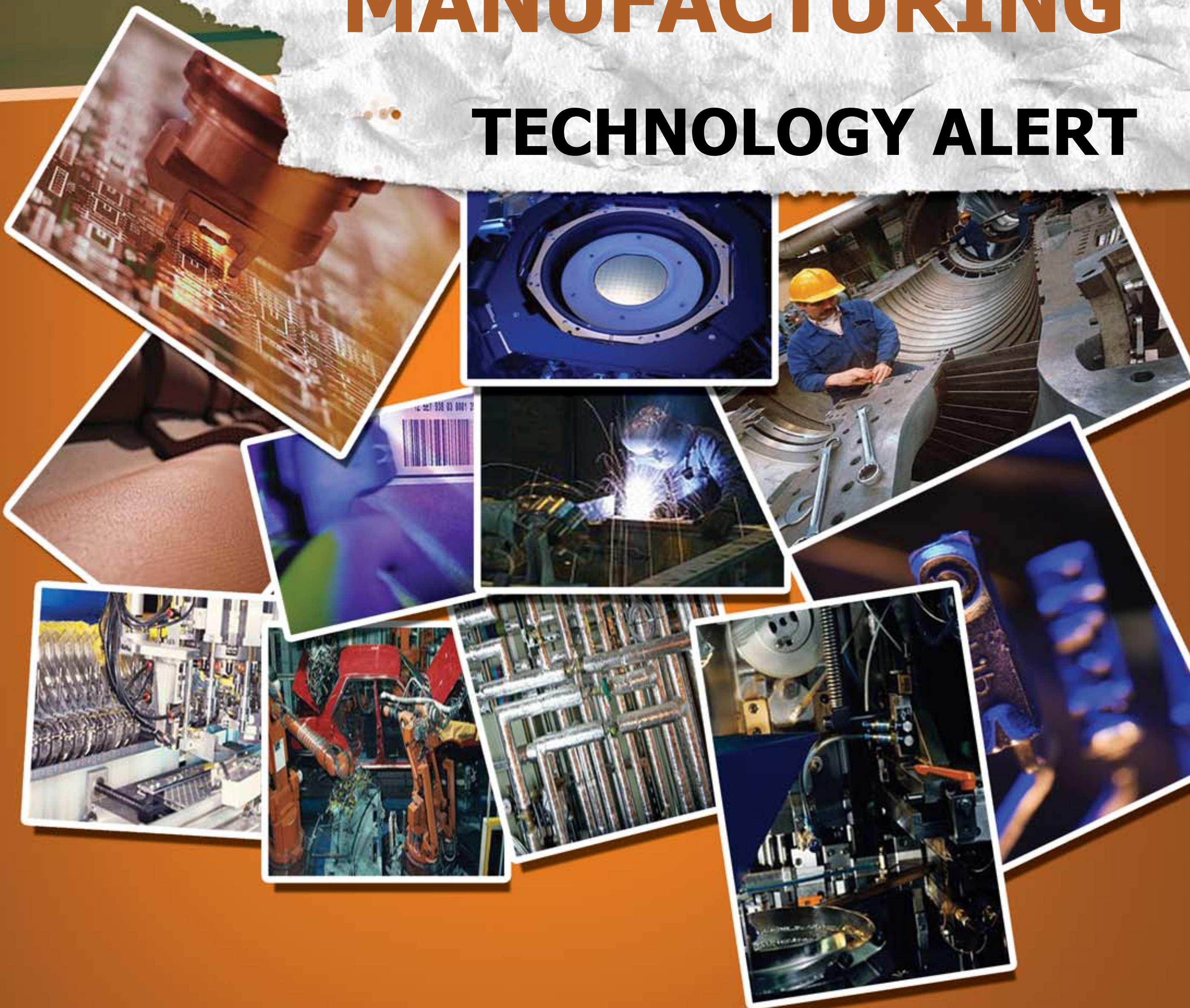
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



14th November 2014

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1. METHOD OF MANUFACTURING MORE SENSITIVE BIOSENSORS

Silicon biosensors are used to detect analytes of interest in a variety of research applications. They employ a layer of dense silicon that does double-duty as a waveguide for the optical signal, which detects the analytes as it provides the surface for capturing those analytes. However, making biosensors of dense planar silicon limits the surface to which analytes can bind, thus minimizing the desired response from light interacting with the analyte.

Some biosensor developers have sought to address this drawback by creating pores in silicon biosensors to increase their surface area. These efforts, for example, using hydrofluoric acid and electricity to etch ports into doped silicon, have minimally increased the surface area of doped silicon and have reduced the transport of optical signals through the material.

Researchers at the Georgia Institute of Technology in Atlanta, Georgia, have developed a new microscale manufacturing technique to increase the surface area, and thus the sensing capability, of silicon biosensors. The Georgia Tech scientists developed the new manufacturing technique as part of the Centers in Integrated Photonics Engineering Research (CIPhER) program. CIPhER is a US Defense Advanced Projects Agency program funded by $4.3 million over a two-year period to support the development of next-generation laboratory-on-chip sensing technology to detect multiple biological and chemical threats on a single compact and integrated platform. In addition to Georgia Tech, Emory University, Massachusetts Institute of Technology, University of California-Santa Cruz, and Yale University also participate in CIPhER.

The Georgia Tech team was led by Ali Adibi, Joseph M. Pettit Chair and a professor in the School of Electrical and Computer Engineering and Kenneth H. Sandhage, B. Mifflin Hood Professor in the School of Materials Science and Engineering. The scientists departed from previous attempts to increase the surface area of the silicon biosensor by restricting the pores they created to the thin film layer atop the silicon, leaving the dense silicon layer intact. This approach does not compromise the optical transport characteristics of the sensor.

The team manufactured a silicon-based optical sensor equipped with a long oval shaped optical resonator. The latter couples robustly with light that passes through an optical waveguide located in proximity at particular light frequencies. The scientists chemically altered the resonator surface so that it will bind with specific analytes of interest.

When the optical signal passes through the silicon waveguide and resonator, its associated electromagnetic field will interact with one or more specific types of chemical components that are captured on the sensor's surface. The presence of a target analyte will alter the resonance frequency of the optical resonator and affect the power that is transmitted through the waveguide. The greater the concentration of the analyte, the more the frequency shifts, and thus the greater the effect on the transmitted power.

Specifically, the Georgia Tech teams used an oxidation process to grow silicon dioxide (silica) atop the dense silicon layer. The academic scientists employed a shape-preserving magnesiothermic reduction process to expose the silica layer to magnesium gas that they generated by heating magnesium silicide. This process has earned Georgia Tech Research Corp US Patent 7,615,206.

The magnesium gas reacted with the silica layer and yielded a fine mixture of silicon and magnesium oxide, without reacting to the dense silicon layer beneath it. The Georgia Tech scientists dissolved the magnesium oxide via a weak acid solution and obtained a porous silicon layer with very fine 3-D-connected pores. Those pores effectively trapped analytes without scattering light appreciably and could be customized to a nanometer of thickness.

A key step in the fabrication process was cutting channels in the porous silicon and dense silicon underlayer with electron beams to form a patterned structure. Using this microlithography method enabled the scientists to carve tiny trenches in the porous silicon and dense silicon to serve as porous-silicon-on-dense-silicon waveguides and microresonators that will guide the optical signals so that they can detect analytes. Computer aided modeling supported this design and assisted the scientists in producing effective microresonators.

A key advantage of the George Tech micro-manufacturing technique is its ability to precisely control the creation of 3D interconnected pores in silicon. This can extend this advanced manufacturing technique's application to the anodes of lithium ion batteries--an area of intense scientific research--and optical displays.

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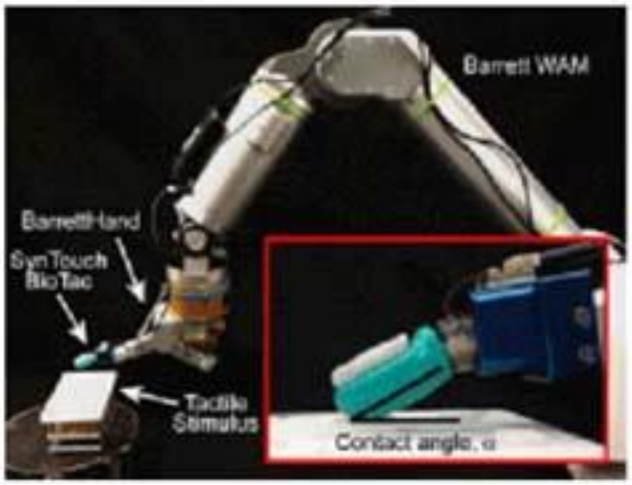
2. ROBOTICS ADVANCES FROM UCLA ENGINEERING RESEARCH

The University of California Los Angeles (UCLA) Henry Samueli School of Engineering and Applied Science conducts leading-edge robotics research in the Department. of Mechanical and Aerospace Engineering. Some of these advances can improve manufacturing activities. This engineering school is especially well known for its work in electrical engineering and computer science. UCLA and Stanford Research Institute (now known as SRI International) were the first 2 nodes on the ARPANET (a packet-switching data communications network using the TCP/IP protocol, first demonstrated back in 1969), a forerunner of the Internet.

One of the relevant projects at UCLA’s Biomechatronics Laboratory (formerly located at Arizona State University for several years), under the direction of Dr. Veronica Santos (associate professor of mechanical and aerospace engineering), is development of technologies for artificial hands that are more tactile and sensitive. That technology can open industrial robots to much more delicate manufacturing tasks and avoid wrecking fragile work-pieces by being too clumsy and forceful. The human-inspired hand technology, assisted by deformable polymeric tactile sensor skins, will better facilitate grasping, manipulating and exploring objects on the factory floor. Well-engineered fingertip sensors on the UCLA artificial hand can detect the temperature and texture of objects, as well as other key parameters.



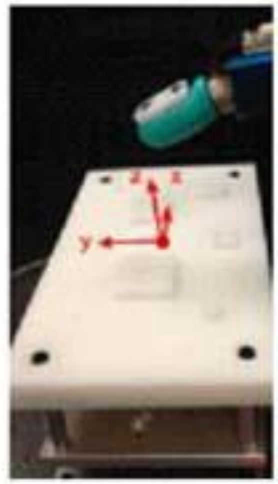


Exhibit 1 depicts a tactile sensor research apparatus on an artificial hand at UCLA's Biomechatronics Lab.

Picture Credit: http://uclabiomechatronics.wordpress.com/2014/05/08/research-on-haptic-exploration/

According to Dennis Hong, professor of mechanical and aerospace engineering, "Robots are needed for what are known as the 'three Ds' --dull, dirty, and dangerous. These are jobs unsuitable for humans." Other key robotics programs being researched at UCLA engineering include bipedal humanoids that can respond to disasters, natural or man-made. These machines need to be able to drive vehicles, get around rough terrain, and climb ladders with ease.

The engineering staff are also working on surgical robots, under the direction of Dr. Jacob Rosen, professor of mechanical and aerospace engineering. Such robots can be teleoperated by a surgeon over long distances. One key technology that makes surgical surgery possible is high-definition (HD) machine vision offering exceptional resolution of the tissues being operated on. Such advanced computer vision technology, under active research & development at UCLA Engineering, is also useful for industrial robots in manufacturing.

To summarize UCLA Engineering's robotic fields of expertise, they include: dynamic systems and controls, micro-electromechanical systems, manufacturing and design, computer vision, artificial intelligence, and medical robotics. Novel means of robot locomotion are also under study at UCLA's Robotics and Mechanisms Laboratory.

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3. WATER JET CUTTING IN MANUFACTURING OPERATIONS

Water jet cutting (WJC) has earned a permanent spot among the array of cutting tool options in the manufacturing world. Over 50 industries now use WJC technology. Originally developed in the 1930s, it has proven fast, accurate, repeatable, extremely kind to target work pieces, and capable of rather intricate cutting patterns. For example, there is no heat-affected zone (HAZ), unlike rival cutting technologies, such as welding torches, laser cutters, abrasive saws, and EB (electron beam) cutting machines. WJC machines have become indispensable for cutting sensitive materials that can tolerate water exposure, but not heat and sawing forces. The water jet kerf (cut width) typically ranges from 0.5 to 1.5 mm. Pumping pressures up to 60,000 psi are common today but 100,000 psi pressure has been used to cut aerospace materials in the past. Those elevated pressure levels usually require well-sealed costly heavy-duty electric motor-driven multi-stage positive-displacement reciprocating pumps.

Exhibit 2 depicts a water jet cutting machine.

Picture Credit:http://waterjet-cutting.blogspot.com/2011/05/why-choose-water-jet-cutting.html

Just plain water can readily cut through soft materials, such as textiles, wood, and plastics. However, for hard targets, such as concrete and metals, fine abrasives need to be introduced to the water stream. Aluminum oxide (alumina) ceramic and garnet (silicate-based) hard particles are in commercial use as the abrasive addition to water. Waste water left after machining can be cleaned and recycled, but clean make-up water will need to be added from time to time to cover losses. Besides cutting, WJC machines can do 3D shaping of targets as well as reaming of holes (enlarging their ID). Up to 5 axes of cutting may be done with a multi-head WJC machine. Computer numerical control (CNC) is the preferred means of directing the cutting head. Rather, fine edge quality is standard with WJC technology.

One of the technical challenges over time has been to engineer an exit nozzle (and mixing tube ahead of the nozzle) that actually lasts. The abrasive jet of water tends to cut right through these components. The solution is use of a super-hard material, such as industrial diamond, or cemented tungsten carbide (WC) composites (sintered mass of WC powder in a matrix of cobalt [Co] or nickel [Ni], metal content is typically 10% of the composite mass). Corundum (a natural form of aluminum oxide crystals) ceramic nozzles have also been used. Pre-treating the water has been found to extend nozzle life.

One of the current leading-edge upgrades to WJC is going to ultra-fine micro-abrasives that enable kerfs to be as thin as 0.015 inches. The introduction of CNC software developed by OMAX Corp. running on personal computer (PC) controllers, starting in the 1990s, allowed the cutters to vary their traversing speed at every point along the path. As the WJC nozzle approaches corners and detailed areas of cutting, speed needs adjustment for optimal results. A leading supplier of WJC machines (Flow International) licensed the beneficial OMAX technology.

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4. PATENT ANALYSIS OF DIE CASTING

Die casting is a metal casting process in which molten metal is forced under high pressure into a mold cavity. Two hardened tool steel dies, which are machined into shape, are used to create the mold cavity. Nonferrous metals, such as zinc, copper, magnesium, aluminum, lead and tin-based alloys, are used to make a majority of die castings and the type of metal being cast decides whether a hot or cold chamber machine should be used.

A recent patent in die casting, US8807198 B2, was assigned to United Technologies Corporation and pertains to a die casting system and method utilizing a sacrificial core.

Many patents related to vacuum die casting have been filed by companies recently. Examples include KSM Castings Group Gmbh's patent on a vacuum die casting system and method for operating a vacuum die-cast system and Dongnam Precision Co. Ltd.'s patent on a high vacuum die casting method.

Companies are also focusing on using die casting for various purposes. For example, United Technologies Corporation's has a patent on die inserts for die casting and Apple Inc.'s patent, 'cold chamber die casting with melt crucible under vacuum environment' pertains to the methods and systems for casting metal alloys into articles highlight this trend.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Die casting system and method utilizing sacrificial core	Aug 19, 2014 / US8807198 B2	United Technologies Corporation	Steven J. Bullied, John Joseph Marcin, Dorothea C. Wong	A method for die casting a component includes inserting at least one sacrificial core into a die cavity of a die comprised of a plurality of die elements. Molten metal is injected into the die cavity. The molten metal is solidified within the die cavity to form the component. The plurality of die elements are disassembled from the component, and the at least one sacrificial core is destructively removed from the component.
Vacuum die-casting system, and method for operating a vacuum die-cast system	Aug 26, 2014 / US8813815 B2	Ksm Castings Group Gmbh	Michael Werner, Thomas Zwirner, Juergen Hofmeister, Roman Kaczmarczyk	The invention relates to a vacuum die-casting system and a method for operating a vacuum die-casting system.
Die inserts for die casting	Aug 26, 2014 / US8814557 B2	United Technologies Corporation	Daniel A. Bales, Steven J. Bullied, Carl R. Verner	An apparatus for casting material has a die for receiving a compressive force, the die having a shaped-opening for receiving a die insert. The die insert has an exterior shape that is adapted to cooperate with and be received in the opening such that compressive forces impinging upon the die are focused upon the die insert such that tensile forces within the die and impinging upon the die insert are minimized.
Cold chamber die casting with melt crucible under vacuum environment	Sep 9, 2014 / US8826968 B2	Apple Inc.	Theodore A. Waniuk, Joseph Stevick, Sean O'Keeffe, Dermot J. Stratton, Joseph C. Poole, Matthew S. Scott, Christopher D. Prest	Exemplary embodiments described herein relate to methods and systems for casting metal alloys into articles such as BMG articles. In one embodiment, processes involved for storing, pre-treating, alloying, melting, injecting, molding, etc. can be combined as desired and conducted in different chambers. During these processes, each chamber can be independently, separately controlled to have desired chamber environment, e.g., under vacuum, in an inert gas environment, or open to the surrounding environment. Due to the flexible, independent control of each chamber, the casting cycle time can be reduced and the production throughput can be increased. Contaminations of the molten materials and thus the final products are reduced or eliminated.
High-vacuum die-casting method	Sep 9, 2014 / US8826965 B2	Dongnam Precision Co., Ltd.	Yong Hyun Kim, Deak Soo Kim, Joo Yul Park	A high-vacuum die-casting method includes an injecting step of moving a plunger in a sleeve so that a molten metal fed to the sleeve is pushed by the plunger to be injected into a cavity formed by a fixed mold and a movable mold, a cavity vacuumizing step of vacuum absorbing a gas in the cavity to discharge the vacuum-absorbed gas to the outside through a first path, and a sealed space vacuumizing step of vacuum absorbing a gas in a sealed space in which an eject plate and one ends of eject pins are arranged to discharge the vacuum-absorbed gas to the outside through a second path while the injecting step is performed. The sealed space vacuumizing step is started prior to the cavity vacuumizing step.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Die-casting die	Jun 24, 2014 / US8757242 B2	Mitsubishi Heavy Industries, Ltd.	Masafumi Hamasaki	Provided is a die-casting die which is less likely to cause gas defects. A die-casting die in which a runner (1) is branched at a branch section (3), and cavities are connected to the respective downstream ends of the branched runner, wherein the runner (1) comprises a main runner (2) that is located upstream of the branch section (3) and a plurality of sub-runners (4) that are located downstream from the branch section (3), a volume section (5) having an opening (6) that opens toward the main runner (2) is formed at a portion of the branch section (3) that represents an extension of the direction of the main runner (2), and the width of the opening (6) is greater than the width of the main runner (2).
Electrically driven injection device for die-casting machine	Aug 19, 2014 / US8807200 B2	Toyo Machinery & Metal Co., Ltd.	Yoshihisa Nakatsuka	The invention is provided with a first injection electric motor used for low-speed injection and increasing pressure, a second injection electric motor used for high-speed injection, first and second power transmission mechanisms for transmitting rotary motion of the injection electric motors to a screw shaft, first and second clutch mechanisms provided in the power transmission mechanisms, an injection plunger advanced and withdrawn integrally with respect to a nut threaded on the screw shaft, and a controller for controlling the driving of the injection electric motors and the clutch mechanisms. The controller starts the second injection electric motor from a stopped state before the point in time where the high-speed injection step is to commence; and switches the second clutch mechanism from a disengaged state to an engaged state at the point in time where the high-speed injection step is to commence, or at a requisite timing prior thereto.
Oil type release agent for die casting method for getting solvent mixing ratio, casting method, and spray unit	Jul 1, 2014 / US8764897 B2	Aoki Science Institute Co., Ltd., Ryobi Ltd., Kotobuki Kinzoku Kogyo Co., Ltd., Aisan Industry Co., Ltd.	Hisaharu Aoki, Koji Togawa, Hirobumi Ohira, Masanao Kobayashi, Hiroaki Komatsubara, Toshiaki Shimizu, Ryusuke Izawa, Masayuki Harada, Masayuki Kito, Keigo Yorioka, Akihiro Hayashi	An oil type release agent is provided, containing 70 to 98 parts by weight of solvents having dynamic viscosity of 2 to 10 mm^2/s at 40° C. and a flash point in the range of 70 to 170° C., 1 to 10 parts by weight of high viscosity mineral oils and/or synthetic oils having dynamic viscosity of 100 mm^2/s or higher at 40° C., 15 parts by weight or less of a silicone oil having dynamic viscosity of 150 mm^2/s or higher at 40° C., and 1 to 5 parts by weight of additives having a lubricating function. The flash point of the agent is in the range of 70 to 170° C., and the dynamic viscosity of the agent is 2 to 30 mm^2/s or higher at 40° C.
Method for producing melt supply pipe for aluminum die casting	Jul 8, 2014 / US8771789 B2	Toshiba Kikai Kabushiki Kaisha	Jun Masuda, Ryosuke Fujimoto	Methods are disclosed for producing melt supply pipes. In one illustrative implementation, there is provided a method for producing a melt supply pipe, composed of an inner ceramic pipe and an outer steel pipe fitted to the inner pipe, the melt supply pipe directed to connecting a melting furnace and a plunger sleeve of a die casting machine. Moreover, the method may include forming a Ni alloy layer over the inner circumferential surface of the outer steel pipe, burying the outer pipe in and bonding the surface of the Ni alloy layer to TiC particles, and fitting the inner ceramic pipe into the outer pipe with the TiC particles bonded to the inner circumferential surface.
Die casting design method and software	May 31, 2011 / US7950442 B2	Die Therm Engineering Llc	J. Scott Kirkman	A method for designing the location, surface temperature, flow rate, length and type of cooling lines within a mold for a casting process. The method allows the user to optimize each value for each individual cooling line of the mold. The method can utilize one or more parameters of the casting process and the heat load to be carried by each of the cooling lines in designing the mold.

Exhibit 3 depicts patents related to die casting.

Picture Credit: Frost & Sullivan

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