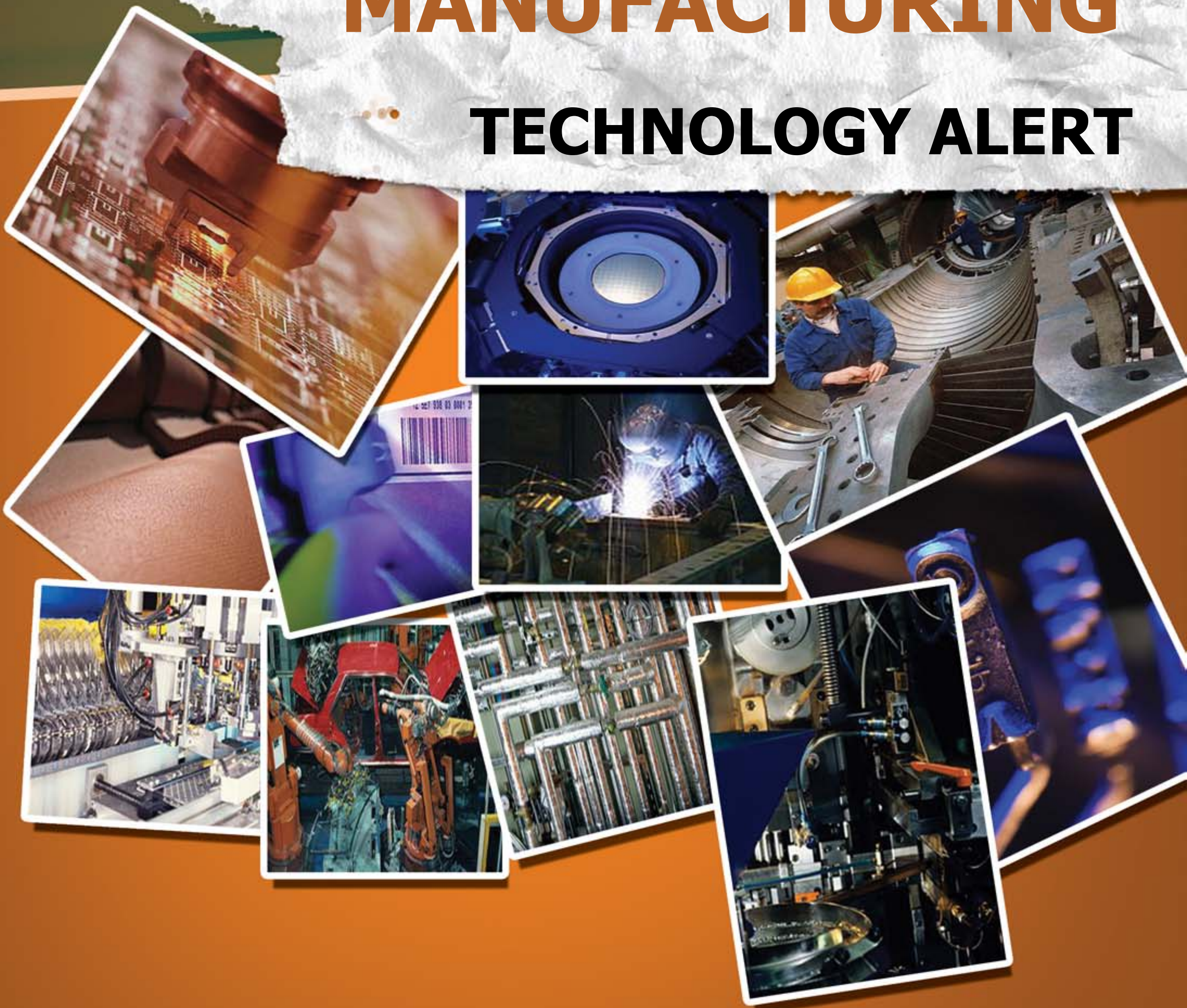
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



08th May 2015

1. MEMS MAGNETIC REED SENSOR WITH EXPANDED APPLICATIONS

The reed sensor or reed switch has traditionally been one of the simplest types of magnetic field sensors. The basic reed switch consists of a pair of flexible, ferromagnetic contacts or blades hermetically sealed in an inert gas-filled container. A magnetic field along the length of the contacts magnetizes the contacts, which causes them to attract one another to close the circuit.

Magnetic reed sensors are used in diverse applications such as proximity switches to monitor opening of doors or windows, automated test equipment (ATE), motor vehicles, washing machines, interplanetary probes, hearing aids, and laptop computers.

Reed sensors or switches have a number of benefits including immunity to dirt and contamination, simplicity of operation, freedom from maintenance, zero power consumption, and reliability. Disadvantages of reed sensors have included their relatively large size and their being relatively expensive to manufacture.

US-based Coto Technology, a key, longstanding producer of reed sensors and reed relays, has introduced the RedRockTM MEMS magnetically operated sensor, which combines the key features of conventional reed sensors (such as zero power operation and high-power hot switching capacity) with the benefits of MEMS (micro-electromechanical systems) processing (including economies of scale and reproducibility realized through lithographic semiconductor fabrication methods).

The RedRock MEMS sensor is unique, as it uses High Aspect Ratio Microfabrication (HARM) fabrication to produce a commercially available sensor. Coto sources have noted that the HARM process produces switch structures, which generate contact closure forces many times greater than those exhibited by previous MEMS-based magnetic sensors, thereby enabling hot switching up to several hundred milliwatts. Moreover, the high retract forces developed in the sensor when it opens alleviate the sensor's susceptibility to sticking shut during hot switching or after a long closure period. The sensor's tendency to stick shut under such conditions has plagued earlier MEMS sensor designs. Wafer scale packaging results in a surface-mounted compatible sensor with a footprint of only 1.26 mm2 and a height of 0.94 mm, allowing cost-effective use in size-limited applications.

The MEMS-based reed sensor contains a metal cantilever, which bridges two massive electrically isolated metal blocks--which act as magnetic field amplifiers--in the fashion of the external leads in a con-ventional reed sensor. A small gap exists between the cantilever and one of the blocks. Mflux from an external magnet builds up in the gap and pulls the cantilever into electrical contact with the block. The contacts are coated with ruthenium for optimal contact longevity.

In high aspect ratio microfabrication (HARM), the sensor is fabricated vertically with respect to the sensor substrate, which distinguishes this new technology from planar MEMS reed sensors. In the planar process for an MEMS reed sensor, the blade is electroplated on top of a base substrate, and then a sacrificial layer under most of the blade is etched away, freeing up the blade so that it can bend. The HARM fabrication process grows the blades by electroplating; however, they are grown edge-on and vertically relative to the sensor substrate. Via HARM, the blades can be made wider without increasing the footprint of the sensor. This can be done by growing the blades upwards rather than parallel to the base substrate. The HARM process also allows contacts with low-contact resistance and long life. Furthermore, the HARM process offers very good control of the blade's thickness and the size of the contact gap, both of which affect the sensor's closure sensitivity.

The new MEMS-based magnetic sensor is well-suited for demanding applications in medical devices, such as ingestible cap-sule endoscopes, insulin pumps, and hearing aids. In such applications, the need for small size, zero power operation, a low part count, and minimal circuit complexity can bode well for passive sensors, such as magnetic reed sensors, as compared to active magnetic sensors, such as giant magnetoresistive or Hall sensors. The MEMS reed sensor also provides directional magnetic sensitivity, electrostatic discharge resistance, a robust wafer-level package, and operation from a distance of up to 20 mm from the target using a small neodymium iron boron (NdFeB) magnet.

Conventional reed sensors have often been too bulky for such applications. Additional applications for the RedRock sensor include high precision level and position sensing (for example, automotive brake fluid level sensing), and incorporation into very tiny reed relays with integrated coils developed using HARM technology.

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2. VERY PRECISE DETECTION OF TERAHERTZ WAVES

The terahertz (THz) region of the electromagnetic spectrum lies between invisible low-frequency radio waves and high frequency infrared radiation. The terahertz region, which corresponds to wavelengths of 1 millimeter down to 30 micrometers, has very positive characteristics and has been eliciting keen interest. It can yield very high-resolution images and huge amounts of data. Detection in the terahertz region has promise for varied key applications, such as identifying explosives or hidden weapons, medical imaging and healthcare, monitoring in the pharmaceutical industry, astronomy, chemistry, high data rate communications, and so on.

While there has been progress in terahertz source technologies, including quantum cascade lasers, real-world applications for terahertz waves have tended to be elusive.

Researchers at California Institute of Technology (Caltech) in the US, with support from the National Science Foundation (NSF), have advanced terahertz generation and detection technology by creating a frequency comb device that is capable of very precisely generating and detecting terahertz waves over a broad spectral range. The frequency comb device, which uses ultrafast pulsed lasers, or oscillators, to produce thousands of unique frequencies of radiation distributed evenly across a spectrum in the fashion of the teeth of a comb, has promise for enhanced measurement of terahertz waves. The frequency combs can be used like rulers, in which the teeth are lined up like tick marks, to measure light frequencies with extreme precision.

The Caltech team combined commercially available lasers and optics with custom-built electronics to extend frequency comb technology to the terahertz region. The comb's teeth are evenly spaced across the majority of the terahertz region of the spectrum (0.15 THz to 2.4 THz), allowing for simultaneously measuring absorption in a sample at all of these frequencies.

The researchers are able to separate and process more than 10,000 frequencies simultaneously; and they hope to be able to process over 100,000 in the near future. In astronomy, the terahertz comb could enable more precisely identify the chemical fingerprints associated with various molecules available to planetary systems.

After the frequency comb device generates tens of thousands of evenly spaced frequencies, the waves travel through a sample, for example, water vapor. The instrument measures what light passes through the sample and the light that is absorbed by molecules at each tooth along the comb. If a detected tooth becomes shorter, the sample absorbed that particular terahertz wave. The device enables extremely precise frequencies and exact measurements to be obtained.

The terahertz comb would also be beneficial for studying fundamental interactions between molecules. The technique provides a direct means to look at the vibrations between different molecules that influence the behavior of liquids such as water. Furthermore, the technique provides a direct method for looking at vibrations within individual large molecules that are vital to life.

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3. SELF-POWERED CAMERA WITH ENERGY HARVESTING PIXELS

Image sensors are finding expanding use in a wealth of applications, such as digital cameras, mobile phones or tables, automobiles, camcorders, security/defense, medical imaging, as well as scientific research and space applications. Key trends in image sensors include ongoing reduction in pixel size along with increased pixel sensitivity.

A team led by Shree K. Nayar, T.C. Chang, professor of computer science at the Columbia University, has further enhanced image sensing by developing a prototype video camera containing self-powered pixels. This self-powered camera is able to produce an image in each second, indefinitely, of a well-lit indoor scene. The researchers designed a pixel that not only measures incident light, but is also able to convert the incident light into electric power. The research was funded by the Office of Naval Research in the US.

A self-powered camera that is able to function as an untethered device without requiring an external power supply would have profound opportunities in emerging and expanding digital imaging applications, such as wearable devices, smart environments, personalized medicine, or device to device connectivity spearheading by the Internet of Things (IoT) phenomenon.

Nayar realized that photododes are vital in both digital cameras and solar panels. A digital camera has an image sensor chip with numerous pixels. The key device in a pixel is the photodiode, which produces an electric current when exposed to light, enabling each pixel to measure the intensity of light that falls on it. The same photodiode is also used in solar panels to convert incident light to electric power. The photodiode in a camera pixel is used in the photoconductive mode, while in a solar cell it is used in the photovoltaic (solar harvesting) mode.

The researchers used off-the-shelf components to fabricate an image sensor with 30 x 40 pixels. In prototype camera, which is housed in a 3D printed body, the photodiode of each pixel is always operated in the photovoltaic mode.

The streamlined pixel design employs only two transistors. During each image capture cycle, the pixels initially record and read out the image. In order to harvest energy and charge the sensor's power supply, the image sensor continuously toggles between the image capture and power harvesting modes. When it is not used to capture images, the camera can be used to generate power for other devices, such as a phone or a watch. The team used only a capacitor to store the harvested energy. The image sensor’s architecture is conducive to the creation of a compact, solid-state imaging chip.

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4. PATENT ANALYSIS OF PULTRUSION PROCESS

Pultrusion is a type of manufacturing that is employed for producing a continuous length of reinforced polymer shapes having constant cross-sections. The raw materials used in this process are a liquid resin mixture containing resin, fillers, and specialized additives, in addition to flexible textile reinforcing fibers. The pultrusion process involves the pulling the above-mentioned raw materials through a heated steel forming die using a continuous pulling device. The reinforcement materials are in continuous forms, such as rolls of fiberglass. As the reinforcement is saturated with a resin mixture in the resin bath and pulled through a die, the hardening of the resin is initiated by the heat that is produced from the die, and a rigid cured profile of the raw material is formed corresponding to the shape of the die. Many types of pultrusion machines are available, based on the size and shape of the products being manufactured.

From the patents that have been exhibited, it can be seen that research has been carried out to develop pultrusion processes to enable this manufacturing process to produce various types of composite materials (e.g., fiber-reinforced composites). For example, Patent WO 2013127850 A1, assigned to Bayer Intellectual Property GmbH, pertains to a reaction system for preparing a fiber-reinforced composite, and a pultrusion process for preparing a fiber-reinforced composite using the reaction system.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
2-k pultrusion formulation and process	September 6, 2013/ WO 2013127850 A1	Bayer Intellectual Property Gmbh	Stephan Schleiermacher, Dirk Wegener, Harald Rasselnberg	A reaction system for the preparation of a fiber reinforced composite, comprising a continuous fiber reinforcing material and a polyurethane formulation comprising a polyisocyanate component containing at least one polyisocyanate and an isocyanate-reactivecomponent containing a blend of at least threepolyols.The invention further relates to a fiber reinforced composite which comprises a reaction system of the before mentioned type as well as a pultrusion process for the preparation of a fiberreinforced composite using the reaction system.
Reinforced composites produced by a vacuum infusion or pultrusion process	August 22, 2013/ US 20130216390 A1	Bayer Materialscience Llc	Usama Younes, Serkan Unal	Carbon nanotube-reinforced composites are produced by incorporating up to 0.7% by weight of carbon nanotubes into a liquid polymeric material a polymeric material. The viscosity of the carbon nanotube-containing liquid polymeric is sufficiently low that it can be used in vacuum infusion and pultrusion processes to produce large articles such as wind turbine blades.
Pultrusion Process for Preparing Composites Having Low Percentage of Fibers and Articles Made from Same	August 8, 2011/ US 20130204368 A1	Warsaw Orthopedic, Inc	Julien J. Prevost	An improved pultrusion process for preparing composite materials having about 10 percent to about 45 percent by volume of reinforcing fibers so as to produce a composite material having enhanced flexibility as compared with composite materials having a higher percent of reinforcing fibers by volume. Articles of manufacture made from composite material produced by the improved pultrusion process, specifically spinal implants, are also provided.
Release agent for pultrusion molding process of glass fiber reinforced plastic and preparation method thereof	June 5, 2013/ CN 101695860 B	Tianchang wide plexiglass Ltd.	Zhang month	The invention discloses a pultrusion process for FRP release agent and its preparation method is mainly based on the weight of the mixture is 60% alcohol, 20% to 30% of phosphorus pentoxide, 8% to 12% soya bean oil and 2% to 8% of silicone oil as a raw material, a method using a simple and easy to control, was prepared to obtain a resin matrix between different has good compatibility, and can improve the mechanical properties of the mold release agent, particularly suitable for FRP pultrusion process.
Pultrusion process for the manufacture of fiber reinforced composites	February 20, 2013/ EP 2301045 B1	Union Carbide Chemicals & Plastics Technology LLC	Buo Chen	This invention relates to fiber reinforced composites. In one aspect, the invention relates to a pultrusion process for fiber reinforced composites while in another aspect, the invention relates to the wet-out step of such a process. In yet another aspect, the invention relates to a pultrusion process in which the wet-out step employs a highly reactive epoxy resin system applied with a high-pressure spray nozzle while in still another aspect, the invention relates to such a wet-out step in which the filaments of the fiber are spread apart from one another before the resin system is applied.
Bismaleimide resin for microdiameter pultrusion process and preparation method thereof	September 5, 2012/ CN 102167825 B	Nanjing University of Aeronautics and Astronautics	Ren Hua , Xiao Jun , Hu Jingjing , Chen Wenna	The invention discloses a modified bismaleimide resin for a microdiameter pultrusion process The modified bismaleimide resin is prepared from the following raw materials in part by weight: 100 parts of 4,4 '-bismaleimide diphenylmethane, 1 to 30 parts of diamido diphenyl sulfone, 10 to 150 parts of dially bisphenol A and 1 to 50 parts of liquid epoxy resin. The bismaleimide resin has high formingprocessibility and a cured substance has high heat resistance. The invention also discloses a preparation method of the modified bismaleimide resin. The bismaleimide resin with viscosity and activitymeeting a composite material pultrusion process is prepared by prepolymerizing the 4,4 '-bismaleimide diphenylmethane, the diamido diphenyl sulfone, the dially bisphenol A and the liquid epoxy resin by using a high-temperature type radical initiator The reaction is stable;. the process condition is easy to control; byproduct separation is not required in the reaction process; no 'three wastes' aregenerated; and the method is applicable to industrialized production.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Pultrusion process	December 15, 2011/ US 20110306718 A1	Basf Se	Dietrich Scherzer, Andreas Wollny, Simone Schillo	The present invention relates to an improved pultrusion process for producing semifinished products based on polymers, in particular polyesters or polyamides, which comprises adding reactive chain extenders during the process of saturation (impregnation) of the fibers.
Pultrusion process and related article	March 3, 2011/ US 20110052904 A1	Graham Engineering Corporation	Joseph A. Guarriello	A pultrusion article and method for manufacturing the same is disclosed. The article has a core of cured thermoset material and foaming agent. Unidirectional fibers are distributed about the periphery of the article. A shell of cured thermoset material encapsulates the unidirectional fibers, with the shell having a greater density than the core. The core and the shell are bonded together. The article provides increased strength without the use of cross-fibers.
Pultrusion process for production of a continuous profile	February 24, 2010/ EP 2155475 A1	Airbus Operations GmbH	Michael Bechtold	The invention relates to a pultrusion process (known as an 'ADP process') in which a continuous reinforcement profile (11) is formed by canting of at least one prepreg strip (6-9) composed of a fiber-reinforced plastics material. The first shaping of the profile (11) takes place in a preform device (10), which is downstream of a pressure-molding device (12) for final shaping and prehardening. The movement of the profile (11) preferably takes place synchronously with respect to the operating cycle of the pressure-molding device (12) by means of a traction device (14). By using a cutting device (15), it is possible to cut the profile (11) to length and/or to subject edges to subseguent mechanical operations to ensure that correct dimensions are maintained. According to the invention, a continuous {pultrusion) gusset (29) is concomitantly inserted between the prepreg strips (6-9), in a radius region (27) of the profile (11), for example in the region in which the prepreg strips (6 to 9) adjoin one another during the formation of a profile (11) with a vertical web (19) with bilaterally adjacent flanges (17 and 18) (H-shaped cross-sectional geometry), thus filling, in a defined manner, cavities (28) in this region. By virtue of the continuous gusset (29), geometry deviations and/or thickness variations (variations in fiber volume content) in the radius regions (27) are eliminated and the amount of scrap is reduced.
Floating head assembly for a pultrusion process	July 24, 2001/ CA 2169218 C	Stanley Rokicki	Stanley Rokicki	A head assembly for a pultrusion process having a centre line and being substantially fixed to a supporting surface and for putruding pultrudable material, the head assembly comprising a floating adjustable assembly having a front, rear, top, and bottom, and having disposed therewith a pultrusion die having a centre line disposed at the intersection of both the vertical and horizontal planes, said die having a front or entrance, and a rear or exit, the pultrudable material passing from the entrance of the die to the exit of the die and thus substantially forming the finished shape of the pultrudable material, the centre line for acceptable pultrudable material extending within predetermined limits along the centre line of the process as the material passes from the exit of the die, the centre line of the exit of the die always remaining stationary and disposed proximate the centre line of the process, the die being fastened in position with respect to the head assembly by at least one mounting member also having a front, rear, top and bottom, the head assembly having disposed therwith proximate the rear thereof proximate the exit of the putrusion die a fixed frame portion fixed in position with respect to the supporting surface, the at least one mounting member and hence the pultrusion die being moveably affixed (for example pivotable) with respect to the fixed frame portion, the head assembly having disposed therewith at least one adjustment actuator to provide for adjustment of the head assembly and therefore the entrance of the die with respect to the exit of the die, the at least one adjustment actuator being fixed to the supporting surface and affixed with respect to the at least one mounting member and thereby providing the adjustment of the front of the head assembly, wherein should the centre line of the form of the pultrudable material exiting the die be out of line with the pedetermined limits from the centre line of the process the adjustment actuator will upon the operation thereof adjust the position of the entrance of the die with respect to the centre line of the process and the exit of the die by effecting the movement of the front of the at least one mounting member and therefore the front of the die with respect to the fixed frame portion sufficiently until the centre line of the pultrudable material is again substantially in line with and within acceptable limits from the centre line of the process and the exit from the die.

Exhibit 1 depicts patents related to pultrusion process.

Picture Credit: Frost & Sullivan

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