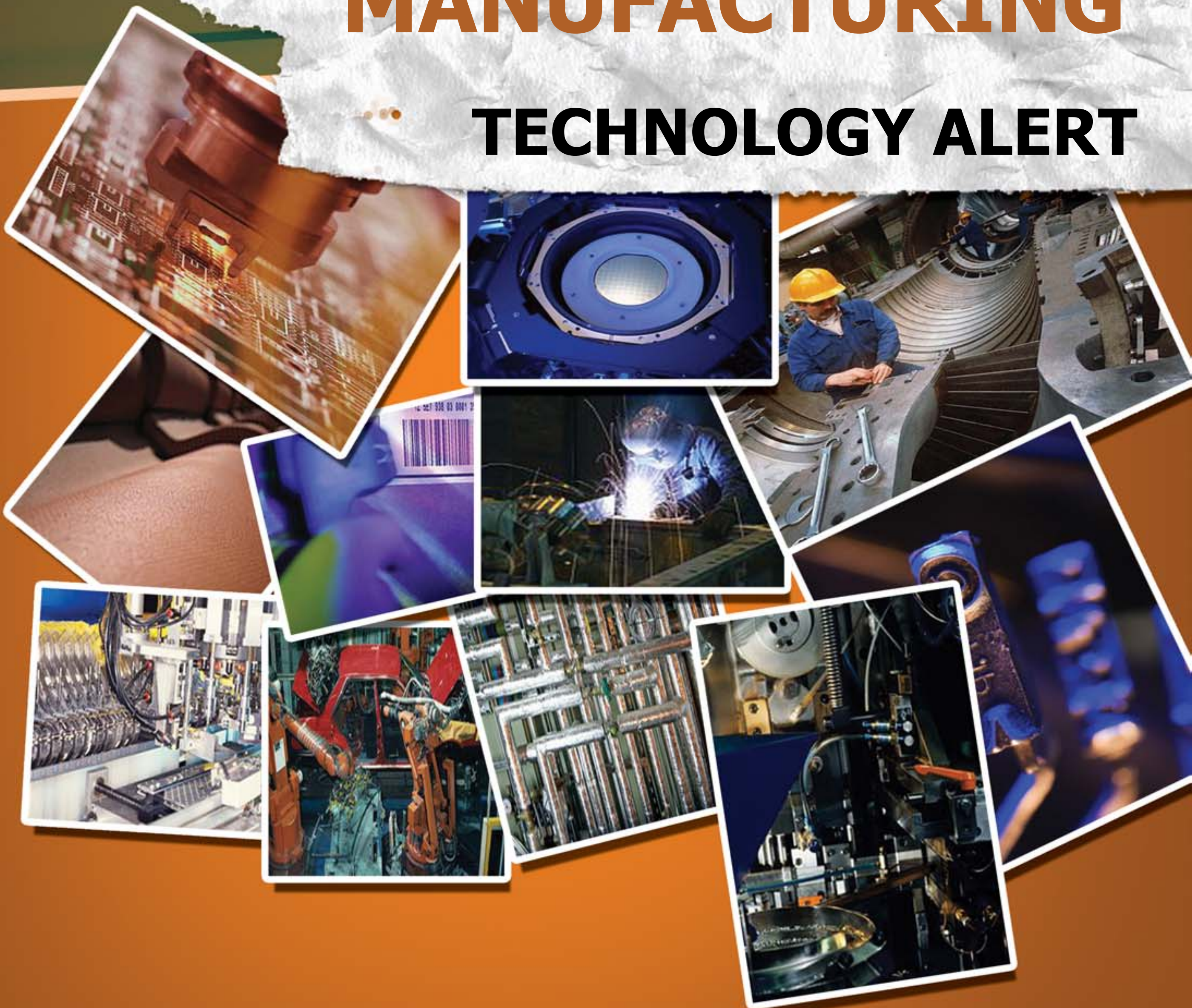
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



04th December 2015

1. NOVEL TECHNIQUE FOR MANUFACTURE OF ULTRATHIN SOLAR CELLS

The increased awareness concerning global warming and various government regulations across the world are pushing the adoption of renewable energy in various sections of the economy. There are many types of renewable energy sources available. Among the various renewable energy sources, the most popular is solar energy simply because of its abundant availability.

Over the years, solar energy harvesting technologies have shown tremendous progress. Technology development has reduced the price of solar cells and panels. Solar cells and an array of solar cells called solar panels convert sunlight falling on them into electricity.

A key technology advancement that has influenced solar cell technology entails ultra-thin films. Ultra-thin film technology has made solar cells very thin and efficient at the same time. Also, ultra-thin film technology involves processes that make manufacturing costs lower than the technologies hitherto available.

Now, a group of researchers from the US Department of Energy's Oak Ridge National Laboratory (ORNL) have found a solar cell manufacturing process that can further reduce the cost of solar cells. The research team consisted of scientists from ORNL’s Spallation Neutron Source (SNS) and the Center for Nanophase Materials Sciences (CNMS). The ultra-thin films of silicon are usually arranged in layers to create organic bulk heterojunction solar cells (BHJs). The silicon films convert the incident solar energy into electricity.

The silicon ultrathin films are produced in a solution that contains equal portions of conjugated polymers and fullerenes. Fullerenes are carbon molecules made up of carbon atoms arranged in soccer ball shape. When the films are still in the solution, the solution is spin cast on a rotating substrate to ensure the polymer and fullerenes are equally distributed on the films. After this stage, the films are subjected to annealing. Annealing is the process of heating a material and then cooling it. Annealing increases the toughness of the film and reduces its hardness.

The annealing process performed on the films is expensive and time consuming. The researchers have found a way to eliminate the thermal annealing process by using a solvent in the solution that is used for producing the films. According to the researchers, the key to achieving the new solution was to optimize the morphology of the film to improve device performance. Identifying ways to tune the morphology of the film is vital for understanding the increased performance of certain morphologies over others.

The solvent used by the researchers is 1,8-diiodooctane (DIO), an organic solvent. This solvent was mixed into the solution of polymers and fullerenes. The solvent helps the fullerenes to dissolve better in the solution. The greater solubility of the fullerenes helps in making the structure of the film more uniform.

Basically, the even distribution of the polymer (light absorbing molecules) and fullerenes ensures better flow of current. If the polymer and fullerenes are not distributed evenly on the film’s surface, separate clusters of polymer and fullerenes are formed on the surface of the film. The clusters will often absorb the flowing electrons and consequently bring down the solar energy conversion efficiency of the film.

The researchers compared the morphologies of silicon solar films produced through thermal annealing and the solvent method by using neutron scattering. Neutron scattering was used because of the dimensions of the thin film. The thin film has a thickness of about 100 nanometers. The comparisons revealed that the morphology of the annealed film samples indicated that there was a significant separation between polymer and fullerene molecules. On the other hand, the films produced by using the DIO solution showed a rather uniform distribution of both the molecules.

The researchers believe that this is a significant step in understanding the morphology of ultrathin solar films. The ability to modify the morphology will aid in understanding and optimizing the photovoltaic properties of thin films, which will pave way for development of customized solar cells with the desired morphology and performance.

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2. MORE ECONOMICAL PRODUCTION OF GRAPHENE

Graphene, a thin (one-atom thick), transparent, planar layer of pure carbon, has key notable properties, such as extraordinary strength and tensile stiffness, excellent conductivity of heat at room temperature, outstanding conduction of electricity, and unique levels of light absorption. Graphene has key potential in a range of applications, such as lightweight, ultra-thin, flexible, yet durable display screens, electronic circuits, solar cells, various medical (including drug delivery), chemical and industrial processes, batteries, and sensing (including chemical sensors, biosensors, photodetectors, Hall effect sensors), and so on.

Another potential opportunity for graphene entails artificial skin, where graphene of high quality and lower cost has potential to provide an ultra-flexible, conductive surface to help provide enhanced sensation in prosthetics.

Despite its extraordinary properties and characteristics, widespread adoption of graphene has been constrained due to challenges in being able to produce high- quality graphene on a large scale at low cost and in a reproducible mode.

Researchers at the University of Glasgow in Scotland, led by Ravinder Dahiya of the School of Engineering at the University of Glasgow, have discovered a way to produce large sheets of graphene by using the inexpensive copper that is employed to manufacture lithium ion batteries. The researchers have been able to produce large-area graphene that is about 100 times less expensive than previously.

A key, common technique for the production of graphene entails chemical vapor deposition (CVD), which transforms gaseous reactants into a film of graphene on a substrate surface. The researchers used a similar process to create high-quality graphene across the surface of commercially-available copper foils; the same type of copper foil frequently used as the negative electrodes in lithium-ion batteries. The copper’s ultra-smooth surface provided an excellent bed on which the graphene forms.

Compared to materials produced from an older process, the graphene produced provided significant improvement in the electrical and optical performance of the transistors created by the researchers. The commercially available copper utilized in the process has a retail price of about $1 dollar per square meter compared to about $115 for a similar amount of carbon now used in graphene production. Furthermore, the more expensive graphene has frequently required preparation before use, which adds to the cost of the process.

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3. NOVEL MARKETING TRENDS IN THE AUTOMOTIVE INDUSTRY

The automotive industry is constantly developing new next-generation technologies which will boost vehicle performance and at the same time increase motorists' user experience.

Volvo, a key participant in the automotive industry released the Google cardboard app in 2014. This app gave users a simulated test-drive, enabling an experience of driving the Volvo XC90 SUV virtually. Now, the company has collaborated with Microsoft Corporation, a giant in the software industry, to develop a new next-generation virtual reality technology using HoloLens.

HoloLens, developed by Microsoft Cooperation is a highly innovative untethered, holographic wearable computer, which is embedded inside a headset. This novel technology will be used to provide customers an interactive, real-time experience in which they will be able to explore different variants, models of the vehicle colors, wheels and even check the skeleton of the vehicle. Using the HoloLens Technology, Volvo is planning to design virtual showrooms, eliminating the requirement of showcasing different models, variants and colors of the car in large showrooms.

The HoloLens consists of a series of advanced sensors, a graphic processing unit (GPU), and a state-of-the art central processing unit (CPU). The device is powered with the help of a holographic chip and a special custom-built silicon chip. The device also uses a Holographic Processing Unit (HPU) to capture real-time images.

Volvo strongly believes that by implementing new and advanced technology to enhance customer experience in a showroom, the marketing and sales of its vehicles will tremendously increase in the near future.

To improve sales and provide customers a better experience in purchasing vehicles, a company called Carvana has designed and built a car vending machine in Nashville (USA).This new car vending machine is one of a kind and is a multi-story atomized building. The vending machine is made of glass and can hold up to 20 cars. The machine also consists of three delivery bays and a reception room.

The customer will first chose and buy the car online in the Carvana website and go to the car vending machine. The customer will first enter the reception and select his/her car in the kiosk. A Caravan-branded coin, which activates the vending machine, is given to the customer. Once this coin is inserted in the vending machine, the chosen car is moved to the delivery bay. The customer also gets a process video which shows the automatic mechanism of how the car is automatically moved to the delivery bay. The company also provides their customers with seven-day test ownership period**.** The car can be returned within this ownership period if the customer is not satisfied with the car.

As this system automatically delivers the cars and does not require any manpower, Carvana is confident that it will be able to decrease the prices of the vehicles accordingly in the near future although the implementation cost of the vending machine is high.

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4. OPPORTUNITIES IN 3D PRINTING OF METALS

Three-dimensional (3D) printing, or additive manufacturing, is a significantly expanding arena that allows fabricating structures, objects, or parts from a digital file via the laying down, rather than removal, of successive layers of material. 3D printing is increasingly capturing interest in key manufacturing industries such as aerospace and automotive, since it enables more efficient and environmentally friendly and less wasteful manufacturing of parts without the need for intermediate tooling.

A key growth arena for 3D printing is the manufacture of metal parts for varied industries or applications, such as aerospace, automotive, oil and gas exploration, healthcare, industrial tooling, heat exchange, and so on. A key emerging sector for 3D printing of metal part sis the aerospace arena, for applications such as fuel nozzles for aero engines, turbine blades, and so on.

Desirable properties of metals for 3D printing include high strength, low weight, corrosion and wear resistance, and biocompatibility (for medical implants). In the aerospace sector, it can also be beneficial to have 3D printed metallic parts that are capable of enduring extreme temperatures and very high mechanical loads. Moreover, other desirable properties for 3D printed metals include less deviation in particle size and pure metals with less oxides that could impair performance.

Indicative of the ongoing interest and expanding opportunities for 3D metal printing, EOS (based in Germany and a key provider of direct metal laser sintering machines for additive manufacturing of metal, as well as selective laser sintering machines for additive manufacturing of plastics) and Netherlands-based Additive Industries, which has unveiled the MeatFAB1metal 3D printer, have signed a patent licence agreement pertaining to industrial additive manufacturing of metals. Initially, the agreement involves licensing certain EOS patents to Additive Industries. The agreement may be extended in the future.

The collaboration will help enable Additive Industries transition 3D metal printing into key, real-world fabrication applications, and can enable expansion of the new production technology from prototyping to the industrial environment. The patent license agreement helps validate the benefits of additive manufacturing for industrial applications. Moreover, the agreement dovetails with EOS' strategy of licensing its intellectual property to others in the additive manufacturing arena.

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5. RECENT PATENTS IN THE FIELD OF NANOMANUFACTURING

Nanomanufacturing involves manufacturing processes aimed at building or assembling nanoscale devices, structures, and features, and producing nanoscale materials. With advancements in reliable, cost-effective means of assembling nanoscale component arrays and improved understanding of systems behavior at the nanoscale, effective nanomanufacturing of integrated systems encompassing devices at the nanoscale, can be achieved.

There are two different techniques adopted in nanomanufacturing, top down manufacturing and bottom up manufacturing. Top down manufacturing involves the use of techniques, such as ultra-precision engineering and lithography. Bottom up manufacturing is opposite of top-down manufacturing, where small pieces are built up to larger pieces using techniques, such as chemicals synthesis, self-assembly and positional assembly.

A recent patent in nanaomanufacturing is powered by inorganic crystallites and additional compounds (US20150210865) is assigned to an individual called Parash Kalita which has been classified as nanomanufactured combinatorial material, coating compositions, such as paints, varnishes or lacquers, characterized by their physical nature or the effects produced.

Nanomanufacturing techniques will highly impact the use of machines that fabricate chips in production. Semiconductor wafers with improved flatness and reduced sub-surface damage will be manufactured. This will result in reduced costs and improved semiconductor device yields. Nanomanufacturing techniques with enhanced chemistries will lead to inexpensive electronic and photonic devices. Combined with advances in self-assembly, this development may bring the semiconductor, materials and chemical industries closer together and enable alternative production methods for chips. Some of the other sectors that would adopt his novel technology on a large scale are health care, automotive and aerospace.

According to the patent filing scenario it can be said that North America has significantly high development in terms of innovation for this novel technology. The US, which has dominated the field of science and space technology, has so far been the leader in nanotechnology research and development. With increasing patents, academic activity, and private and government sector investments, the US nanomanufacturing industry is more advanced than its closest global competitors.

Some of the companies in nanomanufacturing are Zyvex Technologies, Evident, Supervault Energy Inc., Sunvault Energy Inc., and many more.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Combinatorial Materials Architecture and Process for Textiles and Related Applications	30.07.2015; US20150210865	Parash Kalita	Parash Kalita	A multifunctional material composition functioning as a halogen-free flame-retardant finish combined with in certain implementations one or both of antimicrobial and insect-repellant is nanomanufactured by the absorption/adsorption of metallic salts with one or more additional compounds by inorganic crystallites. The identity of the additional compounds is determined by the desired functionality of the substrate. The material composition can be chemically and mechanically applied to substrates (e.g. to cotton, nylon, and polyester based textile fabrics), for example, to yield durable antimicrobial, insecticidal, and environmentally friendly flame retardant materials. The addition of nano-scale metallic deposits to a phosphorous-rich and nitrogen-rich architecture complex improves the flame retardant properties of the substrates.
3-Dimensional Pattern Transfer Nanomanufacturing	19.03.2015; US20150079361	Thomas Crawford	Thomas Crawford	Methods for forming a multi-layered nanoscale structure by forming a stack of individual polymeric layers on a substrate are provided. Each individual polymeric layer comprises a cured polymeric material immobilizing a pattern of magnetic nanoparticles. The pattern of magnetic nanoparticles can be different within each individual polymeric layer due to their nature of formation.
Production method of organic thin-film field effect transistor	06.08.2014; CN103972392	SUZHOU INSTITUTE OF NANO-TECH AND NANO-BIONICS, CHINESE ACADEMY OF SCIENCES	PAN GEBO	The invention provides a production method of an organic thin-film field effect transistor. The method includes a process of producing an active layer on a substrate, and the active layer is formed by jet printing of metal oxides onto a receiving layer via a gasjet printing technique. The gasjet printing technique includes the steps: S1, heating organic semiconductor compounds to enable the same to sublimate to form gas spray; S2 jetting the gas spray onto the receiving layer. Through the gasjet printing technique, the organic thin-film field effect transistor is produced efficiently in nanoscale with low cost, and the method has the advantages of simplicity in operation, accuracy in positioning and wide application range; solids need not to be dissolved into a solution, so that troubles brought by solution preparation in nanomanufacturing technologies such as ink-jet printing and electrospinning can be avoided, and the defects of difficulty in separation and incapability of accurate positioning during traditional PVD (physical vapor deposition), CVD (chemical vapor deposition) and vacuum evaporation can be overcome

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
FABRICATION OF MULTILAYERED NANOSIZED POROUS MEMBRANES AND THEIR USE FOR MAKING NOVEL NANOSTRUCTURES	05.09.2013; US20130228466	Sun Li	Sun Li	Multilayer porous membranes and methods for fabricating the membranes may have applications in filtration, separation, and nanomanufacturing. The layers of the membrane may be selected based on different physiochemical properties, such as ionization rate and/or etch rate. The pores may be formed by high energy particle bombardment and chemical etching. In some embodiments, the multilayer porous membrane may be utilized to form complex nanostructures by selecting different materials for the layers based on physiochemical properties, layer thickness, stacking sequence, and/or varying the pore generation process.
Elastomeric composites with tether-containing conducting polymers for nanoscale diffusion control	29.03.2012; US20120073027	Martin Brett D.	Martin Brett D.	A redox-active conductive polymer includes a charged tether. An interpenetrating network including such a conducting polymer can be switched between two states of diffusivity (porosity) by application of a voltage. Such a material can be useful in breathable protective clothing, controlled release, intelligent sensing/filtration, novel separation processes, nanomanufacturing, and other areas.
"Band-aid"-type potassium ion (K+) biosensor	23.06.2011; US20110152643	Xue Ruipeng	Xue Ruipeng	Potassium ion (K+) is important in regulating normal cell function in the human body, specifically the heartbeat and the muscle function. It is important to be able to monitor potassium ion concentrations in human fluids. This invention describes a novel concept for a potassium ion biosensor that accurately, rapidly, and efficiently monitors the presence and records the concentration of potassium ions with high specificity, not only in serum and urine, but also in the sweat or even eye fluid. This specific biosensor design utilizes a nanomanufacturing technique, i.e. electrospinning, to produce advanced nano-bio-composites that specifically trace even minute quantities of potassium ions through the use of selective bio-receptors (ionophores) attached to high surface area nanofibers. Electroactive polymers are then employed as transducers to produce an electronic (rather than ionic) output that changes instantly with the change in K+ concentration. Such biosensors may be manufactured in a skin patch configuration.
Nanomanufacturing devices and methods	15.04.2010; US20100089869	NanoInk, Inc.	Bussan John Edward	Devices for performing nanofabrication are provided which provide small volume reaction space and high reaction versatility. A device may include a reaction chamber adapted for nanoscale modification of a substrate and vacuum conditions; a scanning probe tip assembly enclosed within the reaction chamber; a first port coupled to the reaction chamber for delivering a gas; a second port coupled to the reaction chamber for applying a vacuum; and a substrate assembly insertedly mounted to the reaction chamber. The reaction chamber may include a body having one or more flexible walls and one or more supports to prevent the reaction chamber from collapsing under a vacuum. The device may further include an electrical conduit for coupling the tips of the scanning probe tip assembly to electrical components outside the reaction chamber. Also provided are apparatuses incorporating the devices and methods of using the devices and apparatuses.

Exhibit 1 lists some of the patents related to nanomanufacturing.

Picture Credit: Frost & Sullivan

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