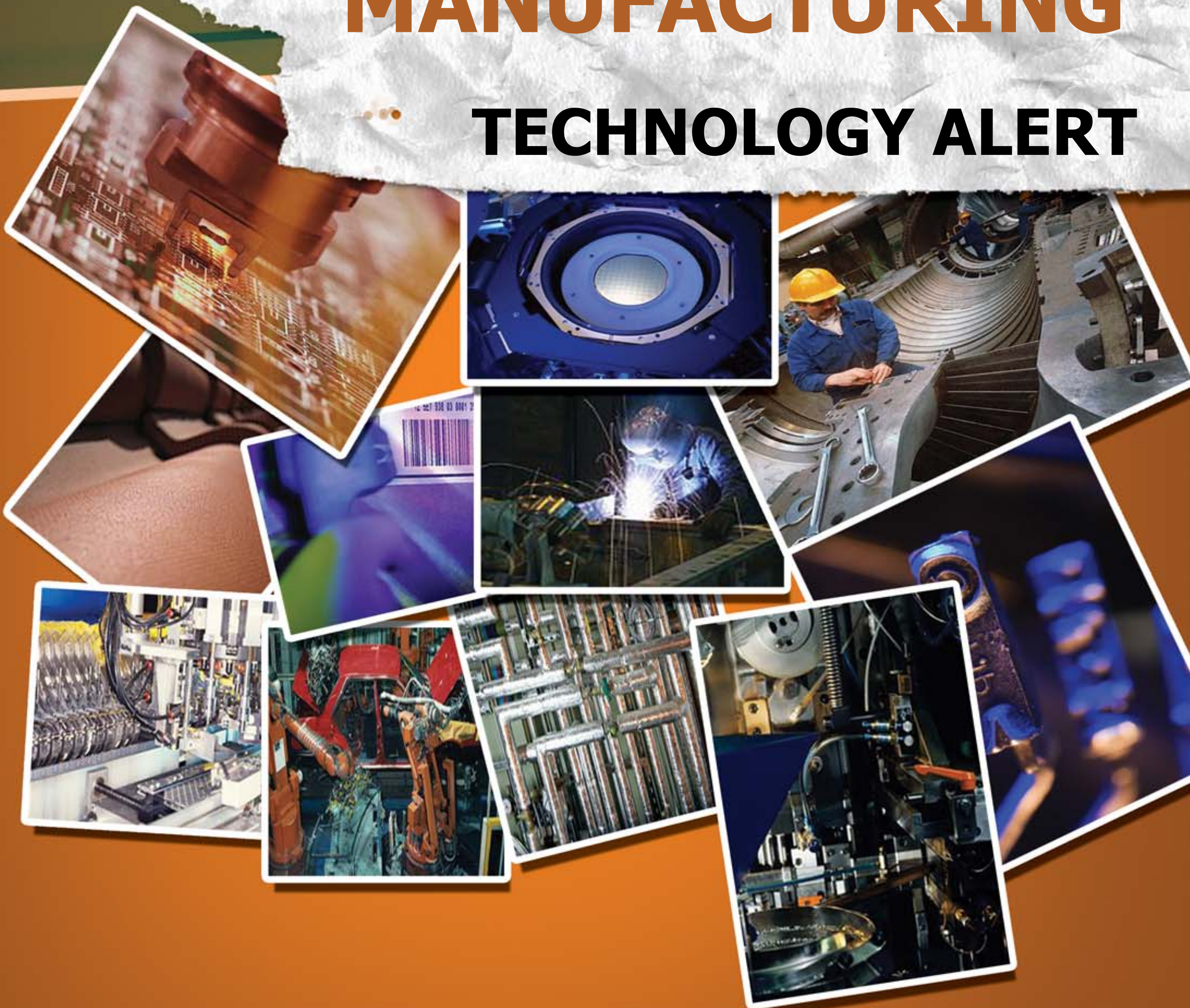
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



12th September 2014

1. INNOVATIVE PROCESS TO INCREASE QUALITY AND STRENGTH OF CARBON NANOFIBERS USING GRAPHENE

Composite materials are used in a wide range of applications, such as airplanes, automobiles, bicycle parts, sporting goods, implants, tooling, and so on. Researchers around the world have been working on improving the strength of the composite materials such as carbon nanofibers. A group of researchers from the University of Nebraska-Lincoln have developed a novel process to improve the quality and strength of the carbon nanofibers.

Researchers from the department of mechanical and materials engineering of the University of Nebraska- Lincoln (USA) have discovered that using significantly small amounts of graphene oxide as a template results in an improved carbon nanomaterial, which in turn improves the composite material. Graphene is one-atom-thick layer of carbon with a crystalline structure thereby making it exceptionally strong and having significantly high heat and electrical conductivity.

The researchers have collaborated with another group of researchers from the Northwestern and Materials and Electrochemical Research Corporation (Tucson, Arizona, USA). They have developed an innovative process to incorporate the graphene oxide nanomaterials as a template that guides the formation and orientation of continuous carbon nanofibers, which improves the properties of the fiber. This process comprises crushing the graphene in a fashion similar to crushing a sheet of paper, which improves the graphene as a templating and orientation agent. By using this process, only a small amount of graphene particles are required compared to the conventional process that involves adding large amounts of graphene particles. The conventional process involves adding large quantities of graphene, which makes the conventional process difficult. However, in this process, the researchers have added a small quantity of graphene and then followed it with the carbonization process. The resulting structure of the carbon nanofiber is seen to have an orientation similar to the fibers with enhanced strength and other material properties. The researchers are currently testing the graphene nanofibres developed by them for enhanced properties and are also working on improving the overall process of producing nanofibers. The graphene-based nanofibers have the potential to significantly reduce the cost of manufacturing composites, since a small quantity of the expensive nanoparticles is used and the process developed by the researchers is said to be inexpensive. The funding for this research was received from the grants of the US Army Research Office Multidisciplinary University Research Initiative, Air Force Office of Scientific Research, and the National Science Foundation.

Some of the advantages of this novel process are that it reduces the cost associated with developing graphene based carbon nanofibers and also increases the strength of the material that is obtained. With the above mentioned advantages, this process has the potential to produce high performance and low-cost nanofibers. This would allow a wide range of industries to adopt this process for producing carbon nanofibers used for various applications.

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2. WET COATING TECHNOLOGY PROMISES HIGH-MATERIAL YIELD

Wet coating processes have been used for a long time for various coating applications. However, there is a need for advanced processes that result in higher material yields and high accuracy of the coating. In this regard, Finland-based Beneq has developed an innovative atmospheric wet coating technology, nFOGTM. The technology combines the advantages of various individual coating technologies, such as spray coating, dip coating, and roller coating. The coating process results in high speed, high material yield, as well as superior quality of coating. This is ideal for various applications including anti-reflective coatings for large area glasses.

The technology is based on a contact-free deposition method that can be used to coat highly sensitive substrates with varied dimensions in terms of thickness, size, and shapes. It can provide high coating uniformity of about 3%. The process is based on aerosol coating and is compatible with a wide range of liquid materials such as water-based solutions or colloids as well as alcohol-based solutions or colloids. The coating thickness achieved by the process is typically within the range of 10 nm to 500 nm. This thin layer of coating is essential for achieving high-quality coating.

The deposition system that uses this technology is Beneq's ACS 200. The system has no moving parts, and the process is highly robust and repeatable. The process results in high material yield of about 95%, which is possible due to the recyclability and reusability of most of the material. The process can be used for scaling up lab scale liquid-based or sol-gel based coating processes to the industrial scale without compromising on quality of the coating.

For research purposes, the ACS 200 lab scale equipment combines fast sampling with low-material consumption. Sample sizes of up to 200 mm can be accommodated for the fully automatic coating process. The base equipment can be used before scaling up production to the industrial scale. Beneq also offers its customers the option of renting pilot scale test systems that are able to process larger substrates (up to 800 mm x 1400 mm). For industrial production, Beneq can provide turnkey solutions for the nFOG TM technology that can be integrated into existing production lines.

Beneq's nFOG TM technology is expected to enable better coatings, especially for large area glass surfaces. The ACS 200 equipment will allow customers to test the coating process and perform specific research and development before industrial scale manufacturing is carried out.

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3. MINIATURIZED MASS SPECTROMETER USING ADVANCED MANUFACTURING TECHNIQUES

Mass spectrometry is a chemical process that is used to identify the chemical elements in a sample. This process has been extensively used for applications such as environmental testing, chemical analysis, forensic work, and so on. It works by vaporizing a sample of the material and then ionizing it. The ions are then accelerated and by using electromagnetic forces the elements are separated based on their mass-to-charge ratio. This process is very accurate, but can pose a major challenge--it has been predominantly a laboratory process.

Researchers at the Massachusetts Institute of Technology, USA, have now developed technologies that have the potential to develop inexpensive handheld mass spectrometers. The researchers engineered scaled down versions of key components of a mass spectrometer. The key components include ionizing sources, quadrupole for sorting chemical compounds, and chip scale vacuum pump. They also developed technologies that can be used for mass production of the components.

The team developed miniaturized gas ionizers using arrays of self-aligned conical nanoscale tips that can work at vacuum pressures. The ionizers make ion production more efficient as well as negate the requirement of vacuum pumping, which is used in commercial systems. The quadrupole, which essentially constitutes four parallel rods and creates an oscillating current, was developed using microfabrication techniques. A 3-stage vacuum pump was also developed using standard fabrication technologies used in semiconductor chip manufacturing. This chip consists of very few moving parts and is able to support a miniaturized mass spectrometer. For developing the liquid ionizer, the MIT researchers used a high electric field electrospraying technique in which voltage is applied to liquids for creating evenly dispersed charged particles. This process can not only be used for making portable mass spectrometers, but can also be used for chip cooling, high throughput nanomanufacturing, as well as nanosatellite propulsion.

Extending the use of the electrospraying technique, the researchers were able to lay down nanofilms that can be used to develop, for example, printable analytic sensors.

The miniaturized system provides various advantages such as lower power consumption, lower operating voltages, portable systems, as well as provide higher throughput. Also, by making batches of microfabricated components, the overall cost can be made to decline by a factor of ten. The low cost can allow miniaturized mass spectrometers to be used for various new applications such as monitoring of gases in buildings, toxic gas detection, and so on. The miniaturized systems would ideally be the size of a smarp phone without compromising the performance of laboratory scale equipment.

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4. PATENT ANALYSIS OF SELECTIVE LASER SINTERING PROCESS

Selective laser sintering (SLS) is a type of additive or rapid prototyping technology where a high-powered laser is employed to fuse small particles of materials such as thermoplastics, metals, nylon, and ceramics. This process is similar to stereolithography where the prototype is produced through continuous layering of materials.Selective laser sintering was originally developed at The University of Texas at Austin. In this process, the laser selectively fuses powdered material by scanning cross-sections generated from a 3-D digital description of the part on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer thickness, a new layer of material is applied on top, and the process is repeated until the part is completed. The SLS machine preheats the bulk powder material in the powder bed somewhat below its melting point to better enable the laser to raise the temperature of the selected regions the rest of the way to the melting point. Once the material is made to form the shape of the object that is being manufactured, it is then sintered using the laser, which forms an additional layer on the part that is manufactured.

Some of the advantages of selective laser sintering process are that the prototypes and the end products manufactured using this process can have high durability and high density and no support structures are required during the forming process.

From the patents that have been exhibited, it can be seen that research is being carried out to improve the components. materials, or processes used in selective laser sintering, such as the forming platform, providing window mirror protection, a method to avoid irregularities on the contour, and metal powder for producing a 3D shaped object.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Forming platform of selective laser sintering device	April 8, 2013/ CN 203140769 U	Yu Zhen	Yu Zhen	The utility model relates to a forming platform of a selective laser sintering device. The forming platform comprises a base and an aluminum plate paved on the base, a resin layer is further paved on the aluminum plate, and the aluminum plate and the resin layer are fixed on the base through screws. The forming platform of the selective laser sintering device is simple in structure and low in cost, rigidity, flatness and uniformity of working temperature of the forming platform are promoted, deformation of the forming platform caused by thermal expansion and cold contraction is prevented, and thus forming quality of a product is prevented from being affected.
Selective laser sintering (SLS) window mirror protection device	February 24, 2012/ CN 202411419 U	Hunan Hua Shu-tech Co., Ltd.	Liu Xin Yan, Xu Xiaoshu	The utility model provides a selective laser sintering (SLS) window mirror protection device. The device is characterized by comprising a window mirror protection plate, a window mirror and a window mirror pressing plate, wherein the window mirror protection plate is a cylinder of which the middle is provided with a through hole; the window mirror pressing plate and the window mirror are arranged on the upper side of the window mirror protection plate in sequence; an air inlet is formed on the window mirror protection plate and communicated with a semi-annular upper gas channel in the window mirror protection plate; the upper gas channel is communicated with an annular lower gas channel close to the inner side through gas connecting channels at two ends; and a plurality of air outlets are formed on the lower gas channel close to the inner side. The device has a symmetrical structure, so that air flow is uniformly distributed; and air is uniformly blown into the window mirror through the air outlets, a blind area is avoided when the window mirror is protected by an air curtain, the window mirror is kept clean constantly in the sintering process, and the phenomenon that the laser power of projection is influenced because floating dust is condensed and crystallized when meeting the window mirror is avoided, so that high processing quality is ensured.
Method for selective laser sintering and system for selective laser sintering suitable for said method	September 22, 2011 / WO 2012038507 A3	Siemens Aktiengesellschaft	Oliver Hofacker, Martin Schäfer	The invention relates to a method for selective laser sintering and to a device for carrying out such a method. In the method for laser sintering, energy (1 to 6) is applied linearly to a cross-sectional surface (17) of the component to be produced in order to compact the powdery material. According to the invention, in the case of components comprising cross-sectional surfaces (17) that have a curved contour (20), the application of energy can be guided in a line-shaped manner following the curved contour so that the contour (20) of the workpiece that develops is continuously replicated. Advantageously, irregularities in the contour, which are caused by the raster predetermined by the laser sintering method, can thus be largely avoided. The device according to the invention for laser sintering according to said method comprises a powder delivery unit which can rotate about a rotational axis located in the interior of an annularly closed cross-section of the workpiece to be produced.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Metal powder for selective laser sintering, method for manufacturing three-dimensional shaped object by using the same, and three-dimensional shaped object obtained therefrom	May 23, 2011/ US 20130065073 A1	Panasonic Corporation	Isao Fuwa	There is provided a metal powder for use in a selective laser sintering method for producing a three-dimensional shaped object, wherein the metal powder comprises a powder mixture of a precipitation-hardening metal composition. In particular, the metal powder of the present invention is configured to have a Fe-based component powder and a Ni-based component powder which are individually included in the powder mixture wherein a powder made of an alloy of Fe-based and Ni-based components is not included as a main powder in the powder mixture.
Method and device for smoothing elements made using the sls incremental technology	May 11, 2011/ WO 2011145960 A1	Mbm Technology Spolka Cywilna	Piotr Jankowski, Grzegorz Sworobowicz	Method and device for smoothing elements made using the SLS incremental technology (Selective Laser Sintering) of materials based on polyamide powder - PA. The method consists in that the element is subject to effects of vapours of a chemical compound from the following group: formic acid, acetic acid, m-creozol, acetic anhydride, so that the applied chemical compound, in atmospheric pressure, is brought to a temperature above its specific boiling point for a time of 1-350 seconds, counting from the moment when vapours of the chemical compound condensate on the processed prototypical element. The device has a chamber (3) with working space, below which there is a container of the active substance dispenser and heating element (6), separated from the working space with the movable screen (7), and vapour extraction system (8) with ventilation duct.
Selective laser sintering double-roller powder spreading device	December 21, 2010/ CN 201906824 U	Hunan Midea satisfied Technology Co., Ltd.	Xuxiao Shu Zhao, Deng Meijun	The utility model discloses a selective laser sintering (SLS) double-roller powder spreading device which comprises a working table and a powder spreading device, wherein the powder spreading device is arranged on the working table; the SLS double-roller powder spreading device is characterized in that the powder spreading device comprises a powder storage cylinder and two parallel powder spreading rollers including a left powder spreading roller and a right powder spreading roller; and a closed system is formed by the powder spreading device and the working stable. The double-roller powder spreading device is simple in structure and convenient to control, the space of an SLS device is effectively saved, the size of the device is reduced, the complexity of the device is reduced, the cost of the device is lowered, the reliability of the device is improved, and the work environment in the device is guaranteed to be clean.
Polyoxymethylene laser sintering powder, process for its production, and moldings produced from this laser sintering powder	October 26, 2010/ CA 2779082 A1	Basf Se, Claus Dallner, Steffen Funkhauser, Frank Mueller, Juergen Demeter, Mark Voelkel	Claus Dallner, Steffen Funkhauser, Frank Mueller, Juergen Demeter, Mark Voelkel	The invention relates to a powder made of polyoxymethylene (POM) for use in a selective laser sintering process, comprising the following parameters: isothermal crystallization time (at 152 °C) > 3 min, Mn 22000 - 25000 g/mol, Mw 60000 - 140000 g/mol, Mw/Mn 3 - 5, MVR 15 - 70 [cm3/10 min], average particle size d50 60 μm, particle size 30 - 130 μm. The invention further relates to a method for the production thereof and molded parts produced using said powder by means of a selective laser sintering process.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Purge and sealant cap for selective laser sintering build frame	April 9, 2008/ US 8373092 B2	The Boeing Company	David M. Dietrich	A selective laser sintering apparatus is adapted contain or receive a build frame and comprises a cap assembly which includes a removable plate assembly having at least one gas inlet formed therein. The removable plate assembly sealingly covers the build frame. The cap assembly further comprises at least one gas line fluidly connectable to the gas inlet via a gas port to deliver inert gas to the interior of the build frame. The plate assembly comprises upper and lower plates defining a spacing therebetween. A seal extends around a periphery of the upper and lower plates and is sandwiched therebetween to enclose the spacing. The lower plate has a plurality of gas inlets formed therein which are in fluid communication with the spacing such that inert gas may be delivered to the build volume while the cap assembly is installed thereupon.
Method for joining parts fabricated via selective laser sintering while maintaining proper alignment	July 6, 2006/ EP 1760384 A2	Northrop Grumman Corporation	Christopher H. Husmann, Gregory N. Stein	Mating air ducts may be joined to each other via an integrally formed protrusion on male air duct and an integrally formed groove on a female air duct for effecting linear and angular alignment of the mating air ducts. The integrally formed protrusion and groove may be formed on the air ducts via a process known as selective laser sintering or stereo lithography. Further, more than one groove and protrusion may be formed on the air ducts in an uneven manner such that the protrusions fit within the grooves in only one angular orientation. The protrusion may be a nub or a thread. Also, the groove may be a channel aligned to a central axis of the female air duct or a helical groove. The male air duct is linearly aligned and/or angularly aligned to the female air duct when the protrusion engages a distal portion of the groove or an abrupt change of the groove.
Selective laser sintering process and polymers used therein	March 28, 2005/ WO 2005097475 A1	Paul Boehler, Raffaele Martinoni, Valspar Sourcing Inc	Paul Boehler, Raffaele	A selective laser sintering process to provide an article of manufacture having a plurality of sintered layers is disclosed. The process utilizes an endcapped polymeric particulate material of high stability, and the articles of manufacture prepared therefrom having excellent interlayer adhesion, breakout, surface properties, and strength.

Exhibit 1 depicts patents related to selective laser sintering process.

Picture Credit: Frost & Sullivan

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