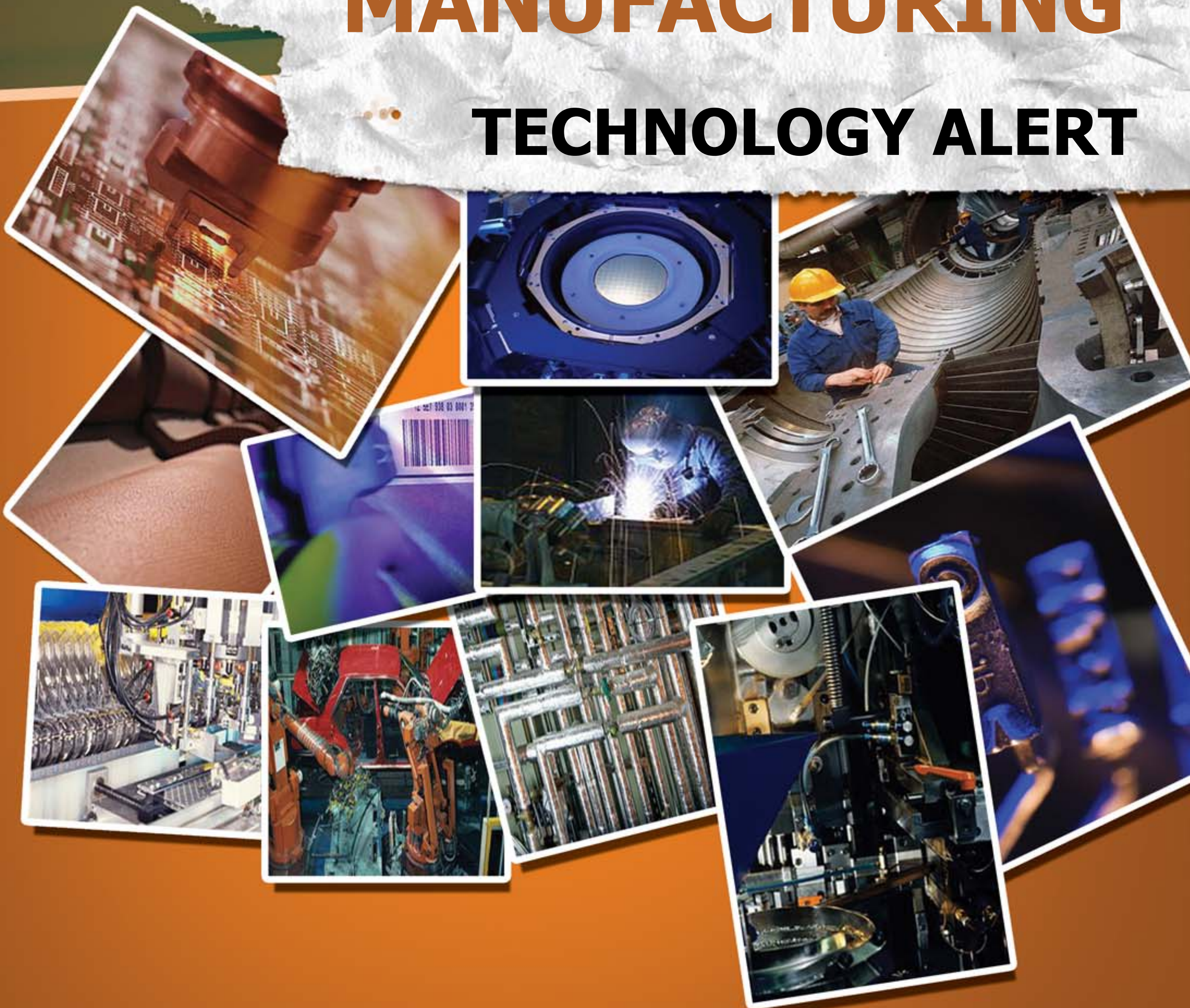
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



25th July 2014

1. WEARABLE ROBOT FOR PERFORMING HOUSEHOLD TASKS

In addition to industrial applications, robots are eliciting increased interest for household functions as well for wearable applications to help people with various disfunctions. Researchers from an university in the United States have developed a novel robotic finger that could be used for performing various household activities.

A group of researchers at Massachusetts Institute of Technology (MIT) has developed a robot that is aimed at enhancing the grasping motion of the human hand. This robotic device can be worn around a person’s wrist and works essentially like two extra fingers adjacent to the little finger and thumb. The above mentioned capability has been achieved using a novel control algorithm that enables the robot to move in sync with the wearer's fingers to grasp objects of various shapes and sizes. By wearing the robot, a user could use one hand to use perform different tasks, for instance, hold the base of a bottle while twisting off its cap. The researchers believe that this is a completely natural way to move the robotic fingers for users. With a little training, the users would be able to notice that the robotic fingers appear to be a part of their body. The novel robot is expected to help people with limited agility to perform routine household tasks such as opening jars and lifting heavy objects.

The robotic finger consists of actuators that are linked together for exerting forced that are as strong as those of human fingers during a grasping motion. While developing the algorithm for the robotic fingers,the researchers have assumed a biomechanical energy that might be seen with not only five human fingers but seven. Their assumption was tested by wearing a glove outfitted with multiple position recording sensors and attached to their wrist. The researchers grasped each object with their hands and then manually positioned the robotic fingers to support the object. The researchers then recorded both hand and robotic joint angles multiple times with various objects, then analyzed the data, and found that every grasp could be explained by a combination of two or three general patterns among all seven fingers. The information obtained from the above mentioned tests is said to have helped in developing a control algorithm to correlate the postures of the two robotic fingers with those of the five human fingers. The algorithm is said to essentially teach the robot to assume a certain posture that the human expects the robot to take. Currently, the robotic finger is said to mimic the grasping of the hand, closing and in spreading apart in response to a human finger. Further research is being made to develop this robotic finger to further develop in controlling the force in addition to the position. In addition to the above mentioned developments, research is also being carried out to scale down to the down to a less bulky form.

Some of the advantages of l robotic finger is that, it helps the people with disfunctions and also provides them the ability to carry out tasks in a more efficient manner.

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2. NOVEL METHOD TO DEVELOP THERMOELECTRIC MATERIALS

Most electronic devices ranging from cars, laptops, and other devices that are used on an everyday basis consume significantly high amounts of energy through heat loss. In order to counter the above mentioned challenge, thermoelectric materials are used to convert heat energy to electricity and vice versa. These materials have the potential to harness the heat that is wasted, thereby providing green technology energy efficiency that is required for a sustainable future. To create the technology needed to capture this heat, researchers around the world have been trying to engineer more efficient thermoelectric materials. One promising material is one that is filled with tiny holes that range in size from about a micrometer to about a nanometer. Heat travels through a material through phonons, which are quantized units of vibration that act as heat-carrying particles. When a phonon runs into a hole, it scatters and loses energy. Phonons thus cannot carry heat across a porous material as efficiently, giving the material low-thermal conductivity, which in turn increases the efficiency of electricity that is obtained from heat. It also seen that the material with more pores is a better thermoelectric material as it can lower thermal conductivity. Researchers from a research institute in USA have developed technology for making thermoelectric material--that would be used in devices in the future--more efficient.

A group of researcher's from American Institute of Physics has developed a novel method to manufacture thermoelectric materials that addresses the above mentioned challenges and helps in developing thermoelectric materials with significantly high efficiency. In this method, the pores of the thermoelectric material have been made smaller and packed closely together thereby lowering the thermal conductivity. Based on the various tests it has been found that the theoretical calculations made by the researchers have matched with the practical experiments. It has been also been found that the micro- nano-porous materials can be significantly more efficient when compared to the conversion of heat energy into electricity by materials containing no pores. By varying the material used, the researchers developed four different models for their experiments. In the first model, the researchers used a material filled with holes of random sizes, ranging from micrometer to nanometers in diameter. The second was with multiple layers in which each layer contained pores of different size scales, thereby giving it a different porosity. The third was a material composed of a three-dimensional cubic lattice of identical holes. The fourth was another multilayered system. From the analysis of the above mentioned models, it has been seen that the first and fourth models have lower thermal conductivities than the second. The third model was found to be having lower thermal conductivity than the fourth model. It was also found that, the method used in the first model could be more suited for developing materials that are to be used in the devices.

The advantages of this method are that, it significantly increases the efficiency of the products that are manufactured using the thermoelectric material developed with the novel method. All the above mentioned capabilities and advantages of this method increases the chances of its being adopted for manufacturing products in various industries.

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3. INNOVATIVE TECHNIQUE TO DEVELOP LIGHTWEIGHT CELLULAR COMPOSITES

Sandwich construction of materials is used on a large scale by a wide range of manufacturing industries in different industrial sectors. For instance, automotive and aerospace sectors are known to have the above type of construction in their materials for manufacturing different products. Manufacturers of turbine blades have been using wood for manufacturing their products and are now looking for newer methods of making their products in order to achieve precise performance requirements of turbine blades and other sophisticated applications. In order to meet the above mentioned requirements, turbine manufacturers are looking for novel sandwich construction and material options. Researchers from a university in the USA have found a solution for the above mentioned challenges.

Researchers from the Harvard University School of Engineering and Applied Sciences (SEAS) and the Wyss Institute for Biologically Inspired Engineering have developed cellular composite materials that are lightweight yet stiff. The material has been developed using a cocktail of fiber-reinforced epoxy-based thermosetting resins and three-dimensional (3D) extrusion printing techniques. Due to the mechanical properties and fine scale fabrication of the novel material that has been developed it has a significantly high potential in manufacturing of turbine blades. The researchers also believe that it has the potential to mimic and improve conventional materials (such as wood) and even commercial 3D-printed polymers and polymer composites. The results from this research have been published in the July 2014 edition of the journal, *Advanced Materials.* Until now, 3D printing has been developed for such materials as thermoplastics and UV (ultraviolet) curable resin materials that are not typically considered as engineering solutions for structural applications. By moving into new classes of materials such as epoxies, the researchers believe they have opened up new applications sectors for 3D printing by making it capable for constructing lightweight products. The direction in which the fillers are used for depositing the ink controls the strength of the materials. By using the technique adopted by the researchers, it seen to yield cellular composites that are as stiff as wood, 10 to 20 times stiffer than commercial 3D-printed polymers, and twice as strong as the best printed polymer composites. The ability to control the alignment of the fillers has enabled the fabricators to digitally integrate the composition, stiffness, and toughness of an object with its design. Potential applications of the research include the use in many industrial sectors such as the automotive industry where lighter materials hold the key for achieving the reduced fuel standards. Lightweighting of parts used in the automotive products could have significantly high savings in terms of the money that is being spent on fuel.

The advantage of this technique is that, it opens up potential market sectors for the 3D printing technology and also helps in manufacturing light weight components for various products. Due to the above mentioned capabilities and also the development of newer business models for 3D printing technology, this technique has the potential to be adopted in the future.

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4. PATENT ANALYSIS OF SOLID STATE SINTERING PROCESS

The solid state sintering process is a type of layer manufacturing process that is employed for making a wide variety of three-dimensional (3D) parts, which have a complex geometry. In this process, the parts are manufactured by merging consecutive layers of powder material that is used for manufacturing the certain part on top of each other. The consolidation of the powdered particles on top of each other is carried out using thermal energy. A focused laser beam is used in this process for developing the thermal energy that is required. Each layer of the powdered particle is examined with galvano mirrors and is correlated with the corresponding cross sectional area that is calculated from the computer aided design model. In solid state sintering process thermal temperature that is usually maintained are around half of the materials melting temperature. By reducing the free energy between the powdered particles, it is possible to bind these particles together. Using this process, successive powdered layered having a thickness of around 20 micrometers to 150 micrometers can be achieved. The kinetic energy required for transporting the particles and filling up the vacancies around the grain boundaries is achieved with the temperature of the thermal energy. The solid state sintering process is a slow process; therefore, preheating of the powdered material is carried out. The preheating is done to increase the diffusion rate of atoms and thereby helping in achieving an acceptable velocity that is required for laser scanning. The advantage of solid state sintering process is that a wide variety of material powders can be used in this process for manufacturing parts.

From the patents exhibited below, the recent filings indicate that organizations are carrying out research to improve the methods to execute this manufacturing process an expand its applications. For example, the patents include those on a method for producing an impregnated solid-state composite cathode and a pressureless sintering process for producing elemental iron and aluminum.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Impregnated sintered solid state composite electrode, solid state battery, and methods of preparation	March 1, 2013/ WO 2013130983 A2	Excellatron Solid State, Llc	Joykumar S. THOKCHOM, Davorin Babic, David Ketema JOHNSON, Lazbourne Alanzo ALLIE, Lonnie G. Johnson, William Rauch	An impregnated solid state composite cathode is provided. The cathode contains a sintered porous active material, in which pores of the porous material are impregnated with an inorganic ionically conductive amorphous solid electrolyte. A method for producing the impregnated solid state composite cathode involves forming a pellet containing an active intercalation cathode material; sintering the pellet to form a sintered porous cathode pellet; impregnating pores of the sintered porous cathode pellet with a liquid precursor of an inorganic amorphous ionically conductive solid electrolyte; and curing the impregnated pellet to yield the composite cathode.
Processing of iron aluminides by pressureless sintering of elemental iron and aluminum	August 15, 2012/ EP 2425027 A1	Philip Morris USA Inc.	Seetharama C. Deevi, Shalva Gedevanishvili	A pressureless sintering process for producing FeAl wherein the heating rate is controlled in a manner which minimizes expansion of a mixture of elemental powders of iron and aluminum. During the process, the heating rate is maintained below 1 °C/min to minimize the volume expansion during the formation of the intermediate phase Fe2Al5. As a result of the process, the final density can be increased up to 95 % of the theoretical density. The sequence of phases formed during the heating of Fe+Al mixture were identified by X-ray diffraction, optical microscopy, SEM and along with DSC data were correlated to the expansion and shrinkage behavior of the samples.
Ore fine agglomerate to be used in sintering process and production process of ore fines agglomerate	November 17, 2010/ WO 2011061627 A1	Vale S.A.	Pimenta Hamilton Porta, Castro Dutra Flavio De	An ore fine agglomerate to be used in a sintering process is disclosed, wherein the ore fine agglomerate is formed by a mixture of ore fine particles and an agglomerating agent, and wherein the particles have diameters between 0.01 mm and 8.0 mm. A production process of ore fines agglomerate is disclosed comprising the steps of using ore fine particles with a granulometry lower than 0.150 mm, mixing the ore fine particles with an agglomerating agent in a ratio of 0.5 to 5.0% by mass of sodium silicate, forming wet particles with diameters between 0.01 mm and 8.0 mm with an addition of water, and drying the wet particles at a temperature varying from 100°C and 150°C to form dry particles that are resistant to mechanical efforts and the elements.
Process for sintering nanoparticles at low temperatures	March 24, 2010/ EP 2411560 A1	Yissum Research Development Company of the Hebrew University of Jerusalem, Ltd.	Michael Grouchko, Alexander Kamyshny, Shlomo Magdassi	A process for sintering nanoparticles (NPs) on a substrate, the process comprising contacting said NPs with at least one sintering agent at a low temperature, thereby obtaining a sintered pattern on said substrate.
Geometry adaptive laser sintering system and process using the same	October 14, 2009/ WO 2010045382 A1	The Boeing Company	David M. Dietrich, Richard L. Eason	An apparatus comprises a deformable platform (530) and a laser delivery system. The deformable platform (530) has a surface capable of changing to conform to a shape of an object as the object is being manufactured during a sintering process. The laser delivery system is capable of sintering powder on the deformable platform to manufacture the object.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Solid-state image capturing device; manufacturing method for the solid-state image capturing device; and electronic information device	August 28, 2008/ US 20090078974 A1	Sharp Kabushiki Kaisha	Kenichi Nagai, Noboru Takeuchi, Kazuo Ootsubo, Yuji Hara	A solid-state image capturing device is provided with a plurality of light receiving elements arranged on a surface section of a semiconductor substrate, a color filter of each color for each of the plurality of light receiving elements, and a plurality of microlenses each for condensing incident light into each of the plurality of light receiving elements, in which the interlayer insulation film is provided directly below the color filter of each color in a state where a passivation and hydrogen sintering process film is removed from the interlayer insulation film.
Process for producing sintered porous materials	June 27, 2006/ EP 1896379 B1	K.U.Leuven Research & Development	Jan Fransaer, Bram Neirinck, Der Biest Omer Van, Jozef Vleugels	The invention provides a process of making porous structures or materials, including the colloidal processing (e.g. slip casting, pressure casting, tape casting or electrophoretic deposition) of solid particle emulsions to form a green body that can be directly sintered without a de-binding step.
Processes for sintering aluminum and aluminum alloy components	December 1, 2003/ EP 1694875 B1	The Ex One Company	Jianxin Liu	Methods for sintering aluminum powder comprise providing aluminum powder and heating the aluminum powder in a nitrogen atmosphere containing a partial pressure of water vapor in the range of about 0.001 kPa to about 0.020 kPa to sinter the aluminum powder to a transverse rupture strength of at least about 13.8 MPa. The aluminum powder is not pressed together by a mechanical force that substantially deforms particles of said aluminum powder either prior to or during the step of heating. Articles comprising sintered aluminum powder. The sintered aluminum powder has a transverse rupture strength of at least about 13.8 MPa. The microstructure of the sintered aluminum powder contains no compositional concentration gradients indicative of the use of a sintering aid and no evidence of particle deformation having occurred by an application of a mechanical force prior to or during the sintering of the aluminum powder.
Process for forming 312 phase materials and process for sintering the same	December 21, 2000/ EP 1268362 B1	Sandvik Intellectual Property AB, Drexel University	Tamer El-Raghy, Michel W. Barsoum, Mats Sundberg, Hans Pettersson	Metals are generally easily machined but do not retain their machined form at high temperatures. Ceramics retain their shape at extremely high temperatures, but are brittle and very difficult to machine into a desired shape. Materials scientists have directed a great deal of effort towards finding compositions that are easily machined into a desired shape and are stable at extremely high temperatures.
Simplified deformation-sintering process for oxide superconducting articles	April 1, 1998/ EP 0832050 A2	American Superconductor Corporation	William L. Carter, Qi Li, Alexander Otto, Eric R. Podtburg, Gilbert N. Riley, Jr., Martin W. Rupich, Elliott Thompson, Patrick John Walsh	A method is described to prepare a highly textured oxide superconductor article in a single deformation-sinter process. A precursor article including a plurality of filaments comprising a precursor oxide having a dominant amount of a tetragonal BSCCO 2212 phase and a constraining member substantially surrounding each of the filaments is provided. Each of the filaments extends along the length of the article. The oxide article is subjected to a heat treatment at an oxygen partial pressure and temperature selected to convert a tetragonal BSCCO 2212 oxide into an orthorhombic BSCCO 2212 oxide and, thereafter, roll worked in a high reduction draft in a range of about 40 % to 95 % in thickness so that the filaments have a constraining dimension is substantially equivalent to a longest dimension of the oxide superconductor grains. The rolled article is sintered to obtain a BSCCO 2223 oxide superconductor.

Exhibit 1 depicts patents related to solid state sintering.

Picture Credit: Frost & Sullivan

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