TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

26th September 2014

1. ROBOTIC ARM THAT CAN MOVE THROUGH PIPES

In circa the last 50 years, robotic technologies have had an enormous impact on industry and society at large. For example, in automobile manufacturing and in processing of goods, robotic manipulators are employed to improve the efficiency of tasks. As speed and accuracy are the two main qualities required for these robots, they are typically designed and programmed to repeat a limited number of tasks. More recently, there has been an increasing interest in a completely different type of robot—soft and biologically inspired robots. Biological systems are rarely composed of rigid mechanical components. They are made of soft, elastic, and flexible materials in order to survive in complex unstructured environments. Control architectures of soft robots are very different from conventional robots by reflecting the differences in underlying material properties. The mobility of traditional hard robots is limited by their fixed joints. They can't move in confined spaces and have to be programmed very precisely to avoid collisions that might harm them or their environments. In contrast, the deformable structure of soft robots means that they can squeeze into tight spots and change direction more nimbly. They are also resilient enough to handle minor collisions and potentially use these encounters to gain information about their surroundings.

Over the last few years, the researchers at the Massachusetts Institute of Technology (MIT)'s Computer Science and Artificial Intelligence Lab (CSAIL) have developed biologically inspired robots designed to fly like falcons, perch like pigeons, and swim like sword fish. Their next development is a soft robotic arm, inspired by the design of octopus tentacles, which can snake through a pipe like environment with out a human operator. The arm is fabricated using three-dimensional (3D) printed molds. The researchers at MIT have developed complex algorithms to determine the body curvature needed for the robot to make a diversity of different motions.

Even though the area of soft robotics offers a lot of potential, the field's relative newness means that the researchers are still exploring the best approaches to topics such as motion planning and actuation. One of the challenges was that the robotic arm is so soft that a typical motor shaft cannot be attached. To overcome this, the CSAIL team designed hollow, expandable channels on both the sides of the arm. These channels--when pressurized with air--will put strain on the elastic silicone and cause it to change shape like a balloon allowing the arm to bend to one side. Another unique feature is that the arm is made completely of silicone rubber. This was a limitation that challenged the research team to develop the necessary programming for a robot that, with its 100% soft body, is better suited to navigating human environments.

The robotic arm could have applications ranging from finely tuned tasks in factories to handling delicate specimens in research labs to assisting in certain kinds of minimally invasive surgeries. The next version of the arm will include a finger gripper, which can be used to pick and place objects.

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2. 3D PRINTING EXPLORED FOR SPACE TECHNOLOGIES

Additive manufacturing is a vital manufacturing technology, profoundly impacting the manufacturing scene as the top companies in the world started moving from analog to digital manufacturing and from substractive to additive manufacturing. Additive manufacturing uses 3D printing to transform engineering design files into fully functional objects. The technology creates objects by laying down successive layers of materials until the entire object is created. Each of these layers can be seen as a thinly sliced horizontal cross section of the eventual object.

One of the challenges of using 3D printing technology in space is that the materials used in space should have a smooth finish with no loose particles. Any extra space between the particles means a far greater risk of developing cracks. The materials have to be clean to surgical standards.

The European Space Agency (ESA)'s Clean Space initiative is working on finding ways of reducing the environmental impacts of space technologies; and 3D printing seems to be the solution. Highly complicated parts can be printed and made as light as possible using this technology. On the dow nside, there is a drawback in 3D printing. The objects created using 3D printing tend to end with rougher surfaces than their traditional counterparts.

The new ESA project aims at investigating the surface features of 3D printed parts to scrutinize the suitability of standard surface treatments for typical satellite materials such as aluminum, titanium, and stainless steel. It will assess the different manufacturing techniques such as laser and electron beam melting along with surface treatments such as sandblasting, etching, nickel coating, and painting. It will also assess the mechanical properties of the processed parts for resistance to stress corrosion and the tendency to fracture. It will evaluate the usefulness of non-destructive investigations such as ultrasound and X-ray examination as methods for ensuring the soundness of parts. It also aims at testing the samples against the high humidity found at ESA's equatorial launch site in South America and the temperature extremes found in space.

3D printing technology can have key cost advantages in making prototypes or parts in relatively limited volumes when compared to traditional manufacturing techniques. In traditional manufacturing, the objects are created in a subtractive manner by trimming and shaping the materials from a larger source. This process generates substantial waste, which can be harmful to the environment. In 3D printing, there can be little or no waste in creating objects as the objects are built by adding materials layer by layer. It is also a very energy efficient and environment friendly manufacturing option.

Another advantage of 3D printing is that it creates product prototypes swiftly. It can also be used to create specialized products, which can replace worn or broken industrial parts.

The 3D printing technology is used by the manufacturers across several industries to produce a range of products, which includes (primarily protoype) engine components for automotive applications; impellers and blades for aerospace use; patternless sand molds for pumps used in the oil and energy industry; and medical prosthetics or implants, which require easily adaptable design modifications.

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3. SLOW-MOTION VIDEOS OF ULTRA PRECISION MACHINING

Precitech (USA) manufactures innovative ultra precision machining solutions. They have designed and manufactured machine tools for turning, milling, and grinding. Vision Research is a global leader in high-speed digital imaging systems. Levicron manufactures precision air-bearing spindles for microprecision and ultraprecision machining.

Precitech, a business unit of AMETEK Inc., along with another AMETEK's business unit, Vision Research, has created and released two slow motion videos of ultra-precision machining.

The first video of the series, released in July 2014, shows an ultra-precision milling process creating a brass lenslet using a Levicron high-speed milling spindle. This video shows two different perspectives of the same process. The first segment of the video is recorded at 500 frames per second (30000 frames per minute) using a Phantom® Flex4K high-speed digital camera from Vision Research. During the entire process, the camera and the spindle remained in sync with one another, capturing every rotation of the spindle, which was operating at 60000 rpm. The result of that the tool appeared stationary while creating the lenslet. The second segment of the video had Vision Research's Phantom® v2010 ultrahigh speed digital camera focused on the tool at 40000 frames per second. At this speed, individual chips removed from the part can be clearly seen. These two segments give viewers a unique perspective of the ultra-precision milling process. The spindle used in this video is a Levicron model ASD060-Cx high speed, air bearing, and tool holding spindle capable of operating up to 100000 rpm.

Precitech has expertise in providing diamond turning machines for the manufacture of infrared lenses. The second video of the series is about ultra precision diamond turning of infrared lenses. The first segment of the video shows the machining of germanium using a wide radius diamond tool. With a wide radius tool, the germanium lenses can be machined faster with comparable form and finish results than with a small radius tool. The second segment of the video shows the machining of silicon using a chamfered edge diamond tool. Silicon is a very challenging material to diamond turn because of the cutting forces required and the chemical reaction that occurs between the part and the tool.

The Nanoform® X machining system was used to record the milling and the turning process. Precitech's latest small-frame lathe is designed for high productivity and ease of use in ultraprecise diamond turning, milling and grinding of optical lenses, mold inserts, mirrors and precision mechanical components.

Vision Research's Phantom® Flex4K high-speed digital camera and Phantom v2010 ultra high-speed digital camera were used to record the videos. The Phantom Flex4K delivers high-image quality with extremely low-noise performance and wide dynamic range. Built-in software allows complete on-camera control and editing eliminating the need for a computer on set. The Phantom v2010 is one of the fastest 1 megapixel cameras on the market. The v2010 achieves 22500 frames per second at full 1 megapixel resolution and up to 1 million frames per second at lower resolutions. The v2010, with its picture quality, software and analytical tools, is a valuable tool for industrial, diagnostic troubleshooting applications.

The slow-motion videos allow viewers to see the ultra-precision machining process in detail. The videos also help in improving the productivity in this area.

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4. PATENT ANALYSIS OF LASER ENGINEERED NET SHAPING PROCESS

The principle behind the the laser engineered net shaping (LENS) process is that a laser is employed to selectively clad the metallic powder. In this process, a molten weld pool is created from a metal substrate by using a high-powered laser, which is usually greater than 300 watts. The metallic powder is then sent into the weld pool by using an inert gas, which is then melted in the pool. As the laser passes by the deposit, it is cooled thereby creating a thin line metal. The substrate is then moved relative to the beam in order to deposit the thin metallic lines with a finite width and thickness. As the laser focusing lens and powder delivery nozzle are raised along the z-axis, successive cross sectional layers are added to form the final metal product. Once the final part is completed, the substrate is removed by machining or by dissolving in chemicals. The LENS system can contain control system hardware and a cooling system for the powder nozzle in addition to the basic hardware. The cooling system is employed for the powder nozzle since it is exposed to a thermal load caused due to the scattered and reflected radiation from the laser. The control system hardware can include various sensors and charge couple device (CCD) cameras, which helps in providing the online control. Some of the commonly used materials in this process are titanium, nickel, cobalt, and steel.

The advantage of this process is that, it can deposit a variety of metal, composite, functionally graded materials.. LENS, moreover, has the ability to mix powder streams of different materials to generate components with precise composition control; and could allow for changing geometric properties or material properties within an item of manufacture. It also has the ability to fabricate large, fully dense metal parts and tooling. Due to the above mentioned advantage this process can be used by a wide variety of industrial sectors for manufacturing their products.

From the patents that have been exhibited, it can be seen that research is being carried out to, for example, improve the ability of LENS technology to additively manufacture an item composed of difficult to weld material and to fabricate gradient alloy articles.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Double lens laser welding assembly	April 27, 2013/ CN 203265908 U	Dalian Hongik Precision Parts Manufacturing Co., Ltd.	Lin Bo , Sun Haijun , Jia-Ming Zhang	The utility model is a dual-lens laser welded components, including single-focus lens A (3), single-focus lens B (8) and lens mounting plate (2), characterized in that the fixed plate (2) on the bracket with a lens A (1) install a single-focus lens A (3), with a lens holder B (7) mounted a single-focus lens B (8), two single-angle zoom lens for α; lens mount plate (2) above install a flat position to traverse device (13); lens mount plate (2) below the middle of the lens bracket (9) fixed connection, the lens bracket (9) and the pressure cam (11) is connected, press the cam (11) mounted at the left end of the platen (10); pressure cam (11) provided below the turntable (4), a turntable (4) mounted to a right end of the stopper (12), a turntable (4) provided below the indexer (5), Indexer (5) in the middle with output shaft (6). The utility model to solve the technical problems of pure aluminum welding equipment, welding points will get double the energy to make it easier to induce the formation of the initial welding, greatly improving the reliability and stability of welding, improved product quality.
Silver-based alloy powder for manufacturing of 3-dimensional metal objects	March 1, 2013/ WO 2013128416 A2	Legor Group S.P.A.	Andrea Basso, Massimo Poliero	The invention relates to a silver-based alloy powder comprising from 70% to 99.99 wt% of silver and from 0.01% to 5 wt% of at least one element chosen from germanium (Ge), aluminium (Al), silicon (Si) and boron (B), or a mixture thereof. The powder is used in a method of direct manufacturing or prototyping (for example, selective laser melting, selective laser sintering, or Electron Beam Melting) for the manufacturing of 3 -dimensional metal objects such as a piece of jewellery, a component for the watch, spectacle or pen industry; a component for the accessory industry; an object or part of an object of art; a component for the medical industry; or a component for the high-tech industries.
Wear resistant low friction coefficient surfaces for joint and bone replacement materials and devices	February 11, 2013/ WO 2013122862 A1	Washington State University	Susmita Bose, Amit Bandyopadhyay	A metal matrix has a biocompatible solid lubricant in at least a portion of its surface and the solid lubricant functions to protect the interior of the metal matrix and minimize the friction coefficient and related wear induced damage at the articulating surface of the metal device. The lubricated biocompatible metal device is made of materials compatible for in vivo and ex vivo applications in order to minimize wear induced degradation as well as metal ion release. The lubricated biocompatible metal device is suited for use as medical implants.
Method for additively manufacturing an article made of a difficult-to-weld material	December 6, 2012/ WO 2013087515 A1	Alstom Technology Ltd	Lukas Emanuel Rickenbacher, Alexander Stankowski, Simone Hoevel, Thomas Etter	The invention relates to a method for additively manufacturing an article (10) made of a difficult-to-weld highly-precipitation-strengthened Ni-base super alloy that comprises Al and Ti in the sum of more than 5 wt. -% or a difficult-to weld carbide/solution-strengthened cobalt (Co)-base super alloy, whereby a metal particle mixture (14) of at least a first phase (11) and a second phase (12) is provided as a starting material, said first phase of the mixture being a base material and said second phase of the mixture being a material which is a derivative of the first material and has relative to said material of said first phase an improved weldability, and whereby the metal particle mixture (14) is processed by means of an additive manufacturing process which is one of selective laser melting (SLM), selective laser sintering (SLS), electron beam melting (EBM), laser metal forming (LMF), laser engineered net shape (LENS), or direct metal deposition (DMD).

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Methods for fabricating gradient alloy articles with multi-functional properties	October 30, 2012/ WO 2013112217 A2	California Institute Of Technology	Douglas C. Hofmann, John Paul C. BORGONIA, Robert P. DILLON, Eric J. SUH, Jerry L. MULDER, Paul B. GARDNER	Systems and methods for fabricating multi-functional articles comprised of additively formed gradient materials are provided. The fabrication of multi-functional articles using the additive deposition of gradient alloys represents a paradigm shift from the traditional way that metal alloys and metal/metal alloy parts are fabricated. Since a gradient alloy that transitions from one metal to a different metal cannot be fabricated through any conventional metallurgy techniques, the technique presents many applications. Moreover, the embodiments described identify a broad range of properties and applications.
Laser with beam transformation lens	November 9, 2011/ EP 2591875 A1	Leister Technologies AG	Ulrich Gubler, Daniel Vogler, Thomas Didden	The system (1) comprises a laser beam source (6) for generating a laser beam (7) having a non-uniform beam profile, and a laser lens system (2) for forming laser beam and for projecting the laser beam onto the workpieces (5), arranged in the radiation direction of laser beam source. A laser mask is arranged close to the workpieces, between the laser optical system and the workpieces. The lens system comprises a beam transfofrmation lens (3) to homogenize the beam profile, and an optical element (4) for collimating the laser beam, arranged in the radiation direction of lens.
Method of manufacturing a component by hot isostatic pressing	July 25, 2011/ EP 2551040 A1	EADS Deutschland GmbH, EADS UK Ltd.	Achim Schoberth, Frank Palm, Dr. Erhard Brandl, Jonathan Meyer, Chris Turner, Andrew Hawkins	In a method for manufacturing a homogenous near net-shape component made of a material selected from a metal, a metal alloy, or a metal matrix composite, with the proviso that said the material does not decompose or otherwise undergo a quick chemical reaction before or during it melts or before or during the metal or metal alloy in the metal matrix composite melts, a gas tight container having one or more cavities and one or more walls is formed of said material by additive layer manufacturing (ALM) such that the container contains said material in comminuted form, whereafter the container and its content consisting of the same material is subjected to hot isostatic pressing. A system based on electron beam ALM consisting of a gas tight container without any welding seem and a communited material of the same kind from which the container is formed in the cavity or cavities thereof is also disclosed.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Personal fit medical implants and orthopedic surgical instruments and methods for making	April 15, 2010/ WO 2010120990 A1	James Schroeder	James Schroeder	The present invention provides methods, devices, systems, and instruments related to medical implants and surgical instruments produced to precisely fit individual subjects. In particular, the present invention utilizes a combination of medical imaging, quantitative image analysis, CAD, CAM, and additive manufacturing processes to personalized biocompatible devices.
Laser based metal deposition (lbmd) of antimicrobials to implant surfaces	June 7, 2007/ WO 2008002750 A3	David William Britt, Durga Janaki Ram Gabbita, Daniel F Justin, Medicinelodge Inc, Brent E Stucker	David William Britt, Durga Janaki Ram Gabbita, Daniel F Justin, Brent E Stucker	A method is provided for depositing a hard wear resistant surface onto a porous or non-porous base material of a medical implant. The wear resistant surface of the medical implant device may be formed by a Laser Based Metal Deposition (LBMD) method such as Laser Engineered Net Shaping (LENS). The wear resistant surface may include a blend of multiple different biocompatible materials. Further, functionally graded layers of biocompatible materials may be used to form the wear resistant surface. Usage of a porous material for the base may promote bone ingrowth to allow the implant to fuse strongly with the bone of a host patient. The hard wear resistant surface provides device longevity, particularly when applied to bearing surfaces such as artificial joint bearing surfaces or a dental implant bearing surfaces. An antimicrobial material such as silver may be deposited in combination with a metal to form an antimicrobial surface deposit.
Rapid prototyping of ceramic articles	July 6, 2006/ US 8575513 B2	Siemens Energy, Inc.	Zafir A. Abdo, Ahmed Kamel	A method for forming ceramic articles for prototypes that involves the use of metal particles or metal-coated ceramic particles that are formed into ceramic articles using a laser engineered net shaping process. The metal particles or metal coating on the ceramic particles facilitates bonding between the ceramic particles to enable quick manufacture of ceramic articles using the laser engineered net shaping process. The ceramic articles may be ceramic core prototypes and may be used in a variety of different industries.

Exhibit 1 depicts patents related to laser engineered net shaping process.

Picture Credit: Frost & Sullivan

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