines that are perfectly uniform and aligned to reflect natural atomic structures, it is not designed to be crafted or made into actual circuits.

"AIPEL will likely be used to augment existing devices like semiconductors by providing ultra fine details in certain parts that can enhance overall properties," the professor said. He said the technique has the potential to be used in the creation of nano-scale electronic devices, new image and sound recording disks, super fine beams and sensors.

The 21 Century Frontier R&D Program supported by the Ministry of Education, Science and Technology said while more work is needed, the new discovery overcomes existing limits in nanotechnology that have not been resolved in the last decade. It added that while Japan's JEOL took part in the construction of the AIPEL, the Republic of Korea held the basic patents for this discovery and will have an edge in this field in the coming year. The cooperation was necessary since the Republic of Korea does not have the required technology in the electron microscope field.

<http://www.korea.net>

MALAYSIA

Low cost hydro-power system

Supplying electricity to the remote communities in Malaysia is difficult due to their distance and difficult terrain, yet most of these villages are situated near fast flowing rivers, where potential energy lies untapped. UNIMAS researchers have built a low-cost system which is currently undergoing its pilot project.

A micro-hydro system can be made possible to electrify these areas; even though earlier efforts on micro-hydro project development have not generated interest on the part of the government. Marred by failure to deliver, the high initial cost (RM 4-20 million) involving foreign expertise was not practical, especially when one is looking at the need to serve thousands of remote villages.

Using off-the-shelf materials, and maximizing local expertise and manpower, a micro-hydro system can be built to suit local requirement. By eliminating the foreign elements (foreign exchange rate and expertise), a low-cost system was

built at a fraction of the normal cost. The pilot project was conducted in Kampung Abok Mawang, Sri Aman, Sarawak, where a locally-built turbine was used to run a conventional AC generator.

The power generated from the test turbine was used to power common household electrical appliances. Improved future supply would see to the need of village industry, especially agricultural product processing and ICT usage.

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<http://www.innovations-report.com>

THAILAND

Oral AIDS vaccine

Mr. Vichai Jirathitikal, a pharmacology graduate of Mahidol University has developed an oral AIDS vaccine originally named V-1 or V1. V1 comprises pooled, inactivated HIV antigens derived from E and B clades of HIV-1 strain predominant in Thai population, and is currently manufactured at a pharmaceutical plant owned by his family. The factory received GMP status from the Thai FDA in July 2001. In contrast to other AIDS vaccines, V1 is administered orally and not by injection.

V1 is a specially formulated pill that contains HIV-1 viral antigens capable of withstanding the degradation in the stomach. As a result, V1 can pass into the gastrointestinal tract and will be eventually presented by intestinal enterocytes to underlying mucosal immune cells. The V1 is presented as an 850 mg, pink-coloured oval-shaped pill. V1 can be stable at ambient temperatures for more than a year.

In the last few years, Mr. Jirathitikal has treated about 500 HIV-positive patients at his clinic in Bangpakong near Bangkok City. In June 2001, V1-Immunitor was distributed free of charge to about 40 thousand HIV-infected individuals. Immureboost Corporation primarily sponsored the distribution.

V-1 is the most advanced product that has been used by over 66,000 thousand AIDS patients in more than 60 countries around the world. In a recent clinical study, V-1 has normalized elevated liver enzymes in 95 per cent of treated patients within one month, indicating that V-1 is potentially effective for hepatitis treatment.

<http://www.biospectrumasia.com>

EUROPE

Novel class of hybrid materials

A novel class of hybrid materials made from metals and organic compounds is changing the face of solid state chemistry and materials science just 10 years after its discovery, with applications already in safe storage of highly inflammable gases such as hydrogen and methane.

Europe is aiming to capitalize on core strengths in the field and build a critical mass by combining the diverse range of skills required within a coherent research network, following a major workshop organized by the European Science Foundation (ESF).

The materials called MOFs (Metal Organic Frameworks) represent one of the biggest breakthroughs in solid state science whose potential is only just being realized, according to the ESF workshop convenor Gérard Férey. "The domain is currently exploding, and there are so many potential applications that it is difficult to decide how to prioritize them. The only limit is our imagination," said Férey.

There is no doubt though that the first big application of MOFs - storage of gases - will be highly important, given the urgency of developing alternatives to fossil fuels for automobiles. "For hydrogen storage, MOFs are already used, and many carmakers have these products in prototypes," said Férey.

MOFs are porous materials with microscopic sized holes, resembling honeycombs at molecular dimensions. This property of having astronomical numbers of tiny holes within a relatively

small volume can be exploited in various ways, one of which is as a repository for gases. Gas molecules diffuse into the MOF solid and are contained within its pores. In the case of gas storage, MOFs offer the crucial advantage of soaking up some of the gas pressure exerted by the molecules. This makes hydrogen derived from non-fossil energy sources such as fuel cells, or even genetically engineered plants, potentially viable as a fuel for cars while the alternative of pressurized canisters is not. The key difference is that the amount of gas stored in a conventional cylinder at say 200 atmospheres pressure could be accommodated in an MOF vessel of the same size at just 30 atmospheres, which is much safer.

The porous nature of MOFs enables them to be exploited in quite another way as catalysts to accelerate chemical reactions for a wide variety of materials production and pharmaceutical applications, although this field, as Férey noted, is still in its infancy. Yet already the field is gaining interest beyond academia from serious companies, with a significant development at the ESF workshop being the presence and support of German chemicals giant BASF. This, in turn, has provided high endorsement of the field's potential and has stimulated interest from other companies, according to Férey.

But several challenges remain before this potential can be realized, the first one being to assemble research and development teams with the right body of skills. As Férey noted, many of the skills already exist but the researchers need to expand their horizons and focus more broadly on the big picture beyond their specialised domains. There is also the technical challenge of learning first how these materials are formed, and then applying the knowledge to design MOFs matched to specific requirements. MOFs are crystalline solids that form in highly regular patterns from solutions, just as salts and sugars do. Researchers need to learn how to manipulate the starting conditions to obtain just the crystalline composition and arrangement they want.

<http://www.innovations-report.com>

GERMANY

Diesel particulate filter technology

Most diggers and construction machines discharge unfiltered exhaust fumes into the air. This is because special vehicles are made in small batches, and each requires a different filter geometry. Diesel soot filters of varying shapes can now be produced at competitive prices.

Modern diesel cars are not only quieter than their predecessors but also release considerably fewer exhaust fumes into the atmosphere. The filters for heavy-duty, construction and off-road vehicles are not yet state-of-the-art. A new diesel particulate filter technology will soon teach even these vehicles to give up smoking.

Conventional diesel soot filters usually consist of cylindrical ceramic blocks crisscrossed by numerous channels. A block of this kind cannot be made in one piece. Instead, individual quadratic honeycomb segments are bonded together to form a large block. The bonds act as expansion joints that offset the temperature stresses during operation. This is vital, for a solid ceramic block would break apart. The drawback of these square honeycombs is that the angular bonded block has to be ground into a cylindrical shape at the end of production, thus wasting valuable material. What is more, this smooth finishing takes time and requires expensive machinery.

Together with filter manufacturer CleanDieselCeramics CDC and sponsored by Saxony's Ministry of Economics, developers at the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden have developed a honeycomb structure with a different geometry. Rather than being rectangular, it takes an irregular four-cornered shape. This allows a wide variety of filter geometries to be created - even close-to-cylindrical ones. Grinding is no longer necessary.

An added advantage of this development is the altered geometry of the channels. Usually, the gas flows into the filter through four-sided channels. The Dresden researchers have opted

for a smaller, triangular cross-section. This enlarges the filter surface in the tiny channels. The triangular shape is also more stable, and the filter is less sensitive to lateral pressure.

The partners in this venture have tested and optimized the production method on a pilot production line at the IKTS - and also tested the third innovation, a silicon carbide ceramic developed at the IKTS.

The advantage of this latter innovation is that the researchers can easily and precisely adjust the size of the pores for optimum filtration of the soot particles. "As far as the performance and quality of our new development is concerned, we can hold our own against anything on the market," says IKTS project manager Jörg Adler. The up-and-coming firm CDC is currently building its first plant near Dresden. About 40,000 filters will be produced there this year annually, and installed in construction machinery as an upgrade kit.

<http://www.sciencedaily.com>

THE NETHERLANDS

Cheap solar cell process

A cheap alternative to silicon solar cells can be found in dye-sensitized solar cells. This type of cell imitates the natural conversion of sunlight into energy by, for instance, plants and light-sensitive bacteria. Annemarie Huijser, who will soon receive her PhD from TU Delft, has succeeded in substantially improving a process in this type of solar cell, which is similar to Grätzel cells.

The use of solar cells is increasing very slowly. One of the reasons is that the most commonly used type, made from silicon, is quite expensive to manufacture. That is why there has been a great deal of research in alternative solar cells over the past few years.

In searching for solutions, scientists are inspired by nature. Plants are able to transport absorbed solar energy over long distances, typically about 15-20 nanometres, to a location in which it is converted into chemical energy. This is because the chlorophyll molecules in their leaves are arranged in the best

possible sequence. Annemarie Huijser attempted a partial recreation in solar cells of this process as found in plants.

She focused on what are known as dye-sensitized solar cells. These comprise a semiconductor, such as titanium dioxide, covered with a layer of dye. The dye absorbs energy from sunlight, which creates what are known as excitons. These energy parcels then need to move towards the semiconductor. Once there, they generate electric power.

By studying the best sequence of dye molecules, Annemarie Huijser succeeded in increasing the average distance which the excitons move in the solar cell by twenty times up to a distance of approximately 20 nanometres, comparable to systems found in nature. This substantially increases the efficiency of the cells.

Grätzel cells

The solar cells used by Huijser are closely related to the more widely known Grätzel cells. In the case of Grätzel cells, however, the dye and semiconductor are very close to each other, almost blended. As a result, the excitons do not need to move that far. One disadvantage of this type of cell, however, is the complicated method of charge transport. For this reason, Huijser chose to adopt a different approach and use this simple dual-layer system of dye and semiconductor.

<http://www.innovations-report.com>

SWEDEN

Photonic technology boosts microwave signals

Researchers at Chalmers University of Technology have investigated the possibility of using fibre optic technology to generate and distribute microwave signals in future wireless networks. This technology is important to meet the increase in demand for mobility and high data rates.

Using optical fibre for the distribution of microwave signals has several benefits compared to using electrical ca-

bles. Optical fibre has low loss and frequency-independent attenuation. It is also insensitive to electromagnetic interference, low in weight, small in size and low in cost.

To meet the future demand generated by the constantly increasing number of devices that are wireless connected, and at the same time maintain full mobility and high data rates, new higher frequencies must be brought into use, as the frequency space is becoming congested.

In a new PhD thesis by Andreas Wiberg at the Photonics Laboratory at Chalmers, research is presented which deals with optical generation, modulation and distribution of signals in micro- and millimetre-wave applications. The results obtained include demonstrations of transportation of 40 GHz signals over 44 km of optical fibre modulated with 2.5 Gbit/s data, transmitted through a wireless link in a laboratory environment.

"Fibre optic solutions are particularly beneficial at high frequencies and over longer distances. Combining photonic technology and microwave applications opens up new, interesting possibilities and technical solutions," says Andreas Wiberg.

In order to also maintain sufficient coverage at high frequencies, new wireless systems with distributed antennas are required for both indoor and outdoor solutions. These antennas can be managed from a central location and with centralized control; and dynamic channel allocation is possible in order to follow fluctuations in traffic load and maintain good wireless coverage.

Researchers at the Department of Microtechnology and Nanoscience at Chalmers University of Technology have investigated the possibility of using fibre optic technology to generate and distribute microwave signals for future networks with wireless Gigabit's data rates so-called Radio-over-Fibre.

The work by Andreas Wiberg also presents details of how several frequencies and/or frequency bands can be sent in parallel through a microwave photonic system in which optical filtering is used to separate the different frequencies. It is also shown that optical

techniques could be used to generate high-frequency harmonics from electrically generated signals.

The use of photonic technology in microwave applications is referred to as Microwave Photonics and has many applications apart from communication. Microwave Photonics can also be used in analogue applications, such as reference signal generation and distribution of these signals to antenna arrays. Examples of such applications could be phase-steered radar antennas or large antenna arrays for radio astronomy.

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NORTH AMERICA

USA

Cheap, efficient thermoelectrics

Thermoelectric materials promise everything from clean power for cars to clean power from the sun, but making these materials widely useful has been a challenge. Now researchers at MIT and Boston College have developed an inexpensive, simple technique for achieving a 40 per cent increase in the efficiency of a common thermoelectric material. Thermoelectric materials, which can convert heat into electricity and electricity into heat, hold promise for turning waste heat into power. But thermoelectric materials have not been efficient enough to move beyond niche applications. The new jump in efficiency, achieved with a relatively inexpensive material, may finally make possible such applications as solar panels that turn the sun's heat into electricity, and car exhaust pipes that use waste heat to power the radio and air conditioner.

The researchers started with bismuth antimony telluride, a thermoelectric

material used in niche products such as picnic coolers and cooling car seats. Then Gang Chen, a professor of mechanical engineering at MIT; MIT Professor Mildred Dresselhaus; and Boston College physics professor Zhifeng Ren crushed it into a powder with a grain size averaging about 20 nanometers, and pressed it into discs and bars at high heat. The resulting material has a much finer crystalline lattice structure than the original material, which is made up of millimeter-scale grains. Chen and Ren's nanocomposite formulation of the material is 40 per cent more efficient than the conventional form of the material at 100 °C, and it works at temperatures ranging from room temperature to 250 °C.

"Power-generation applications (for thermoelectrics) are not big now because the materials aren't good enough," says Chen. He believes that his group's more efficient version of the material will finally make such applications commercially viable.

Thermoelectric materials must be able to maintain a heat gradient, which means that they must be good conductors of electrons and good thermal insulators. When one end of a bar of thermoelectric material is heated, electrons move from the hot side to the cold, creating an electrical current. If a material conducts heat well, this current-generating temperature gradient will dissipate. Unfortunately, in most bulk materials, electrical conductivity and thermal conductivity "go hand in hand," says John Fairbanks, who heads thermoelectrics efforts in the Department of Energy's Vehicle Technologies Program.

One approach to making better thermoelectric materials has been to build nanostructured materials from the bottom up. Interfaces in these materials reflect the flow of heat without impeding electrical current. Researchers who have grown arrays of silicon nanowires, pressed silicon and germanium nanowires into millimeter-scale bars, and tested single organic molecules have had success on a small scale, but making such materials in bulk is a major hurdle.

The researchers' nanocomposite technique creates many interfaces in the

material that reflect thermal vibrations, says Chen. Peidong Yang, a professor of chemistry at the University of California, Berkeley, says that the work is "a great example of how defect engineering can significantly impact the (vibration) transfer in solids."

Ren says that it is easy to make large amounts of the nanocomposite material: "We're not talking grams; we're not talking kilograms. We can make metric tonnes." Because bismuth antimony telluride is already used in commercial products, Ren and Chen predict that their technique will be integrated into commercial manufacturing in several months.

<http://www.technologyreview.com>

Bioinformatics technology

Scientists may gain a new insight into the relationship between viruses and their environments thanks to a new computational technology developed by researchers at the U.S. Department of Energy's (DOE) Argonne National Laboratory. This technology has already been used to identify subtle differences in the metabolic processes of microbial communities. The ability to determine such differences may help scientists detect environmental changes at early stages and identify previously unknown pathways for treating disease.

The researchers analyzed the frequency distribution of more than 14 million microbial and viral sequences from almost 90 different ecological communities, called metagenomes. By doing so, they hoped to produce a biological profile for the samples taken from diverse environments, ranging from underground mines to sea and fresh water.

"Metagenomics enables the DNA from all microbes to be sequenced at once, without any culturing," said Robert Edwards, a computational biologist at Argonne and San Diego State University and one of the project's principal investigators. "Such an approach was impossible even a decade ago."

While the researchers had expected to find similar lifestyles among the viral metagenomes in every environment,

they instead found that the metagenomes have distinctive metabolic profiles. Researchers may be able to use these profiles in the future to answer questions about the viral dynamics in, for example, the lungs of cystic fibrosis patients.

As the use of metagenomics has become increasingly common, scientists have had to address the challenge of analyzing an enormous number of genomic sequences. To ease this process, scientists at Argonne and the Fellowship for Interpretation of Genomes (FIG) developed a system that contains all known DNA and protein sequences. Using this directory, known as SEED, biologists can identify matches between metagenomes and profiles already in the SEED database.

For this study, DNA sequences were first analyzed by using a high-throughput pipeline called the metagenomics RAST (Rapid Annotation using Sub-system Technology) server (<http://metagenomics.theseed.org/>), developed by researchers from Argonne in collaboration with FIG, the University of Chicago, San Diego State University and Hope College.

"Comparing such a huge number of metagenomes is an enormous computational task," said Rick Stevens, a principal investigator in the project and associate laboratory director of Computing, Environment, and Life Science at Argonne. "This automated technology revolutionizes the steps needed to acquire an accurately annotated genome."

The sequences then were compared to the SEED platform by using the compute cluster at the National Microbial Pathogen Data Resource. The database allows an overview of the microbial communities and the ability to focus on one metabolic area and detect differences in the proteins being used by the microbes in each environment.

"The initial analysis took months of computer time," said Stevens. "We eventually determined that more than 1 million sequences from the microbial metagenomes and more than 500,000 from the viral metagenomes were significantly similar to functional genes within the SEED."

<http://www.eurekalert.org>