TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

25th April 2014

1. INNOVATIVE MICRO ROBOTS FOR MANUFACTURING APPLICATIONS

Micro robots have potential for varied applications, such as healthcare, hazardous situations, or enabling smart manufacturing of electronics or other smart structures. A research institute in United States has developed a novel micro robot that is capable of performing various manufacturing activities.

A group of researchers from the SRI International, a research institute in United States, has developed a swarm of micro robots that are capable of building products when they are made to work in a coordinated manner. The micro robots are suitable for working in micro factories in the future, where these ant-like micro robots can be made to handle solid and liquid materials such as electronic and mechanical parts. The micro robots are designed in a way that they can assemble components and small structures. According to the researchers, the swarms of micro robots are actuated magnetically when they are made to work together, which makes it easy to collaborate large swarms of these robots. SRI's novel robots are manufactured using simple low cost magnets, thereby making it significantly easy to scale to a large number of robots at a very low cost. The architecture of the robots consists of printed circuit boards (PCBs) that drive and control the micro robots. This architecture has further enhanced the drive and control of the micro robots, which has resulted in finer control of the robots, at a significantly faster rate. When the micro robots are placed on a surface with a specific pattern in the electrical circuits placed inside them, the current flowing through the coils that are beneath the circuit exerts a force on the magnet and steers the movement of robots around the work environment.

The researchers have also developed the software required for the maneuvering of the robots and have conducted experiments on the movement of these tiny robots in a complex circulating pattern. Through these experiments, they were able to prove that these micro robots are capable of working in a large team.

In addition to the novel architecture and software that is enabled in the micro robots, the researchers have also employed their patented technology,

named Diamagnetic Micro Manipulation (DM3,) in this micro robot. This patented technology is being made available as a research platform for universities and other researchers in order to explore newer applications of micro robots. The researchers are working on using their DM3 technology in the Defense Advanced Research Projects Agency (DARPA's) Open Manufacturing program for reducing the cost and increasing the delivery speed for high quality manufactured products. In another experiment that was conducted on the micro robots, it has been seen that these micro robots are capable of climbing straight walls and traveling in any directional orientation on any flexible circuit. In this experiment, 73 micro robots were made to carry out coordinated moves at 19 moves a second each. The total rate of speed was recorded to be 1386 moves/second when they were given the task of joining two carbon fiber rods. These micro robots are expected to be commercialized on a large scale by 2018.

The potential applications for these micro robots include providing manufacturing solutions such as picking and placing of parts or products, rapid prototyping of parts, manufacturing of electronic components such as optoelectronics and hybrid circuits, microfluidic lab on a chip, and tissue manufacturing. The advantages of these micro robots are the speed and precision with which the various activities are carried out. Due of the wide range of applications that can be carried out with these micro robots, this technology has the potential to be adopted in varied industries once it is commercialized.

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2. LUG FOR JOINING FIBER COMPOSITE MATERIALS

Unidirectional carbon fiber composite rods are known to have significantly high strength. Bolting techniques do not work with unidirectional composites, and bonding of the materials is difficult due to the mismatches in the stiffness of the metallic and composite connections. With any joining technology, a thick bond is desired so that the relatively softer adhesive would be able to shear and distribute the shear stresses instead of peaking at the ends of the bonds. This type of thick bond is difficult to obtain with conventional joining technologies.

Researchers from the Ames Research Center, United States, have developed a novel lug that can facilitate the joining of fiber composite rods with a

high degree of efficiency. The shape of this novel lug is designed to provide high joint strength and can be manufactured through a simple process. In addition to the above-mentioned advantages, the design of the lug also helps in improving its robustness by providing fitting yields before the adhesive fails. The strength of the joint is also controlled through the precise bond line control, which is regulated by a tight fitting bore provided in the root of the lug. This eliminates the need for conventional bond line control method, which causes irregularities in the thickness of the bond and further complicates the manufacturing process. Using this novel lug, the assembly process is streamlined in a manner that the rod can be inserted in the lug and the bore is able to hold the rod with a proper alignment. Once the lug is fitted into the rod, adhesives are then injected. An inspection hole is also provided on the lug, which allows the user to check whether the joint has been completely filled with adhesives and also prevents the adhesives from flowing into the alignment hole.

The lug has three regions. The first is the trivial clevis, bolted using two fasteners, which allows use of conventional mechanical fastening methods. The second region is on the other end of the lug, which is the bond section. In this region, the composite rod is made to enter into the fitting to transfer the entire load into the metallic connection. This region has been designed in a manner that the shear stress in the adhesive is reduced significantly, which in turn increases the joint strength. The third region is located in the middle of the lug, which is close to the tolerance bore hole that engages with the composite rod. This location hole aligns the rod to the lug, thereby eliminating the need for traditional bond line control techniques. A key advantage of eliminating the need for traditional bond line control techniques is that the bond thickness can be increased or customized according to the requirement.

This novel lug would offer the various manufacturing industries a significant advantage in joining various fiber composite materials that are being used in different application and products.

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3. SWARM ROBOTS WITHOUT MEMORY OR PROCESSING POWER

Swarm robotics refers to coordination of multiple robots and a desired collective behavior resulting form interactions among such robots and between the robots and their environment. A innovative way of manufacturing a swarm of hundreds or thousands tiny robots, which are capable of carrying out various tasks in a group without using any memory or processing power, has been developed by the engineers at the University of Sheffield, UK.

The engineering team from the Sheffield Centre for Robotics (SCentRo) in the engineering faculty of the university has succeeded in programming significantly small and simple robots that have the potential to form a dense cluster without the help of complex computer algorithms. The working of the simple swarm robots is seen as very similar to the operation of a swarm of bees or birds that work together for carrying out various tasks. It is envisioned that in the future swarm robots that could be developed for use in applications in the agricultural industry to facilitate precision farming techniques using simple and less expensive robots. In one of the experiments, a group of 40 robots were programmed to perform the task of clustering, and the developers of these robots believe that by using computer simulations, the number can be expanded to accommodate thousands of robots. Each of these robots is equipped with only one sensor, which enables it to see another robot that is in front of it. Based on whether or not the robots can see another robot in front of them, the robots either rotate on the spot or move around in a circle till they see another robot. By doing so, the robots would be able to gradually form and maintain a cluster formation for performing tasks. According to the developers, the uniqueness of the robots is in the simplicity with respect to architecture and working. For instance, since these robots do not require any memory, the need for performing any calculation is completely eliminated, and also significantly less information is required about the environment. Swarm robots developed previously required complex programming, making it difficult to decrease the size of the robots. With this innovation by the engineers from SCentRo, the development of nanoscale robots has been made possible. One of the other unique features of these robots is that, even if some of the information is corrupted, the other robots in the swarm would be able to work together and complete the task. The potential applications for these novel robots include tasks such as monitoring the levels of

pollution in the environment. They can be used for performing tasks at places that are considered dangerous for humans, and, because of their small size, they can be employed in the healthcare industry for diagnosis of vascular network in a noninvasive manner.

These swarm robots have a large number of advantages such as significantly small size, simple architecture, and working principle, thereby making them less expensive.

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4. PATENT ANALYSIS OF ATOMIC LAYER DEPOSITION

Atomic layer deposition is a process (ALD) in which precursor gases or vapors are alternatively pulsed into the surface of the substrate. The precursor gases are introduced onto the substrate surface where the reaction takes place at the surface level. Surface reactions on ALD are complementary and self-limiting. The ALD cycle of a metal oxide deposition is composed of the following steps: first, the precursor pulse and purge of the non-adsorbed precursor with inert gas and oxidant pulse, such as, ozone or water, are pulsed into the surface, which is then followed by the second gas purge. Desired product thickness can be achieved by adjusting the number of the above-mentioned cycles. In order to control the chemical composition of the resulting layer, various metal precursors are applied alternatively. ALD is seen as a promising ultra-thin film deposition method for preparing a variety of materials, since it produces high quality films with precise control of film thickness and allows manipulation of the materials' composition. This process can be used for depositing a wide range of materials based on the precursors that are used in the system. Some of the advantages of ALD process are that a wide range of film materials can be employed and highly repeatable film thickness can be achieved. In addition to the above-mentioned advantages, it is also seen as a simple process for batch processing of products.

From the patents that have been exhibited, it can be seen that research has been carried out to develop this process for a range of applications, such as, DRAM (dynamic random-access memory) capacitors, germanium-antimony-tellurium alloy film, and hafnium oxide deposition. ALD research has also involved certain precursors (for example, silylantimony) used in the ALD process.

Exhibit 1 depicts patents related to atomic layer deposition.

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
SENSOR SYSTEMS FOR MEASURING AN INTERFACE LEVEL IN A MULTI-PHASE FLUID COMPOSITION	03.04.2014; WO/2014/051989	GENERAL ELECTRIC COMPANY	SURMAN, Cheryl, Margaret	A sensor includes a resonant transducer, the resonant transducer being configured to determine the composition of an emulsion. The composition of the emulsion is determined by measuring the complex impedance spectrum values of the mixture of the emulsion and applying multivariate data analysis to the values.
FLUID LEVEL SENSOR AND RELATED METHODS	27.03.2014; US 20140085363	Van Brocklin Andrew L	Van Brocklin Andrew L	In an embodiment, a fluid level sensor includes a sensor plate and a current source. The fluid level sensor also includes an algorithm to bias the current source such that current applied to the sensor plate induces a maximum difference in response voltage between a dry sensor plate condition and a wet sensor plate condition.
ADHESIVE DISPENSING DEVICE HAVING OPTIMIZED RESERVOIR AND CAPACITIVE LEVEL SENSOR	20.03.2014; US 20140076923	NORDSON CORPORATION	Clark Justin A.	An adhesive dispensing device includes a heater unit for melting adhesive, a fill system communicating with a receiving space for feeding the heater unit, and a reservoir for receiving melted adhesive from the heater unit. The dispensing device also includes a capacitive level sensor located along a sidewall of the receiving space such that the level of adhesive in the receiving space can be detected by sensing the difference in dielectric capacitance where the adhesive is located compared to where air acts as the dielectric. The size of the driven electrode produces a broader sensing window capable of generating multiple control signals corresponding to different fill levels of adhesive. The receiving space and reservoir are minimized in size so that adhesive is not held at elevated temperatures long enough to char or degrade

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
ACOUSTIC FLEXURAL ORDER LEVEL SENSOR	20.03.2014; WO/2014/043356	STREET SMART SENSORS LLC	KNOWLES, Terence, J.	A liquid level sensor includes a rod having a first portion and a second portion, and a wave generation unit affixed to one end of the rod. The wave generation unit generates a wave group that propagates in at least a shear order and a flexural order, and the frequency of the shear wave is based on the diameter of the rod.
FUNNEL WITH LEVEL SENSOR	06.03.2014; US 20140060698	TENNISON Tamara L	TENNISON Tamara L	A funnel for transferring a flowable ingredient into a receiving container and which indicates the level of the flowable ingredient in the receiving container. The input end of the funnel extends downwardly to the output end which has a smaller circumference than the input end. At least one sensor is located on the outer surface of the funnel body adjacent to the output end with each sensor located at a different distance from the input end. As the flowable ingredient fills the receiving container, the flowable ingredient is sensed by each sensor which then activates a display to provide an indication of the level of the flowable ingredient in the receiving container, with the final indication being that the receiving container is full. The final indication causes the output end to seal such that transfer of the flowable ingredient is stopped.

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
SYSTEM FOR MEASURING MATERIAL LEVELS USING CAPACITANCE AND TIME DOMAIN REFLECTOMETRY SENSORS	20.02.2014; US 20140049274	Hafer Kevin G.	Hafer Kevin G.	An apparatus and system for measuring levels of two or more materials maintained within a storage tank using a combination of both a capacitance sensor and a time domain reflectometry ("TDR") waveguide sensor is disclosed. The apparatus includes a combined circuit for the capacitance sensor and TDR sensor that creates a separation between the return signal from the capacitance sensor and the TDR sensor. The need for the return signal separation is due to the generation of false reflection signals from the capacitance circuitry. In a preferred embodiment, the separation in time is created by moving the capacitance false reflections further in time than the true signal returns. An alternative preferred embodiment would delay the true TDR signals passed the capacitance false reflections. Another alternative preferred embodiment would provide a substantially matched impedance of the capacitance circuit to the TDR circuit, to substantially eliminate the false reflections.
FAULT DIAGNOSIS DEVICE FOR FUEL LEVEL SENSORS AND FAULT DIAGNOSIS METHOD FOR FUEL LEVEL SENSORS	06.02.2014; WO/2014/021136	NISSAN MOTOR CO., LTD.	TAKAHASHI, Akio	A fault diagnosis device for fuel level sensors, for detecting fuel remaining in a fuel tank provided with at least a first tank and a second tank, comprises a area determination means for determining, on the basis of fuel level sensor output values, a fuel residual area divided in accordance with output characteristics of a fuel level sensor, and a area fault diagnosis means for diagnosing faults in a fuel level sensor for each area by comparing the amount of fuel consumed from when the area changed and a fault determination threshold set separately for each area. The area fault diagnosis means sets the fault determination threshold to the value corresponding to the fuel consumption equivalent required for exiting a dead zone area in the dead zone area, in which the change in fuel level sensor output values is smaller when the fuel consumption source switches from the first tank to the second tank.

Exhibit 1 depicts patents related to atomic layer deposition

Picture Credit: Frost & Sullivan

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