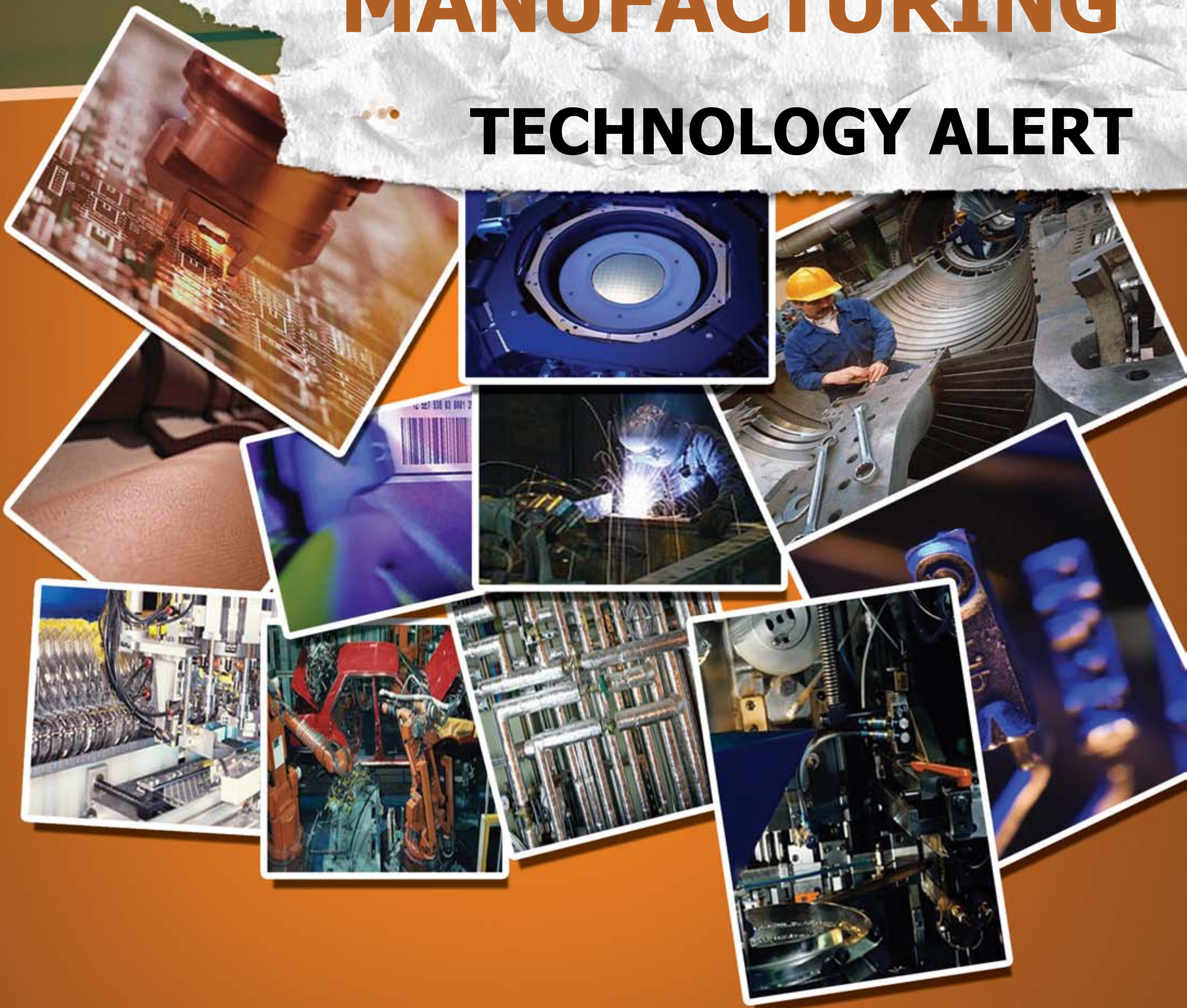
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



14th March 2014

1. ALLIANCE FORGED TO INCREASE TECHNOLOGICAL DEVELOPMENTS IN ADVANCED MANUFACTURING

There is intense research in the manufacturing sector worldwide to enable technological advancements to meet growing market needs. The alliance between The Commonwealth Center for Advanced Manufacturing (CCAM), USA, and the public-private Digital Manufacturing and Design Innovation (DMDI) institute, USA, can be viewed as a major advancement in manufacturing technology research. DMDI, launched by the US government earlier this year, is one of the manufacturing innovation institutes led by the Department of Defense (DoD). DMDI and the Lightweight and Modern Metals Manufacturing Innovation (LM3I) institute have formed an industry-university consortium for the development of various manufacturing technologies to meet security and energy needs.

This collaboration would allow DMDI to use the research capabilities and facilities of CCAM to achieve the various goals of the partnering institutes. This also provides an opportunity for the partnering institutes to be a part of various projects of DMDI, leading to innovations and developments in the field of manufacturing. Another objective of the collaboration between DMDI and LM3I is to increase product development and manufacturing processes across various industrial sectors in the US. It is also expected to help in the creation of job opportunities through novel innovations in the field of advanced manufacturing. DMDI's consortium is said to have a total of 73 companies, universities, research labs, and nonprofit organizations across the US and it is led by the University of Illinois Labs headquartered in Chicago. CCAM and DMDI have received funding of USD $140 million as part of the federal funds specifically dedicated to aid the manufacturing innovation institutes. In addition to the federal funds, the institutes have also received funding from their various consortium members.

CCAM, located at Prince George County, Virginia, USA, has a state-of-the art facility designed for providing production solutions in advanced manufacturing for various member companies. The solutions can be directly implemented by the companies in their processes. The members of the consortium also help in guiding the research, leveraging the resources and opportunities that are available within CCAM and various other top Universities in Virginia. This is achieved by a collaborative model that enables the members to share various research and development initiatives, thereby increasing efficiency. Some of the work in advanced manufacturing and surface engineering carried out by CCAM brings together research and commercialization, thereby accelerating the entry of novel technologies into markets which could also help address some of the key issues in the market. Canon Virginia Inc., Chromalloy, Newport News Shipbuilding, Rolls-Royce, Sandvik Coromant, Siemens, Sulzer Metco, Aerojet, Hermle Machine Co., Mitutoyo, TurboCombustor Technology Inc., Buehler, Cool Clean Technologies, GF AgieCharmilles, Blaser Swisslube, Mechdyne, National Instruments, and NASA Langley Research Center are some of the key industry and government members of CCAM.

The advantage of this collaborative partnership is that it increases the opportunity for creating newer technologies in the advanced manufacturing sector which would in turn help various industrial sectors to meet the growing needs of customers. This strategic alliance has the potential to help the manufacturing industry grow in the coming years, and more such alliances are expected in the future.

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2. NOVEL 3D PRINTED BICYCLE FRAME

Three-dimensional (3D) printing technology has been employed by various industries for manufacturing different products. For example, automotive manufacturers have been using this technology for producing relatively small parts and prototypes, such as air ducts, instrument panels, engine covers, exhaust manifolds, emergency brake liners, and so on. Renishaw, a UK-based company, which produces metal-based additive manufacturing machines, has manufactured the entire frame of a bicycle.

Renishaw has collaborated with Empire Cycles Ltd., a dedicated high-end manufacturer of mountain bikes in the UK, for manufacturing unique 3D-printed metal frames for bicycles. Empire designed the mountain bike to be stronger and lighter by employing a process called topological optimization and by using Renishaw's AM250 3D printing machine. This additive manufacturing process offers advantages in design, construction, and performance, which increases capabilities, such as blending of complex shapes or hollow structures having internal strength features. In addition to the above-mentioned advantages, additive manufacturing has also helped in giving the flexibility that is required for making improvements in the design from the start of production and manufacturing customized parts and products. By using the additive manufacturing technique, the company has been able to develop the novel frame with a titanium alloy, thereby reducing the weight by almost 33 percent when compared to conventional techniques, which manufacture the parts individually and then bond them together.

The initial idea for the collaboration was to optimize and manufacture only the seat post bracket for the bike. However, once it was successfully manufactured, the companies decided to manufacture the entire frame of the bike using additive manufacturing. A replica of the current aluminum frame of the bike was first 3D printed; and then the sections of the frame were divided into various sections which could be manufactured using the 12-inch build of the AM250 3D printing machine. Design improvements to the frame were then updated by Renishaw's applications team. The design improvements were focused on eliminating various downward facing surfaces, which could result in wasteful support structures. Such changes and solutions were achieved using topological optimization. The topological software program employs a set of iterative steps and finite element analysis steps that are used for determining the most feasible placement and removal of the material. Once the feasible placement has been obtained, the material is removed from areas of low stress until optimized load bearing is achieved.

Renishaw's AM250 employs a high-powered fiber laser in order to produce completely dense metal parts directly from the 3D computer-aided design data. Once the design is obtained, the parts are built layer by layer. The thickness of each layer ranges from 20 to 100 microns containing various fine metal powders that are controlled in a tightly held atmosphere. A completely welded vacuum chamber and ultra low oxygen content in the build atmosphere enables the processing of reactive materials, such as titanium and aluminum.

Additive manufacturing has allowed the design of this bicycle frame to have the capabilities of pressed steel construction, which is currently used in the construction of motorbikes and cars, without having to invest significantly high amounts of money for tooling and machinery.

With this latest development, it can now be seen that 3D printing is employed for manufacturing the entire product, in this case a bicycle. Especially with further advancements in speed, materials, and quality, 3D printing will have the potential to be adopted by other manufacturers, such as those in aerospace, or possibly over the longer term by automakers, for part production.

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3. INTERACTIVE SIMULATION TOOL FOR VEHICLE TESTING

Simulation is a very important tool these days in the automotive industry. With simulation tools, manufacturers are able to make better products. Some of the key properties of vehicle components, such as their responsiveness to accidents, reliability, and energy efficiency, are investigated using simulation tools.

A group of researchers from Fraunhofer Institute for Industrial Mathematics (ITWM), Germany, have developed an innovative interactive driving simulator using a robot-based driving and operation simulator (RODOS). This interactive driving simulator is capable of simulating and analyzing the realistic interaction between humans and vehicles. Until now, algorithms have been largely used for representing humans in simulators. The drawback in using the algorithms is that they do not completely represent the human factor in the simulations. In order to overcome this drawback, researchers at ITWM have used a hybrid design for developing the simulator. By using a hybrid design, they have been able to replicate the exact human behavior in a simulation environment. It is similar to that of a flight simulator. The automotive sector has not adopted such a simulator, as development and manufacturing costs are significantly high.

ITWM's simulation facility structure consists of a real vehicle interior where the test driver would be able to operate the steering wheel, accelerator, and brakes, in the fashion of an actual car. The interior of the vehicle is integrated with a 6-axis robotic system which looks similar to that of a large gripper arm. This robotic arm has the capability to simulate acceleration, braking, and maneuvering tight curves by leaning and rotating. For test drivers to have a realistic atmosphere in a simulator, it is necessary to have the feeling that they are in a moving vehicle. If the movements of the simulators do not match the visual impressions, then they result in different driver reactions which in turn affect the end result of the analyses. In order to prevent miscalculations and to obtain a fair analysis, the researchers at ITWN have developed and used motion curing algorithms which generate control signals for the robot. With these control algorithms, it would be possible to match the motions of simulators to the visual input which can be perceived in a natural way for test drivers. This driving simulator has also taken into account the human effects on a vehicle, which are becoming increasingly important these days. One of the key reasons for this, according to the researchers, is the growing number of driving assistance systems, which would make the human machine interface in automobiles increasingly important. The researchers at ITWN have developed the algorithms using their proprietary technology which gives them the advantage of customizing it for specific industry participants based on their demands and requirements. ITWN is currently working on two projects in collaboration with the Volvo Construction Equipment company. The researchers are presenting this simulator and the technology used in it at the Hannover Messe trade fair (April 7th to 11th, 2014), Germany.

The advantage of this simulator is that it provides a more realistic environment for test drivers to test automobiles. This would result in better analysis of the vehicles when compared to the conventional simulators currently available in the market. With the technologies employed in automobiles growing by the day, there is a need for a simulator that is capable of providing detailed analysis. This innovative simulator has the potential to be adopted by automotive manufacturers in the future.

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4. PATENT ANALYSIS OF LASER MICROMACHINING PROCESS

Laser machining is a process in which a focused optical light beam is employed for selectively removing the materials from a substrate, thereby creating a desired feature on the surface or internal part of the substrate. It is a non-contact type of process, yet it has high-spatial confinement. When compared to the other mechanical machining processes, the amount of heat that is deposited on the work piece is significantly low. This process also relies on the linear optical absorption and plasma formation mechanisms.

Laser micromachining involves materials processing at the microscale and the process used to create tiny features in parts. Lasers for micro can offer a wide range of wavelengths,pulse duration (from femtosecond to microsecond), and repetition rates. However, conventional laser machining The key advantage of lasers when compared to conventional machining may not be able to create micro-sized structures, since the linear absorption of the materials often leads to increased heat deposition. The high-heat deposition can also result in the formation of micro cracks and small damage to the surrounding area of the workpiece. Typical applications for laser micromachining include drilling, cutting, structuring, lateral material removal, marking. Lasers for micromachining can employ normally pulsed beams with an average power of well below 1 kW. Some of the other key advantages of the laser micromachining process are that laser micromachining systems are highly flexible, enabling them to cut, drill, weld and deposit materials easily. As a non-contact machining process, there is no requirement for a tool and load bearing structures. Some of the commonly used materials in this process are polymers, glass, ceramics, and silicon wafers. It is also one of the most cost effective processes for both small and large volume applications.

From the patents that have been exhibited, it can be seen that research has been carried out to enhance the capabilities of laser micromachining systems, such as reduction of contamination, post-scan lens deflection, reduction in back reflection, lasers with tailored bursts of short pulses, dual-pulsed laser micromachining. The patents also show improvements in laser micromachining for certain applications, such as thin-walled tubes and formation of optical elements in a substrate.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Coaxial water jet device used for laser micro machining of thin-walled tube	July 24, 2013/ CN 103212845 A	Machinery Co., Ltd.	Wei Zhiling, Ning Jun, Xiafa Ping, Ma Xiuyun	The invention discloses a coaxial water jet device used for laser micro machining of a thin-walled tube. The device comprises a laser generator, a focusing mirror, a protective mirror, a nozzle, a water supply unit and a high pressure auxiliary gas unit, wherein the focusing mirror is used for focusing laser beams sent out from the laser generator; the laser beams penetrating through the focusing mirror are further focused and straightened by the protective mirror, and the protective mirror is coupled with an inner wall of the device in a sealing manner so as to prevent water vapor from entering the device; the nozzle is used for outputting the focused and straightened laser beams for machining; the water supply unit supplies cooling water coaxial with the laser beams outside the nozzle to assist the machining; and the high pressure auxiliary gas unit provides high pressure auxiliary gas coaxial with the laser beams in the nozzle through a gas inlet communicated with the nozzle, and the auxiliary gas is sprayed out from the nozzle so as to prevent the water vapor from entering the nozzle.
Laser micromachining optical elements in a substrate	May 23, 2013/ WO 2013048781 A3	Rambus Inc.	Timothy A. Mccollum, Fumitomo Hide, Ian Hardcastle	Optical elements with small increments in average density are formed in a substrate by laser micromachining using a variable aperture and a pattern mask set of pattern masks each having of shape-defining elements whose density differs among the pattern masks in first density increments. A laser light beam passes through a combined mask formed by the variable aperture and one pattern mask selected from the pattern mask set. The variable aperture controls beam size and the pattern mask spatially modulates its intensity. A focusing element focuses light from the combined mask on a small averaging region of the substrate. Different combinations of the size of the aperture mask and the selected pattern mask are used in combination at respective averaging regions of the substrate. The resulting average densities of the optical elements vary among the averaging regions in increments that are small compared to the first density increments.
Optical component cleanliness and debris management in laser micromachining applications	November 27, 2012/ US 8320424 B2	Electro Scientific Industries, Inc.	Bryan C. Bolt, David M. Hemenway, Mark Kosmowski, A. Grey Lerner, Brady E. Nilsen, Richard Pope	Preferred embodiments of a purge gas port, laser beam attenuating input window, and laser shutter constitute subsystems of a UV laser optical system in which a laser beam is completely enclosed to reduce contamination of the optical system components. Purge gas is injected through multiple locations in a beam tube assembly to ensure that the optical component surfaces sensitive to contamination are in the flow path of the purge gas. The input window functions as a fixed level attenuator to limit photopolymerization of airborne molecules and particles. Periodically rotating optical elements asymmetrically in their holders reduces burn damage to the optics.
Laser micro-machining system with post-scan lens deflection	October 16, 2012/ US 8288684 B2	Electro Scientific Industries, Inc.	Mehmet E. Alpay, Jeffrey Howerton, Patrick Leonard, Michael Nashner, David McKeever	A laser micro-machining system includes a laser source positioned to direct a laser pulse through a scan lens to a work piece mounted on a work surface and a mirror positioned between the scan lens and the work piece and tilted with respect to the work surface to reflect the laser pulse toward the work piece. The mirror can be indexed to a number of positions so that only portions of the mirror are used for a number of processing steps, extending the life of the mirror.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Reducing back-reflection in laser micromachining systems	October 11, 2012/ WO 2012082930 A3	Electro Scientific Industries, Inc.	Mehmet E. Alpay, Guangyu LI	Systems and methods reduce or prevent back-reflections in a laser processing system. A system includes a laser source to generate an incident laser beam, a laser beam output to direct the incident laser beam toward a work surface along a beam path, and a spatial filter. The system further includes a beam expander to expand a diameter of the incident laser beam received through the spatial filter, and a scan lens to focus the expanded incident laser beam at a target location on a work surface. A reflected laser beam from the work surface returns through the scan lens to the beam expander, which reduces a diameter of the reflected beam and increases a divergence angle of the reflected laser beam. The spatial filter blocks a portion of the diverging reflected laser beam from passing through the aperture and returning to the laser beam output.
Method for laser micromachining	September 11, 2012/ US 8263901 B2	Oerlikon Solar Ag, Truebbach	Robert Bann, Neil Sykes	A method of laser micro-machining, by means of a laser, a work piece (**31**) of the type described comprising the steps of: locating the workpiece on a carrier forming a part of a transport system whereby the carrier can be displaced along a path (P) parallel to an X-axis of the workpiece, a Y-axis lying transverse the path, and a Z-axis lying transverse the path; focusing an image generated by means of an output beam from the laser at a working datum position (A) defined relative to the path which path is established by means of the transport system to traverse the first datum position; a plane defined by the X- and Y-Axis lying substantially perpendicular to the output beam; and displacing the workpiece along the path by way of the transport system so as to enable the work-piece to be subject to micro-machining by way of the laser characterized by the steps of: maintaining distance between the datum position and a current first surface position of the work-piece in the vicinity of the datum position; and varying the working datum position to accord with local variations in thickness of the workpiece so that the working datum position is maintained at a fixed distance relative to a surface of the workpiece apparatus therefor.
Polymer tubing laser micromachining	February 16, 2012/ WO 2012021748 A1	Raydiance, Inc.	Tim Booth, David Gaudiosi, Michael Greenberg, Gordon Masor, Michael Mielke	An apparatus for athermal ablation of a workpiece. The apparatus may include a laser device to direct a laser beam at the workpiece to remove a plurality of sections from the workpiece by athermal ablation. The removal may occur in a plurality of discrete motions that cause the laser beam to trace along outer perimeters of the sections in a specific order maintaining mechanical stability of the plurality of sections. The apparatus may further include a process gas nozzle to deliver process gas coaxially with the laser beam to clear debris and cool the workpiece, and a workpiece holder to hold and maneuver the workpiece during the removal of the plurality of sections.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Laser micromachining and methods of same	February 22, 2011/ US 7893386 B2	Hewlett-Packard Development Company, L.P.	Charles Otis, Mehrgan Khavari, Jeffrey R. Pollard, Mark C. Huth	The described embodiments relate to laser micromachining a substrate. One exemplary method includes forming a feature into a substrate, at least in part, by directing a laser beam at the substrate. During at least a portion of said forming, the method includes supplying liquid to at least a first region of the feature along a first liquid supply path and supplying liquid to at least a second different region of the feature along at least a second liquid supply path.
Laser micromachining with tailored bursts of short laser pulses	January 13, 2011/ WO 2010111089 A3	Electro Scientific Industries, Inc.	Yunlong Sun	A series of laser pulse bundles or bursts are used for micromachining target structures. Each burst includes short laser pulses with temporal pulse widths that are less than approximately 1 nanosecond. A laser micromachining method includes generating a burst of laser pulses and adjusting an envelope of the burst of laser pulses for processing target locations. The method includes adjusting the burst envelope by selectively adjusting one or more first laser pulses within the burst to a first amplitude based on processing characteristics of a first feature at a target location, and selectively adjusting one or more second laser pulses within the burst to a second amplitude based on processing characteristics of a second feature at the target location. The method further includes directing the amplitude adjusted burst of laser pulses to the target location.
Dual pulsed beam laser micromachining method	November 3, 2009/ US 7611966 B2	Intel Corporation	Eric J. Li, Sergei L. Voronov, Christopher L. Rumer	A method is described for laser scribing or dicing portions of a workpiece using multi-source laser systems. In one embodiment, a first laser melts portions of the workpiece prior to a second laser ablating the portions of the workpiece.

Exhibit 1 depicts patents related to the laser micromachining process.

Picture Credit: Frost & Sullivan

Back to TOC