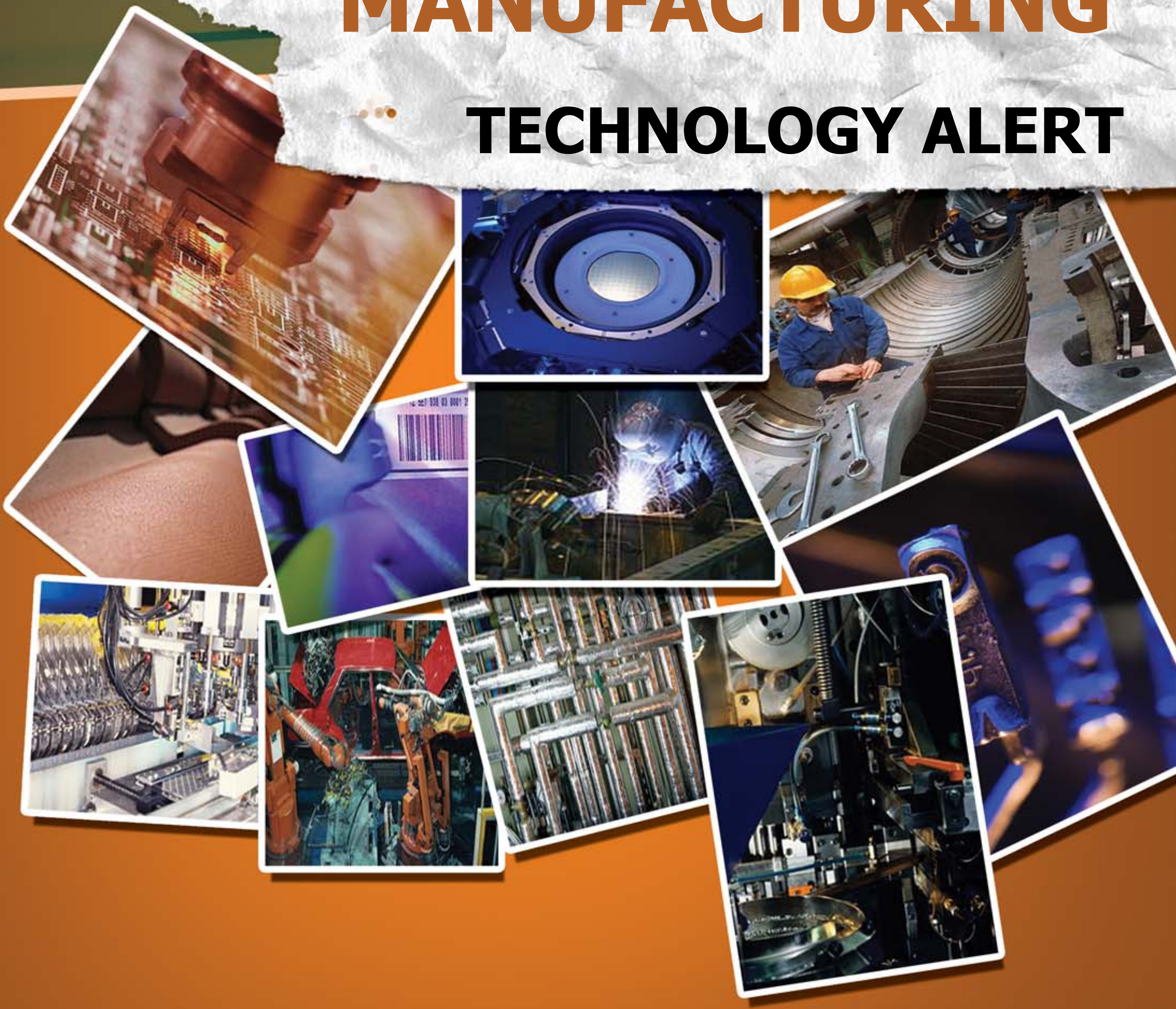
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



09th October 2015

1. OPTICAL SENSORS BOOST ROBOTIC HANDS

Equipping a robotic hand with tactile sensors or pressure, force, or strain sensors allows for significantly improved interaction between the robot hand and objects being grasped or manipulated. Such sensors can give the robot the ability to manipulate objects without breaking or damaging them. Robotic hand sensors can enable the robot to operate at an optimal low power for energy efficiency by exerting minimized grasping force. Sensors embedded in the robot hand allow the robot to work more autonomously, to react in a safe manner to unexpected forces in the environment, and to better perform tasks in an unstructured environment. Moreover, robotic hand sensors made of stretchable, flexible materials enable increased safety during the interaction between the robot hand and an object, reduced risk to workers, and improved sensitivity and sensing feedback. Sensors in the robotic hand can help drive collaborative robotics.

Applications for robot hands equipped with sensors can include, for example, pick and place tasks, welding, inspection, and so on. Optical sensing techniques can provide advantages for use in robot hands, as many sensor elements can be used in the hand.

Manifesting the benefits of optical sensing, researchers at US-based Carnegie Mellon University, in collaboration with researchers at Intelligent Fiber Optic Systems Corp. (Santa Clara, CA) have developed a soft robotic hand, which has three fingers and contains 14 embedded fiber optic (fiber Bragg grating) strain sensors. The fiber optic strain sensors, which detect strain by measuring shifts in the light wavelength reflected by the optical fiber, enable the hand to determine where the fingertips are in contact and to detect forces below a tenth of a newton.

The Carnegie Mellon researchers, moreover, also have developed an innovative stretchable optical sensor, which was not used in this version of the hand; but has potential to be embedded into soft robotic skin to detect contact, measure force, and provide improved feedback.

Conventional pressure or force sensors can have limitations in robotic hands, since (unlike fiber optic sensors) they are vulnerable to electromagnetic interference, can be susceptible to breakage, and can involve complex wiring. In contrast, a single optical fiber can include several sensors. While all the sensors in each of the fingers of the CMU hand are connected via four fibers, in theory, a single fiber could suffice.

Each finger on the Carnegie Mellon University robotic hand mimics the skeletal structure of a human finger, in which a fingertip, middle node and base node are connected by joints. The hand's skeletal bones are comprised of 3D printed hard plastic and incorporate eight sensors for force detection. Each of the three sections is covered with a soft silicone rubber skin; this is embedded with six sensors to detect where contact has occurred. The hand also contains a single active tendon, which bends the finger, and a passive elastic tendon that provides an opposing force to straighten the finger.

Conventional fiber optic sensors have limitations in terms of stretchability; glass fibers hardly stretch, while even polymer fibers generally stretch around 20-25%. To surmount such limitations of conventional fiber optic sensors for a robotic hand, where having a wide range of motion is vital, the Carnegie Mellon researchers, along with a researcher from the University of Texas, used a combination of commercially available silicone rubbers to create a highly stretchable, flexible optical sensor. The soft waveguides are lined with reflective gold. The reflective layer develops cracks as the silicone is stretched, which enables light to escape. Strain or other deformations can be calculated by measuring the loss of light.

This flexible optical sensor could be incorporated into soft skins that are able to measure force as well as detect contact.

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2. 3D PRINTED PARTS FOR RALLY CARS

The automotive industry has been a key user of additive manufacturing, primarily for high-volume prototyping of various kinds of components and parts, such as engine covers, intake manifolds, and so on. The auto industry has key needs for higher performance and weight reduction, which can be facilitated by 3D printing

The motor sports sector has been keenly interested in 3D printing for applications such as solving electrical problems in vehicles, testing the potential of new parts for vehicles, and manufacturing parts for racing cars.

US-based Stewart-Haas Racing has been pro-efficiently using additive manufacturing techniques to produce new parts with conceptual designs faster and cheaper. The company uses the fused deposition modeling (FDM) technique and printers manufactured by US-based Stratasys.

The company first manufactured three-dimensionally (3D) printed radio knobs consisting of D-shaped holes, which were mounted on a stem. Conventionally the radio knob is machined to create the D-shaped hole, but when 3D printed, the requirements for machining and post curing are eliminated. Similarly, the air duct connectors are traditionally manufactured by processes such as molding or composite lay-ups. The traditional processes are time consuming and very expensive. Stewart-Haas Racing was able to manufacture the same air duct connectors using FDM techniques with less process time, manpower and cost. The team was also able to manufacture carbon monoxide filter housing using polycarbonate and can withstand a temperature of 200 degrees Fahrenheit.

Similarly, a UK-based company, Prodrive, one of the major participants in the motor sport and vehicle technology business, was able to manufacture 15 automotive parts for its rally car using FDM. Some of the parts manufactured were wheel arches, hood vents and gauge pods. The rear wheel arches were manufactured within 24 hours for the inspection conducted by the International Automobile Federation (FIA) and have cleared the review board. The front hood vent of the car was optimized and designed for more accurate efficiency and aerodynamics. To achieve the new shape of the vents by molding or by carbon fiber lay-up will be very difficult. Prodrive was able to manufacture the newly designed hood vents using additive manufacturing methods very easily. The newly designed hood is rigid, strong and heat resistant .It is capable of withstanding extracts of air passing through the turbo and exhaust at 1800 degrees Fahrenheit.

Both companies used the FDM process to manufacture different parts and components of a car. This additive manufacturing technology is very user friendly and can be easily maintained. The components manufactured using the FDM process do not require post curing, and direct functional automotive components can be printed with a decrease in lead and cycle time for assembly of the parts. One of the main limitations in the FDM process is that when the volume and depth of the component being designed increases, the process requires support structures while printing these large components. As the size of the components increases, the process time for manufacturing the components also increases. The FDM process has been used in the automotive industry for rapid prototyping of a complete car, headlight bezels, model of the fluid door, filter housing, emission filters and so on. This process is also used in other industries such as aerospace, healthcare and in consumer and commercial applications..

From the patent analysis on FDM, it is evident that most of the patents are filled in China, followed by the US and Japan. Most of the patents pertain to new methods or new materials used in the FDM process. A patent (WO2015037574) filed by Toray Industries Inc., (Japan) pertains to a new material and filament, used for printing a warp-free object without requiring any external apparatus. Similarly, a patent (WO2015028809) filed by The University of Warwick (UK) relates to a new FDM apparatus for printing an object with two different types of materials.

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3. PIXELS SENSE AND COUNT A SINGLE PHOTON

Complementary metal oxide semiconductor (CMOS) image sensors capture photons and convert them into electrical signals that are processed into images. CMOS image sensors have certain advantages over charge coupled device (CCD) image sensors, such as low-power consumption and cost, compatibility with CMOS electronics, miniaturization, and high-speed imaging. Traditionally, CMOS image sensors have had some limitations or challenges, such as sensitivity. Active pixel sensors, where each pixel contains a photodetector or photodiode and an active amplifier, can have reduced sensitivity to incident light due to a limited fill factor (the ratio of light sensitive area to the pixel's total size) and, therefore, less quantum efficiency (the ratio of photon-generated electrons to that the pixel captures to the photons incident on the pixel area). Other limitations of CMOS image sensors have included noise (which can limit their performance under low illumination conditions) dynamic range, and lower image quality, compared to CCD imagers.

The ability of a CMOS image sensor to capture images in low-light environments is important in varied applications, such as security, astronomy, biometrics, consumer imaging, and life science imaging. To be able to distinguish differences between dimly lit objects and very dark objects, the image sensor should have very low dark current (the amount of current flowing through the photodiode even in the absence of incident light). To be effective in low-light conditions, the image sensor should also have high-quantum efficiency.

Eric Fossum, professor of engineering and Ph.D. candidate Jaiju Ma, of US-based Dartmouth College's Thayer School of Engineering have developed pixels that are able to identify and count a single photon. Such pixels, at the proof-of-concept stage of development, can help facilitate the realization of Quanta Image Sensor (QIS) technology, which the Dartmouth researchers have been working on. The goal for QIS is to be able to count every photon that strikes the image sensor, to provide a resolution of 1 billion or more specialized photoelements (called jots) per sensor, and to read out jot bit planes hundreds or thousands of times per second, yielding terabits/second of data. The QIS project has been funded by US-based Rambus Inc. (Sunnyvale, CA).

Moreover, the new sensor has opportunities to improve low-light sensitivity, which is especially valuable in applications in which there are only a few photons.

Light consists of photons that go into the semiconductor sensor chip and break the chemical bonds between silicon atoms. An electron is released when the bond is broken and more electrons are released as the light becomes brighter.

One challenge for the QIS technology is in counting the number of electrons that are set free by photons and, therefore, effectively count photons. This capability is especially important in very low light applications. The Dartmouth researchers were able to create an innovative pixel with sufficiently high sensitivity to see one electron above the background noise. The new pixels, designed to sense only one photon, are smaller than regular pixels. Many more pixels can be placed on the sensor to capture the same amount of total photons from the image.

The new pixels are able to sense and count a single electron, without having to employ techniques such as cooling the sensor to -60 degrees C or avalanche multiplication. Avalanche photodiodes, which can detect single photons, are photodetectors that use avalanche multiplication. Fossum has indicated that the strong electric fields associated with avalanche multiplication lead to reliability issues, and avalanche multiplication is not conducive to making small pixels.

The researchers would like to have one billion pixels on the sensor, while maintaining the size of the sensor.

They are working on the challenges of being able to read out one billion pixels hundreds or thousands of times per second without dissipating too much heat and creating images from all the data that are collected.

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4. NOVEL TECHNOLOGIES BEING DEVELOPED FOR AUTONOMOUSLY DRIVEN VEHICLES

The automotive industry has been heavily concentrating on self-driving cars and other commercial vehicles. Key automotive manufacturers, and others, have been testing and implementing new technologies to achieve this goal. For example, by 2020, Google, Nissan, GM, and Toyota plan to have cars with self-driving capability available.

Daimler, AG, a German automaker, is one of the major participants in the automotive industry currently working on implementing self-driving technology into its trucks. The company built a smart truck equipped with advanced systems such as smart active speed regulators, vehicle location radar devices, sensors and cameras.

This autonomously driven truck was tested in real-time traffic and has driven 20,000 kilometers (about 12,427 miles) on German and US highways. Though the truck is self-driven, there is a need for a driver to take control of the truck during harsh weather conditions or when the road markings deteriorate badly. The advanced highway pilot system installed in the trucks prompts the driver to take over the control under critical circumstances.

Daimler is also confident that the autonomously driven trucks will decrease carbon emissions due to optimized and efficient acceleration, gear-shifting, and braking.

Toyota Motors Corp. demonstrated a self-driven Lexus which uses a new concept called "mobility teammate concept". The car was able to drive autonomously for 10 minutes within a speed limit of 37 mph (meters per hour). The artificial intelligent system was also able to steer, brake and change lanes without the guidance of the driver. The company is currently optimizing the technology for better performance and efficiency as the technology has not been tested for roads with bicyclists and pedestrians.

Another innovative automated technology which Toyota is concentrating on is the "Intelligent Transportation System". This technology works by communicating with the sensory-transmission equipment at street corners. The sensor helps to detect pedestrians and oncoming cars. The technology uses data transmission to warn the car about other vehicles and objects. As the data is collected, the image is seen on the screen mounted on the dashboard and a warning sound is heard to alert the driver. This technology is expected to help the driver to maneuver the car in blind spots where there is a chance for pedestrians and cars to suddenly appear.

This novel technology has the ability to reduce accidents by communicating with other nearby cars using the same technology in the surroundings. The transmission sensors are currently installed in 20 different places in Japan. Toyota is planning to install the transmission sensors in 50 more places in Japan by the end of 2016. Currently, this technology is only available in Japan and Toyota is taking steps to implement it in the US also.

Google Inc. and Nissan have been researching and implementing autonomously driven vehicles and vehicle-detection technology. Though autonomously driven cars have been tested by major automobile manufacturers, there is still a requirement for a driver to quickly take control of the vehicle during critical situations. Toyota and other key participants in the automotive industry are still trying different techniques and technologies to implement self-driving vehicles without the need for human monitoring, which might be a key challenge in the future for automobile manufacturers.

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5. PATENT ANALYSIS FOR LASER WELDING

Laser welding is a manufacturing technique used for joining two components using a laser beam. This is a high-speed welding process and has thin, small weld seams with low distortion levels. This process can be used in open air and can easily weld two high alloy metals. Deep and narrow welds with high weld penetration can be obtained and secondary finishing or rework is not necessary. Laser welding can also be used for welding two dissimilar metals with high accuracy and minimal power usage and loss.

Laser welding also has some disadvantages. The initial and maintenance cost of equipment is very high. The joined metals can crack due to the rapid cooling rate and similarly many flaws or damages can occur in the optical surface of the laser if equipment is not properly assembled and used. Gas lasers followed by solid state and diode lasers are commonly used in this process. Conventionally, the laser welding method is used for joining metals like stainless steel, high strength low alloy steels, aluminum, titanium, carbon steels and so on.

From the patent analysis on laser beam welding, it is evident that most of the patents filed are from Japan and China followed by the US and Korea. Key companies such as Nissan Motors (Japan), Nippon Steel Corporation (Japan), Toyota Motor Corporation and Hyundai Motor Company have filed the most number of patents. Most of the patents filed are pertaining to different laser welding methods, various types of devices and inspection apparatus. A patent (US 20150266131) filed by Toyota Jidosha Kabushiki Kaisha (Toyota, Japan) pertains to a laser welding inspection apparatus for improving the accuracy of weld defects. Similarly, patent number WO 2015139116, filed By Bombardier Transportation GmbH (Germany), pertains to a hybrid welding system that uses laser and arc welding devices to read welding joint characteristics.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Component, laser-welding apparatus and method for manufacturing a laser-welded joint	Oct 01,2015/ WO 2015144365	Continental Automotive GmbH	Izzo, Ivano	A component (1) comprising a first body (10), a second body (12) and a weld seam (14) is disclosed. The first body (10) and the second body (12) are preferably made from stainless steel. The weld seam (14) has a main section (16) which adjoins both the first body (10) and the second body (12) so that a rigid joint between the first body (10) and the second body (12) is established. The weld seam (14) further has an end section (18) which adjoins the first body (10) and has a free end (20) which is spaced apart from the second body (12). In addition, a laser welding apparatus (3) and a method for manufacturing a laser-welded joint are disclosed.
Laser welding device, laser welding method and battery case	Oct 01,2015/ WO 2015146591	Primearth EV Energy Co., Ltd.	Saito, Shigeki	A laser welding device, which welds a lid (320) to an opening portion of a case (310) using a laser, radiates laser light at a part to be welded, including an inner side surface of the case, said inner side surface defining the opening portion, and an outer peripheral surface of the lid, said outer peripheral surface opposing the inner side surface of the case. The inner side surface of the case (310) and the outer peripheral surface of the lid (320) are disposed in such a way that a groove portion (330) is formed therebetween, and are formed including inclined surfaces which are capable of sliding over one another and which function as a sliding portion, in such a way that the width of the groove portion (330) can be varied by causing the sliding portion to slide. By providing a detecting unit (270) which detects the width of the groove portion (330); adjustment force applying units (510, 520) which apply to the case (310) and/or the lid (320), by way of the sliding portion, a force which adjusts the width of the groove portion (330); and a control unit (500) which controls the force applied by the adjustment force applying unit, in accordance with the groove width detected by the detecting unit (270), the effects of the relative positions of the pair of members to be welded, and the effects of differences between individual units, can be suppressed, and the strength distribution of the laser light radiated at the part being welded can be set more appropriately.
Laser welding inspection apparatus and laser welding inspection method	Sept 24,2015/ US 20150266131	Toyota Jidosha Kabushiki Kaisha	Shuhei Ogura	Provided is a laser welding inspection apparatus capable of improving the accuracy for determining the welding defect. The laser welding inspection apparatus includes a head which irradiates a welded portion of a workpiece with a laser beam for inspection, an optical receiver which receives a return light of the laser beam for inspection from the welded portion, an optical system which adjusts at least a focal diameter of the laser beam for inspection applied to the welded portion and a region where the return light from the welded portion is recognized, and a controller which controls the optical system and determines, based on intensity of the return light, whether a welding defect exists in the welded portion. The controller controls the optical system so that a diameter of the region is not more than 1.5 times as large as the focal diameter.
Hybrid laser welding system and method using two robots	Sept 24,2015/ WO 2015139116	Bombardier Transportation GmbH	Legault, Mario	A welding system comprises a two manipulators and a controller. A first manipulator has a joint detection device and a first welding device, usually of the laser type while the second manipulator has a second welding device, usually of the arc weld type. The joint detection device is operative to read welding joint characteristics along a welding joint. The controller determines a corrected trajectory based on a predetermined welding trajectory and on the welding joint characteristics read by the joint detection device. This corrected trajectory is transmitted with a first time delay to the first manipulator and with a second time delay to the second manipulator. The second time delay is a function of a distance between the joint detection device and the second welding device. A corresponding method for welding components along a welding joint is also disclosed.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Laser welding inspection apparatus and laser welding inspection method	Sept 23,2015/ EP 2921250	Toyota Motor Co. Ltd.	Ogura Shuhei	Provided is a laser welding inspection apparatus capable of improving the accuracy for determining the welding defect. The laser welding inspection apparatus includes a head which irradiates a welded portion of a workpiece with a laser beam for inspection, an optical receiver which receives a return light of the laser beam for inspection from the welded portion, an optical system which adjusts at least a focal diameter of the laser beam for inspection applied to the welded portion and a region where the return light from the welded portion is recognized, and a controller which controls the optical system and determines, based on intensity of the return light, whether a welding defect exists in the welded portion. The controller controls the optical system so that a diameter of the region is not more than 1.5 times as large as the focal diameter.
Laser welding method	Sept 03,2015/ WO 2015129248	Panasonic Intellectual Property Management Co., Ltd.	Matsuoka, Noriyuki	The laser welding method according to the present disclosure has a step for emitting laser light in a spiral shape along the welding site on a workpiece. The spiral shape is obtained by combining a circular path, in which a laser beam is moved in a circular shape, and a moving path, in which the laser beam is moved in the advancing direction along the welding site. First energy of the laser beam moving in the circular path so as to have an advancing-direction component is greater than second energy of the laser beam moving in the circular path so as to have a component in the direction opposite the advancing direction.
Laser welding head, laser welding device, and gas nozzle for laser welding head	Aug 27,2015/ WO 2015125522	Amada Holdings Co., Ltd.	Takatsu, Masato	laser welding head equipped with: a hollow head main body on the tip end of which an emission aperture that emits laser light is formed, and which is optically connected to a laser oscillator; a protective glass which covers the emission aperture and is provided on the head main body in a detachable manner; and an annular gas nozzle provided closer to the workpiece than the protective glass. A gas passage capable of being connected to a gas supply source is formed in the interior of the gas nozzle. A first nozzle, which emits gas toward the light axis of the laser light on the irradiation-direction side of the laser light, and second nozzles, which emit gas along the irradiation direction of the laser light, are formed on the gas nozzle. The first nozzle is formed so as to communicate with the gas passage and to surround the light axis of the laser light. The second nozzles are formed so as to communicate with the gas passage and to surround the first nozzle, at a position on the outside of the first nozzle in the radial direction. By means of this laser welding head it is possible to prevent fumes from interfering with the laser light and to reduce the adhesion of sputter on the protective glass.
Laser welding head, laser welding device, and gas nozzle for laser welding head	Aug 27,2015/ WO 2015125522	Amada Holdings Co., Ltd.	Takatsu, Masato	laser welding head equipped with: a hollow head main body on the tip end of which an emission aperture that emits laser light is formed, and which is optically connected to a laser oscillator; a protective glass which covers the emission aperture and is provided on the head main body in a detachable manner; and an annular gas nozzle provided closer to the workpiece than the protective glass. A gas passage capable of being connected to a gas supply source is formed in the interior of the gas nozzle. A first nozzle, which emits gas toward the light axis of the laser light on the irradiation-direction side of the laser light, and second nozzles, which emit gas along the irradiation direction of the laser light, are formed on the gas nozzle. The first nozzle is formed so as to communicate with the gas passage and to surround the light axis of the laser light. The second nozzles are formed so as to communicate with the gas passage and to surround the first nozzle, at a position on the outside of the first nozzle in the radial direction. By means of this laser welding head it is possible to prevent fumes from interfering with the laser light and to reduce the adhesion of sputter on the protective glass.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract
Method and device for laser welding or cutting with a dynamically adaptable analysis region	Aug 13 ,2015/ WO 2015118080	Blackbird Robotersysteme GmbH	Vogel, Wolfgang	The invention relates to a method and a device for welding or cutting at least one workpiece (2) by means of a laser, in which a laser beam (7) is guided along a path (10) to be welded or cut in dependence on movement data of a manipulator (3), in particular an industrial robot, and a beam directing system (6) at a distance from the workpiece (2), wherein an approximating position (14) of the path is previously established offline, to improve accuracy at least the position of a reference feature (17) of the workpiece (2) is determined online by means of an optical recording system (12) in an analysis region (15), which to increase the speed of the evaluation forms a segment of a recording region (13) of the recording system (12), a target position (19) of the path is determined on the basis of the position of the reference feature (17), the approximating position (14) is compared with the target position (19) of the path and, if there are positional deviations, the path (10) is corrected. According to the invention, to increase the immunity from errors, the size, position and/or orientation of the analysis region (15) within the recording region (13) is dynamically adapted by means of the optical recording system (12), in particular in dependence on at least one offline parameter, approximately determining the position of the reference feature (17) within the recording region (13), and/or influencing online paramete
Laser welding method and device	July 02,2015/ WO 2015098463	Amada Holdings Co., Ltd.	Sato, Kazutaka	Provided are a laser welding method and device with which the external shape of a welding bead (WB) can be maintained satisfactorily, and with which it is possible to suppress the generation of lumps which tend to form at the distal end portion of a filler wire (17). A laser welding method in which welding is performed by exposing a welding location (19) of a workpiece (W) to laser light (LB) and supplying the filler wire (17), wherein, in order to improve the shape of the laser welded part and to suppress the generation of a lump on the filler wire (17) at the completion of the laser welding, the filler wire (17) is maintained in a state in which it is pulled obliquely upward and forward in the direction in which the laser welding progresses, and the filler wire (17) is cut by exposing the connecting part between the welded portion of the workpiece (W) and the filler wire (17) to the laser light (LB). The location of the laser light exposure for cutting the filler wire (17) is in a range that includes locations in which the filler wire (17) is inclined upward and which are located remote from the welding bead (WB).
Laser welding method, laser welding device, and cylindrical body	Dec 03 ,2014/ WO 2015056453	Mitsubishi Heavy Industries, Ltd.	Kamitani, Keisuke	In this laser welding method, the end sections of cylindrical bodies (5a, 5b) are placed against one another in the axial directions thereof, a groove section (6) is thereby formed along the circumferential direction, and welding is performed by applying a laser beam to said groove section (6). The laser welding method is provided with: a welding step (S2) in which welding is performed by applying the laser beam across the entire circumference of the groove section (6); and a warping correction step (S4) in which a laser beam that has a smaller heat input amount per unit area than the heat input amount of the laser beam that is applied during the welding step (S2) is applied across the entire circumference of the welded groove section (6).

Exhibit 1 depicts recent patents for laser welding.

Picture Credit: WIPO/Frost & Suulivan

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