TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

19th June 2015

1. DEVELOPMENTS IN HUMAN PRESENCE DETECTION

Accurate, timely, and reliable detection of humans as well as animals is vital in varied industries and applications, such as automotive driver assistance, security, industrial automation, or defense.

The ability to reliably and precisely determine human presence can be challenging due to factors such as unexpected or sudden changes in environmental conditions, which can impair a sensor's functioning; problems created by background signals (including the presence of unwanted signals); variability or unpredictability in appearance or movement, which can create issues for localization and tracking systems; environmental factors, such as poor lighting or interfering sources.

Pedestrian sensors (for example, microwave radar, video image processing, ultrasonic, acoustic, passive infrared, active infrared, piezoelectric, or magnetic sensing technologies) have had limits in detection of pedestrians in real-world settings. The limitations can be due to the dynamic backgrounds of intersections. For instance, variable weather or illumination conditions can impeded the design of features and templates for varied applications. Pedestrian detection has been prone to false alarms.

An inexpensive, widely used type of sensor for human detection, the passive infrared (PIR) sensor can have deficiencies, such as inability to detect individuals who are stationary, and can have problems with animals.

US-based Olea Sensor Networks has unveiled the OleaVision sensor system, which is able to differentiate animate beings and inanimate objects at up to a distance of 5 meters in both mobile and stationary applications. The technology also provides benefits in ability to see or identify a living being through walls, regardless of whether the monitored target is moving or

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motionless, and to differentiate human presence and movement as opposed to animal presence and movement.

The system can have applications in areas such as automotive or transportation, industrial, smart home and security systems for pedestrian and bystander detection, animate-being detection (for example, a sleeping child or pet accidentally left behind in a closed vehicle), collision avoidance, intrusion detection, fire safety, and energy management. The sensor system can offer the detection range and discrimination desired for key applications such as vehicle and industrial equipment producers who seek enhanced safety capabilities to prevent deaths from vehicle and mobile industrial equipment colliding with pedestrians and bystanders.

OleaVision leverages and extends the capabilities of Olea's intelligent IoT platform, which is based on the company's proprietary embedded advanced algorithms and sensor analytic techniques.

Olea's intelligent multi-sensor platform, the company's flagship product launched in 2013, is a handheld/wearable wireless, intelligent multi-sensor data acquisition platform in a form factor the size of a typical smart phone. This solution can serve as a sensor hub with various on-board intelligent sensors, such as a Doppler radar sensor, triaxial magnetometer compass, triaxial accelerometer, triaxial gyro, barometric pressure (altimeter) sensor, temperature and humidity sensor. This platform does not require direct contact with the user.

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2. 2D MOLYBDENUM DISULFIDE CHEMICAL SENSORS

Two-dimensional (2D) materials can offer a range of intriguing electronic, catalytic, and optical properties that differ from conventional nanoparticles. 2D materials provide a platform for designing chemical or gas sensors for diverse applications. Such materials are also well-suited for optical detection, since molecular absorption can be interrogated optically due to the magnified effects on an electronic structure in a film that is highly absorbent.

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When employed as a chemical vapor sensor, graphene (a 2D layered material of carbon atoms in a honeycomb lattice) has exhibited a weak response to certain analytes with limits in selectivity. Graphene is also sensitive to water vapor, which can interfere with the target measurement.

Molybdenum disulfide (MoS2) is a 2D layered atomically thin material that has shown key promise for providing highly responsive and selective chemical vapor or gas sensors.

Reflecting the potential for 2D layered molybdenum disulfide chemical or gas sensors; a research team led by engineers at the University of California, Riverside's Bourns College of Engineering; has developed small, thin, very sensitive and selective atomically thin gas and chemical vapor sensors from molybdenum disulfide. Such sensors were tested in collaboration with researchers at the Rensselaer Polytechnic Institute. The sensors have two-dimensional channels, which benefit sensor applications owing to the high surface-to-volume ratio and widely tunable concentration of electrons.

The researchers demonstrated that the MoS2 thin-film field-effect transistor (TF-FET) sensors are able to selectively detect ethanol, acetonitrile, toluene, chloroform, and methanol vapors. The selective detection did not require any prior functionalization of the surface to specific vapors.

Sensors made with atomically thin layers of MoS2 exhibited better selectivity to certain gases due to the electron energy band gap in the material, which led to strong suppression of electrical current upon exposure to some of the gases.

The researchers noted that sensors with atomically thin MoS2 layers are complementary to graphene sensing devices. Graphene has very high electron mobility while MoS2 has an energy band gap.

In both the atomically thin graphine gas sensors and the atomically thin MoS2 gas sensors that were built, low-frequency current fluctuations were used as an additional sensing signal. Typically, these chemical sensors rely only on the change in the electrical current through the device or a change in the resistance of the device’s active channel.

The researchers, moreover, demonstrated high temperature operation of the molybdenum disulfide atomically thin film transistors. Applications involving high temperature (above 200 degrees C) include control of aero turbine engines, energy generation, oil field instruments.

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The availability of transistors and circuits to operate at temperatures above 200 degrees C is limited. Devices made of silicon carbide and gallium nitride--conventional semiconductors--hold promise for extended high-temperature operation, but are still not cost-effective for high volume applications. There is a need for new material systems that can be used to make field-effect transistors sensors that work at high temperatures.

The efforts at UC Riverside were supported by the Semiconductor Research Corporation (SRC) and Defense Advanced Research Project Agency (DARPA) through the Center for Function Accelerated nanomaterial Engineering (FAME), which was established by the SRC through its Semiconductor Technology Advanced Research network (STARnet) program.

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3. DEVELOPMENTS IN MEMS GYROS AND COMBO SENSORS

MEMS (microelectromechanical systems) gyros that perform angular rate sensing are finding expanding use in demanding or high performance applications (such as avionics, platform stabilization, biomedical instruments), as well as in high-volume consumer electronics applications (such as smart phones, tablets, game controls, and wearable electronics).

Silicon capacitive MEMS gyros that have comb-like structures are currently the dominant type of MEMS gyro in the marketplace. The use of the silicon-on-insulator (SOI) process allows for creating MEMS gyros with high mechanical quality factors.

MEMS capacitive gyros provide key benefits compared to conventional non-MEMS mechanical gyros, such as lower cost, lower power consumption, smaller footprint; and the sensitivity, resolution, and performance of MEMS capacitive gyros have been improving.

Furthermore, a growth area for MEMS inertial sensors (gyros and accelerometers) entails multi-axis combo sensors of up to as many as 10 degrees of freedom (DOF) (which also include magnetometers) and can include pressure for applications such as indoor navigation. Such combo sensing solutions can save board space, provide greater functionality, address more complex applications,

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allow for correcting for the limitations of individual sensors to obtain more accurate position and orientation information, and provide a more user-friendly interface.

Accelerometers detect linear acceleration (gravitational force) and can also provide information about tilt angle, vibration, or velocity. Multi-axis gyros are able to measure complex motion in free space; and are a very desirable sensor for tracking a moving object's position and rotation. In gyros, wafer-level integration of the MEMS sensing element, electronics and packaging can contribute to lower-cost, very compact, high-performance devices.

Magnetometers are used in consumer electronics to detect heading based on the Earth's magnetic field to provide an e-compass in, for example, mobile phones. Such e-compass applications can include correctly orienting a downloaded map on a mobile screen or providing heading information for navigation.

Anisotropic magnetoresistive (AMR) sensors, which are used in consumer electronics (such as mobile phones) as an e-compass, utilize Permalloy, a nickel-iron alloy, on a silicon wafer. The alloy's resistance depends on the angle between the metallization and direction of current flow. The resistance of Permalloy decreases as the direction of magnetization rotates away from the direction in which current flows, and is least when the magnetization is perpendicular to the direction of current flow. AMR sensors can provide enhanced sensitivity; and although their output signal is low, it is sufficient for mobile phones.

Applications for combined, mulit-axis motion sensing (using accelerometers, gyros, and magnetometers) are expected to significantly expand into diverse consumer electronics devices, even electric toothbrushes. Over time, there are also opportunities for combo sensors with a greater number of axes (up to around 10).

To optimize their opportunities with respect to MEMS gyros or inertial sensors in consumer electronics applications, a developer or provider should strive to provide sensing technology that can withstand downward price pressures and also provide extremely low-power consumption and ease of integration with existing devices or electronics in the consumer product.

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4. PATENTS ANALYSIS OF CHEMICAL MILLING PROCESS

The chemical milling process is a milling method used for removal of parts from metals using chemicals instead of physical cutting tools. Although this milling process is suitable only for metal structures with less thickness, this process is a cost-effective machining method for thin metal structures and parts. It is a widely adopted machining process for metal parts with relatively less thickness in various industries. Another advantage of this process is that it does not alter the structure of the metal that remains after milling.

Chemical milling is most suited for creating parts such as heat sinks, haptics, and certain filters. A wide range of metals, including titanium, niobium, and copper, can be milled using this process. Since the chemical milling process can be used for concurrent production of large number of parts, it provides an economical advantage for manufacturers.

Chemical milling is an established milling method. The patent trends indicate that chemical milling is extensively researched in China. This probably is because of the presence of several metal parts manufacturing companies in China.

Metal research institutes and universities are also actively involved in chemical milling research in china and Exhibit 1 shows a few patents filed by Nanchang Hangkong University (related to mchemical milling pretreatment of aluminium alloy) and Institute of Metal Research, Chinese Academy of Sciences (chemical milling of titanium aluminide intermetallics).

Besides the universities, aircraft manufacturing companies in China are involved in chemical milling research, because of the extensive use of the process in aircraft construction. Exhibit 1 shows patents filed by Harbin Aircraft Industry (Group) Co. Ltd. (determination of aluminium content in an aluminium alloy alkaline chemical milling solution), Chengdu Aircraft Industrial (Group) Co. Ltd. (method for an invalid aluminium alloy chemical milling solution), and Shenyang Liming Aero-Engine (Group) Corporation Ltd. (chemical milling method for aero engine corrosion-resistant single crystal blades) during 2012 to 2014.

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Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Determination method for aluminium content in aluminium alloy alkaline chemical milling solution	August 27, 2014 CN 104007112	HARBIN AIRCRAFT INDUSTRY (GROUP) CO., LTD.	WANG ZHENLIN	The invention belongs to the chemical milling technology, and relates to a determination method for aluminium content in an aluminium alloy alkaline chemical milling solution. The determination method comprises the steps of preparing reagents, sampling, testing and calculating the aluminium content. The invention provides the determination method for the aluminium content in the aluminium alloy alkaline chemical milling solution, is beneficial to overcome the problems of milling process control that troubles aviation enterprises for many years, stabilizes quality of the chemical milling process, and guarantees the quality of chemical milling parts in the aviation industries.
Deoxidation treatment method for chemical milling pretreatment of aluminum alloy	May 7, 2014/ CN 103774146	NANCHANG HANGKONG UNIVERSITY	LIU GANG	The invention discloses a deoxidation treatment method for chemical milling pretreatment of aluminum alloy. The deoxidation treatment method is characterized in that a bright and clean chemical milling surface is obtained on the aluminum alloy before the chemical milling process by the deoxidation method in a pretreatment technology. The method comprises the following steps: (1) caustic corrosion; (2) deoxidation treatment; (3) coating protective glue, solidifying and scoring. The deoxidation treatment method has the advantages that the bright and clean surface is obtained at the surface of aluminum alloy such as LY12 and the like after caustic corrosion when an oxide is removed. The protective glue is easily torn, and is not adhered to the surface of the aluminum alloy when the coated protective glue is scored after being dried.
Utilizing method for invalid alluminium alloy chemical-milling solution	April 16, 2014/ CN 103723752	CHENGDU AIRCRAFT INDUSTRIAL (GROUP) CO., LTD.	ZHOU GUOHUA	The invention relates to a utilizing method for an invalid alluminium alloy chemical-milling solution. The chemical-milling solution mainly comprises the following components: 170 g/l of NaOH, 20 g/l of Na2S and 183 g/l of NaAlO2. The utilizing method comprises the following steps: according to the hydrolytic characteristic of NaAlO2, separating aluminium ions in the form of Al(OH)3 crystal from the chemical-milling solution to obtain a solution containing NaOH and Na2S and the Al(OH)3 crystal; adding a proper amount of H2SO4 sulfate into the Al(OH)3 crystal for a neutral reaction to obtain Al2(SO4)3.
Chemical milling method used for aeroengine corrosion-resistant single crystal blades	February 26, 2014 / CN 103602985	SHENYANG LIMING AERO-ENGINE (GROUP) CORPORATION LTD.	Du Jingyuan	The invention discloses a chemical milling method used for aeroengine corrosion-resistant single crystal blades, and belongs to the field of material surface treatment. The chemical milling method comprises following steps: (1) pretreatment of the aeroengine corrosion-resistant single crystal blades; (2) preparation of a chemical milling solution; (3) chemical milling, wherein the temperature of the chemical milling solution is kept at 33 to 37 DEG C, the pretreated aeroengine corrosion-resistant single crystal blades are added into the chemical milling solution, loading amount of the chemical milling solution is controlled less than 0.5 piece per litre, and chemical milling speed ranges from 2 to 4m/min; and (4) aftertreatment, wherein the inner surfaces and the outer surfaces of parts, which are processed via chemical milling, are washed using a high-pressure water gun; the parts are dried with wind blowing, and are subjected to neutralizing treatment; after that the parts are washed with cold water, and dried with wind blowing, are subjected to paraffin removal and protection layer removal in a boiling solution with a temperature of 100 DEG C, and then are washed with hot water and dried with wind blowing. Recrystallization tendency of the aeroengine corrosion-resistant single crystal blades processed via chemical milling is low; qualified rate of the aeroengine corrosion-resistant single crystal blades is increased effectively; and blade production cost is reduced. In addition, the chemical milling method possesses universal reference significance for anti-fatigue manufacturing technology and stress free processing technology of single crystal blades.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Chemical milling solution and chemical milling method of Ti3Al intermetallic chemical compound	February 19, 2014/ CN 103590042	INSTITUTE OF METAL RESEARCH, CHINESE ACADEMY OF SCIENCES	Liu Jianguo	The invention relates to the field of chemical milling processing, in particular to a chemical milling solution and a chemical milling method for a Ti3Al series intermetallic compound material. The chemical milling solution comprises the components as follows: 5-20 wt% of hydrofluoric acid, 10-30 wt% of nitric acid, 1-15 wt% of hydrochloric acid, 2-3 wt% of glacial acetic acid, 0.8-3 wt% of citric acid, 0.2-5 wt% of phosphoric acid or a phosphate, 0.5-3 g/L of hexamethylenetetramine, 0-5 g/L of urea, 2-5 ml/L of glycerine, 0.1-1.5 g/L of a surfactant, 0-100 g/L of titanium ion, 0-40 g/L of aluminium ion, and water in balancing amount. According to the invention, a composite acid system is adopted, additives including the phosphate, the surfactant, the metal ions and the like are added to the composite acid system to prepare the chemical milling solution for the Ti3Al metal intermetallic compound, the chemical milling processing on the material is performed at a temperature from 35 DEG C to 65 DEG C, and the chemical milling speed is about 0.01-0.03 mm/min. The chemical milling solution formula and the chemical milling processing method, provided by the invention, can achieve the chemical milling processing on the Ti3Al material; the chemical milling speed is controllable; the dimensional precision of processed parts meets the requirements; surface roughness is high; the operation is simple during the whole chemical milling process.
Chemical milling solution and chemical milling method of gamma-titanium aluminum-based intermetallic compound	February 5, 2014 / CN 103556151	INSTITUTE OF METAL RESEARCH, CHINESE ACADEMY OF SCIENCES	ZHAO HUAN	The invention relates to the field of the chemical milling, in particular to a chemical milling solution of a gamma-titanium aluminum-based intermetallic compound material and a chemical milling method. The chemical milling solution comprises the following compositions by weight percent: 3 to 20 percent of hydrofluoric acid, 0 to 10 percent of hydrochloric acid, 8 to 30 percent of nitric acid, 1 to 3 percent of glacial acetic acid, 0.1 to 5g/L of a corrosion inhibitor, 0 to 100g/L of titanium ions, 0 to 80 g/L of aluminum ions, and the balance of water. The hydrofluoric acid, hydrochloric acid and glacial acetic acid are used as the corrosion inhibitor, the nitric acid is used as the oxidant, the a certain amount of metal ions and corrosion inhibitor are added to prepare the chemical milling solution of the gamma-titanium aluminum-based intermetallic compound, a material is chemically milled at the temperature of 35 to 60 DEG C, and the chemical milling speed is about 0.01mm/min to 0.04mm/min. By adopting the formula of the chemical milling solution and the chemical milling method, the chemical milling of a gamma-titanium aluminum material can be realized, the chemical milling speed is controllable, the dimensional size precision of a processed component can meet the requirement, the surface coarseness is good, the entire chemical milling process is simple to operate and easy to control, and the production efficiency is high.
Chemical milling method for monocrystalline high temperature alloy precision casting	December 18, 2013 / CN 103451657	Institute of Metal Research, Chinese Academy of Sciences	Meng Jie	The invention relates to a chemical milling method for monocrystalline high temperature alloy precision casting. The method is as below: first cleaning impurities on the surface of the precision casting; then putting a corrosion liquid and a precision casting in a corrosion groove, putting in a test piece with known thickness, immersing the precision casting and the test piece in the corrosion liquid, heating the corrosion groove from outside to maintain the temperature of the corrosion liquid at 20-60 DEG C, corroding for 90-200 min to shed off the corrosion products; taking out the precision casting and the test piece from the corrosion groove, flushing the precision casting and the test piece with clear water, brushing off residual corrosion products, air-drying the precision casting and the test piece, measuring thickness change of the test piece and determining the removal amount of the casting; and if the removal amount is not enough, repeating the above steps until a required removal amount is reached. The method provided by the invention is mainly suitable for chemical milling of Re-containing nickel base monocrystalline high temperature alloy. The chemical milling method is mainly used for removal of local stress concentration on the surface layer of the casting in a casting technology, and can effectively alleviate defect of recrystallization in a subsequent heat treatment process.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Chemical milling method of K423A cast superalloy without intergranular corrosion	December 18, 2013/ CN 103451656	Nanchang Hangkong University	Nanchang Hangkong University	The invention provides a chemical milling method of K423A cast superalloy without intergranular corrosion. The chemical milling method is characterized in that a composite addition agent is added to a chemical milling working fluid, so that after being subjected to chemical milling machining, the K423A alloy has a smooth and sound surface without intergranular corrosion. The chemical milling method comprises the following steps of (1) removing oil by using ultrasonic waves; (2) activating; (3) carrying out chemical milling machining; and (4) carrying out aftertreatment. The chemical milling method has the advantage that after the K423A alloy is subjected to chemical milling machining, the metal surface with small surface roughness, good surface evenness and accurate size and without allowance and intergranular corrosion can be obtained.
Titanium alloy sawtooth-shaped shallow step precision chemical milling fluid and process thereof	June 6, 2013/ CN 103147077	Shenyang Aircraft Industry (Group) Co., Ltd.	Magofuku right	The invention discloses titanium alloy sawtooth-shaped shallow step precision chemical milling fluid and a process thereof. The chemical milling fluid comprises the following components: 105-120g/L of nitric acid, 40-50g/L of hydrofluoric acid, 0.1-0.5 g/L of lauryl sodium sulfate and 25-38 g/L of ethylene glycol butyl ether, and the solvent is water. The chemical milling process comprises the following steps: (1) removing oil; (2) loosening the skin; (3) pickling; (4) coating peelable chemical milling protection glue; (5) curing; (6) scoring; (7) removing the film; (8) chemically milling; (9) washing; and (10) measuring the chemical milling depth. The titanium alloy sawtooth-shaped shallow step is chemically milled by employing the chemical milling fluid and the chemical milling process, and the chemical milling depth, the chemical milling depth tolerance and the like are greatly improved compared with the conventional titanium alloy chemical milling.
Chemical milling technology for surface plasticity deformation layer of single crystal cast blade	December 12, 2012/ CN 102817034	Shenyang Liming Aero-Engine (Group) Corporation Ltd.	Gang Ye	The invention relates to the field of surface treatment of blades, in particular to a chemical milling technology for a surface plasticity deformation layer of a single crystal cast blade. The chemical milling technology comprises the following steps of: firstly, carrying out surface treatment on the blade; secondly, carrying out chemical milling treatment on the blade: carrying out chemical milling treatment on the blade by adopting a chemical milling liquid at the chemical milling temperature of 30-40DEG C, the chemical milling speed of 3.0-4.5mum/min and the chemical milling depth of 30-60mum, wherein the chemical milling liquid in unit volume comprises the following components of 150-250ml/l of nitric acid, 80-130ml/l of hydrochloric acid, 80-130ml/l of hydrofluoric acid, 150-250ml/l of ferric trichloride, 40-60ml/l of acetic acid, 0.3-1.0g/l of lauryl sodium sulfate and 15-30g/l of activated carbon; and finally, carrying out dehydrogenation treatment on the blade in dehydrogenation furnace. According to the chemical milling technology, the treated engine blade meets the requirement of the design and the use reliability of the single crystal cast blade is improved.

Exhibit 1 depicts patents related to chemical milling process.

Picture Credit: Frost & Sullivan

5. TECHVISION 2015

The TechVision program is the premier offering of Technical Insights, the global technology innovation-, disruption-, and convergence-focused practice of Frost & Sullivan. TechVision embodies a very selective collection of emerging and disruptive technologies that will shape our world in the near future. This body of work is a culmination of thousands of hours of focused effort put in by over 60 global technology analysts based in six continents.

A unique feature of the TechVision program is an annual selection of 50 technologies that are driving visionary innovation and stimulating global growth. The selected technologies are spread across nine Technology Clusters that represent the bulk of R&D and innovation activity today. Each Cluster represents a unique group of game-changing and disruptive technologies that attract huge investments, demonstrate cutting-edge developments, and drive the creation of new products and services through convergence.

Our technology analysts regularly collect deep-dive intelligence on several emerging and disruptive technologies and innovations from around the globe. Interviews are conducted every day with innovators, technology developers, funders, and others who are a part of various technology ecosystems. The

respondents are spread across public and private sectors, universities, research institutions, and government R&D agencies. Each technology is rated and compared across several parameters, such as global R&D footprint, year of impact, global IP patenting activity, private and public funding, current and emerging applications, potential adoption rate, market potential, and so on. This organic and continuous research effort spread across several technologies, regions, organizations, applications, and industries is used to generate an annual list of Top 50 technologies that have the maximum potential to spawn innovative products, services, and business models.

Furthermore, we analyse several possible convergence scenarios where two or more of the Top 50 technologies can potentially come together to disrupt, collapse, and transform the status quo. Driven by IP interactivity emanating from each of the top technologies, a whole range of innovative business models, products, and services will be launched at unprecedented speed in the future. We have come up with over 25 such unique convergence scenarios.

The Top 50 technologies we have selected for TechVision 2015 have the power to drive unique convergence and catalyse wide-scale industry disruptions. Frost and Sullivan's TechVision program empowers you with ideas and strategies to leverage the innovations and disruptive technologies that can drive the transformational growth of your organization.

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