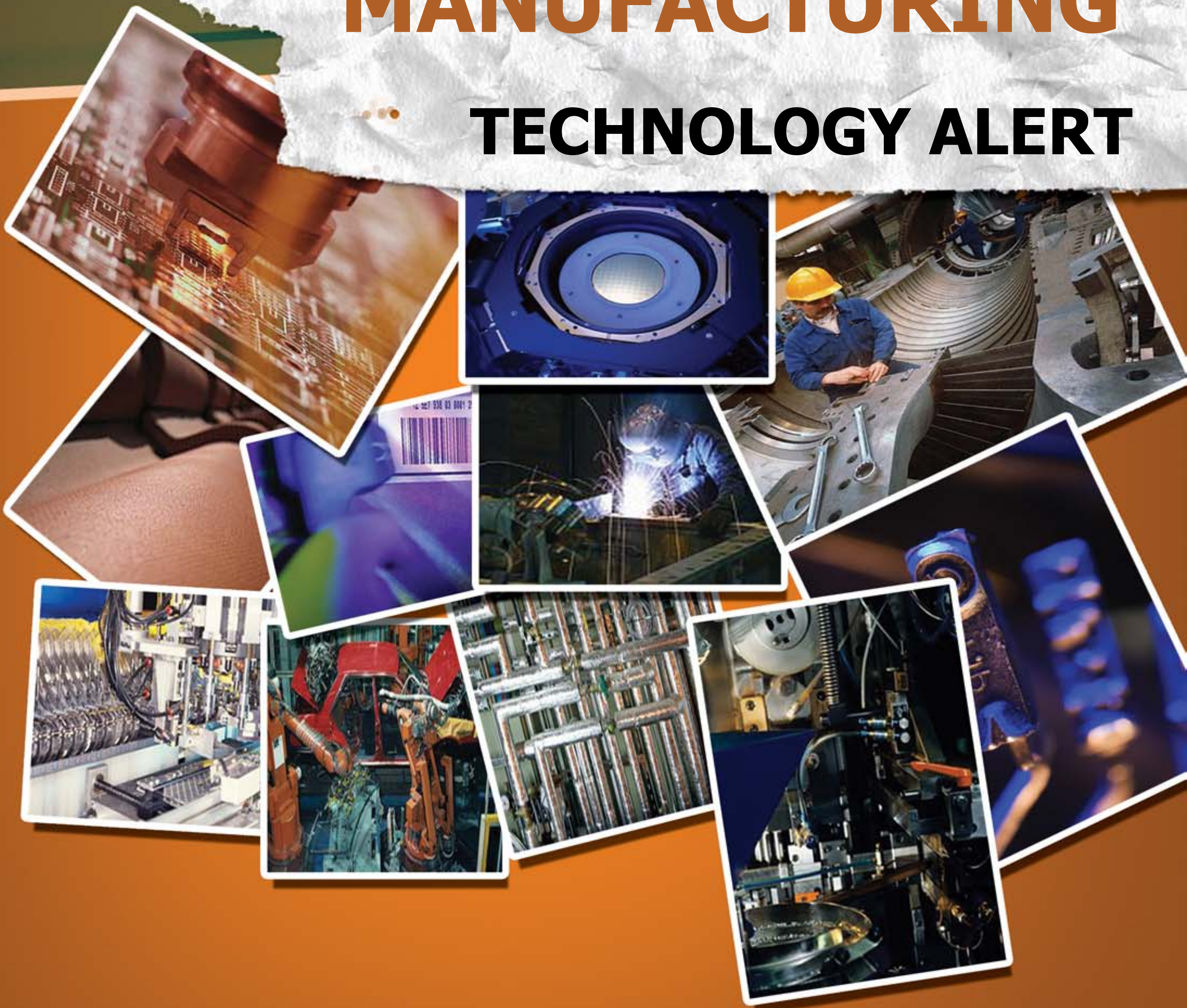
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



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1. COLLABORATIVE LEARNING ALGORITHM FOR ROBOTS

Machine Learning is a technology by which computers learn novel skills using patterns in training data. This technology is used as a basis for the development and advancement of, for example, artificial intelligence, voice recognition, and self-parking of cars. This technology is also used for autonomous robots that are used in building models of their environments. The drawback with implementing the machine learning technology for autonomous robots is that robots are able to work efficiently in collecting the data when they are made to work as a group when compared to working alone. Some issues, such as power constraints, communication and computation, are seen as major factors for the significant decrease in the efficiency of the autonomous robots when they are made to work alone.

Researchers from the Massachusetts Institute of Technology (MIT), USA have developed a novel algorithm that has the potential to make autonomous robots work more efficiently while working alone. Using this algorithm, distributed agents such as robots exploring a building would be able to collect data and analyze the data that is obtained individually. The other key capability of this algorithm is that it allows pairs of robots passing each other in a hall or a production floor to exchange analyses. Based on the various tests that were carried out, it has been found that the distributed algorithm has the potential to outperform a standard algorithm that works on data collected at a single location. For instance, the optimization of data would be difficult when there is only one computer used to learn a model from a single large batch of data. With this new algorithm, the researchers have broken the data into smaller batches which is processed by the individual robots and then combined and shared among groups of robots. The procedure of breaking down the data is said to be robust and flexible. This algorithm is relatively simple, thereby allowing the robots to have a clear understanding of the size of the objects in a particular location in addition to the number of objects that can be placed in the specific location. Over time, the robots would be able to build their own catalogue of the location and the content in the specified location. This information would allow the robots to communicate with each other and eliminate overlaps. The potential applications for this innovative distributed algorithm entail multiple autonomous agents, such as multiple autonomous land and airborne vehicles. In addition to being adopted by industries for implementation in their products, the technology would also have the potential for adoption by other researchers in the coming years.

The advantages of this algorithm are that it can be used to increase the efficiency of autonomous robots that are being increasingly adopted on a significant scale by a diverse range of industrial sectors, where robots are employed for carrying out tasks.

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2. NOVEL MICROBOTS FOR CARRYING OUT A WIDE RANGE OF TASKS

Microrobots or microbots, ultra-miniature, mobile robots, have been attracting increased attention as they are low cost and capable of being used in large numbers. For instance, they can be used for exploring challenging, space-constrained or dangerous environments. A swarm of these microbots can be controlled together to carry out different tasks. Some of the challenges seen with the microbots are the algorithm that is used for controlling them and also the complexity in designing the robots. Researchers are trying to develop a novel microrobot to address the above-mentioned challenges.

A group of researchers from the Harvard School of Engineering and Applied Sciences (SEAS) and the Wyss Institute for Biologically Inspired Engineering at Harvard University have developed a swarm of self-assembling robots named Kilobots. These robots are extremely simple, with each of them only a few centimeters long. The researchers believe that these small robots could be used instead of highly complex robots, providing a simple platform for the enhancement of complex behaviors. In one of the demonstrations at Harvard University, researchers assembled 1024 of these bots simultaneously. The algorithm used in these novel robots, which has been designed by the researchers, is believed to be capable of controlling a large swarm of robots when compared to the conventional algorithms, which could only control a few hundred micro robots.

The Kilobots require no micro management or intervention once an initial set of instructions has been delivered. For instance, four robots mark the origin of a coordinate system and all the other robots receive a 2D image that they should follow. Then, by using very basic behaviors, such as following the edge of a group, tracking a distance from the origin, and maintaining a sense of relative location, the robots take turns moving towards an acceptable position. Kilobots are also capable of correcting their own mistakes; if there is a traffic jam or when a robot moves away from the prescribed route resulting in an error, the nearby robots sense the problem and cooperate to overcome the problem. The researchers have built the Kilobot by using two vibrating motors that allow it to slide across a surface on its rigid legs. An infrared transmitter and receiver have also been used to help the Kilobot communicate with a few of its neighbors and measure their proximity. All the above-mentioned design features have helped the researchers to significantly reduce the manufacturing cost of the Kilobots and also made these robots much simpler in terms of working and design when compared to the conventional robots. The design and software used in the Kilobot which have been developed by the researchers at Harvard are available on an open source platform for non-commercial use. The Kilobots have also been licensed by Harvard's Office of Technology Development to K-Team, a manufacturer of small mobile robots. Some of the potential applications for the Kilobots are industrial uses, disaster management response and so on.

The Kilobots have a simple design and operation. Also, the cost associated with manufacturing is significantly less compared to conventional robots. Due to the above-mentioned advantages and other capabilities, the Kilobots and the technology used in them have the potential to impact microbot development.

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3. REGENERATIVE PLASTIC FOR AEROSPACE AND AUTOMOTIVE PARTS AND PRODUCTS

Self-generating materials have significant potential in vital applications, such as revitalization of damaged materials. The ability of self-repairing materials to regenerate can significantly expand their value and applications.

Researchers at the University of Illinois, Urbana-Champaign (US) have developed a novel material that can not only heal itself but also regenerate. This material has the capability to fill in large cracks and holes by regrouping itself. According to the researchers, this innovation holds significantly high potential for consumer goods and also in such applications as car bumpers or aerospace parts. For instance, when the bumper of a vehicle is damaged, it can repair itself in a short span of time. The material can be very useful for producing parts and products that are difficult to repair or replace, especially in the aerospace sector. The regenerating capabilities are obtained by using specially formulated fibers that disintegrate. Using these fibers, the researchers have been able to create a material with networks of capillaries. The capillaries allow the delivery of large amounts of healing agents, which in turn helps in the restoration of large damaged areas of the product or part. The other advantage of the capillaries is that they can also enable multiple restoration of the material when it is damaged more than once. In the regenerating material, two adjoining parallel capillaries are fixed with regenerative chemicals that flow out when there is damage at a specific point. The two liquids then mix to form a gel, which fills the gap caused by the damage, thereby filling in cracks and holes. Then the gel is hardened further into a strong polymer which restores the mechanical strength of the plastic material.

The researchers have demonstrated this regeneration system by using two types of commercial plastic--thermoplastics and thermosets. Both these plastic variants are used on a large scale for the production of various parts and products used in a wide range of applications in the automotive and aerospace industries. From the demonstration, the researchers have also found that the speed of the gel formation or the hardening speed can be adjusted based on the application area and the extent of the damage that has been caused. For instance, when there is a series of cracks developed in addition to a large hole caused on the bumper of a car, the speed of hardening can be adjusted in a way that all the cracks are first closed before the larger area is closed. This innovation can also help in easing the manufacturing and repair process. The researchers are working on optimizing the regenerative chemical systems for different types of materials.

Some of the advantages of this innovation are that the time and cost associated with the repair work are significantly reduced. It also helps in the development of products and parts with more capabilities than those currently available.

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4. PATENT ANALYSIS OF PLASMA ENHANCED ATOMIC LAYER DEPOSITION

Plasma-enhanced atomic layer deposition (PEALD) is an advanced technique of the atomic layer deposition (ALD) process. PEALD is used for manufacturing metal oxide films having significantly high purity and density at low-growth temperatures. This process utilizes specific chemical precursors, such as the atomic layer deposition process. In addition to the chemical precursors, PEALD makes use of RF plasma in order to create the chemical reaction in a highly controlled manner

One key area of research involves using PEALD to create a conductive metal layer over a dielectric layer, as evident in Plasma-enhanced atomic layer deposition of conductive material over dielectric layers (Patent US 20140008803 A1, assigned to ASM America. There is also research on improving the PEALD process. For example, the plasma-enhanced atomic layer deposition method (WO 2013155432 A2), assigned to Veeco Instruments, pertains to a cyclic PEALD process to build layers of TiN (titanium nitride) on a substrate that are highly conformal and not subject to hydrogen inclusions to the same extent as prior art processes.

Title	Publication Date/ Publication Number	Assignee	Inventor	Abstract

Plasma-enhanced atomic layer deposition of conductive material over dielectric layers	January 9, 2014/ US 20140008803 A1	Asm America, Inc.	Robert B. Milligan, Dong Li, Steven Marcus	Methods of forming a conductive metal layer over a dielectric layer using plasma enhanced atomic layer deposition (PEALD) are provided, along with related compositions and structures. A plasma barrier layer is deposited over the dielectric layer by a non-plasma atomic layer deposition (ALD) process prior to depositing the conductive layer by PEALD. The plasma barrier layer reduces or prevents deleterious effects of the plasma reactant in the PEALD process on the dielectric layer and can enhance adhesion. The same metal reactant can be used in both the non-plasma ALD process and the PEALD process.
Plasma enhanced atomic layer deposition method	October 17, 2013/ WO 2013155432 A2	Veeco Instruments, Inc.	Nigamananda Samal	A cyclic PE-ALD process (Fig. 3) includes four steps in two phases; in a first phase (TDMAT), a TDMAT pulse (e.g. 1 sec) is perfornned followed by a purge (e.g. 1.5 sec), and in a second phase (H_2/Plasma), an H_2 pulse (e.g. 2.5 sec) and RF power for a plasma pulse (e.g. 1 sec) are concurrently performed, followed by a purge. Cycles of this process build layers of TiN on the substrate that are highly conformal and not subject to H_2 inclusions to nearly the same extent as prior art processes. The film quality is further improved by the application of RF power for plasma from beneath the substrate.
Plasma enhanced atomic layer deposition system and method	July 16, 2013/ US 8486845 B2	Tokyo Electron Limited	Tsukasa Matsuda	A method for depositing a film on a substrate using a plasma enhanced atomic layer deposition (PEALD) process includes disposing the substrate in a process chamber configured to facilitate the PEALD process, introducing a first process material within the process chamber and introducing a second process material within the process chamber. Also included is coupling electromagnetic power to the process chamber during introduction of the second process material in order to generate a plasma that facilitates a reduction reaction between the first and second process materials at a surface of the substrate. A reactive gas is introduced within the process chamber, the reactive gas chemically reacting with contaminants in the process chamber to release the contaminants from at least one of a process chamber component or the substrate.

Plasma enhanced atomic layer deposition system	May 23, 2013/ US 20130125815 A1	National Applied Research Laboratories	Bo-Heng Liu	A plasma enhanced atomic layer deposition (PEALD) system used to form thin films on substrates includes a plasma chamber, a processing chamber, two or more ring units and a control piece. The plasma chamber includes an outer and an inner quartz tubular units, whose central axes are aligned with each other. Therefore, plasma is held and concentrated in a cylindrical space formed between the outer and outer quartz tubular units. Due to the first and second through holes, the plasma flow may be more evenly distributed on most of the surface of the substrate to form evenly distributed thin films and nano particles on the substrate. In addition, due to the alignment and misalignment between the first and second through holes, the plasma generated in the plasma chamber may be swiftly allowed or disallowed to enter to the processing chamber to prevent the precursor from forming a CVD.
Operating method for a large dimension plasma enhanced atomic layer deposition cavity and an apparatus thereof	January 17, 2012/ US 8097083 B2	China Star Optoelectronics International (Hk) Limited	Hung-Wen Wei, Hung-Che Ting	An operating method for a large dimension plasma enhanced atomic layer deposition cavity and an apparatus thereof are provided. The present invention reduces the time needed for filling the manufacturing gas into the large volume manufacturing cavity. Therefore, the plasma enhanced atomic layer deposition apparatus can switch the precursors rapidly to increase the thin film deposition rate, reduce the manufacturing gas consumption and lower the manufacturing cost.
Plasma enhanced atomic layer deposition apparatus and the controlling method thereof	March 22, 2012/ US 20120070590 A1	Industrial Technology Research Institute	Jen-Rong Huang	This prevent disclosure provides a plasma enhanced atomic layer deposition apparatus and the controlling method thereof. The plasma enhanced atomic layer deposition apparatus includes: a plurality of reaction chambers, each of the reaction chambers having a first reaction space and a second reaction space; an adjustable partition unit controlled to separate or communicate the first and the second reaction spaces; and a plurality of heating carriers respectively disposed in the plurality of reaction chambers. The method manipulates the movement of the partition plate, leading to separation or communication between the first and second reaction spaces, so as to avoid the interference or inter-reaction between process gases and the resultant particles contaminating the substrates.

Plasma enhanced atomic layer deposition process	July 28, 2011/ US 20110183079 A1	Penn State Research Foundation	Thomas Jackson, Devin A. Mourey, Dalong Zhao	Improved systems, methods and compositions for plasma enhanced atomic layer deposition are herein disclosed. According to one embodiment, a method includes exposing a substrate to a first process material to form a film comprising at least a portion of the first process material at a surface of the substrate. The substrate is exposed to a second process material and the second process material is activated into plasma to initiate a reaction between at least a portion of the first process material and at least a portion of the second process material at the surface of the substrate.
Controlled composition using plasma-enhanced atomic layer deposition	June 1, 2010/ US 7727864 B2	Asm America, Inc.	Kai-Erik Elers	Metallic-compound films are formed by plasma-enhanced atomic layer deposition (PEALD). According to preferred methods, film or thin film composition is controlled by selecting plasma parameters to tune the oxidation state of a metal (or plurality of metals) in the film. In some embodiments, plasma parameters are selected to achieve metal-rich metallic-compound films. The metallic-compound films can be components of gate stacks, such as gate electrodes. Plasma parameters can be selected to achieve a gate stack with a predetermined work function.
Apparatus and process for plasma-enhanced atomic layer deposition	March 23, 2010/ US 7682946 B2	Applied Materials, Inc.	Paul Ma	Embodiments of the invention provide a method for forming a material on a substrate during an atomic layer deposition (ALD) process, such as a plasma-enhanced ALD (PE-ALD) process. In one embodiment, a method is provided which includes flowing at least one process gas through at least one conduit to form a circular gas flow pattern, exposing a substrate to the circular gas flow pattern, sequentially pulsing at least one chemical precursor into the process gas and igniting a plasma from the process gas to deposit a material on the substrate. In one example, the circular gas flow pattern has circular geometry of a vortex, a helix, a spiral, or a derivative thereof. Materials that may be deposited by the method include ruthenium, tantalum, tantalum nitride, tungsten or tungsten nitride. Other embodiments of the invention provide an apparatus configured to form the material during the PE-ALD process.

Plasma enhanced atomic layer deposition system	September 28, 2006/ US 20060213437 A1	Tokyo Electron Limited	Tadahiro Ishizaka, Kaoru Yamamoto	A plasma enhanced atomic layer deposition (PEALD) system includes a processing chamber defining an isolated processing space within the processing chamber, and a substrate holder provided within the processing chamber and configured to support a substrate. A first process material supply system is configured to supply a first process material to the processing chamber, a second process material supply system is configured to supply a second process material to the processing chamber and a power source is configured to couple electromagnetic power to the processing chamber. A contaminant shield is positioned along a periphery of the substrate holder and configured to impede external contaminants that permeate the chamber from traveling to a region of the substrate holder, wherein the film is formed on the substrate by alternatingly introducing the first process material and the second process material.

Exhibit 1 depicts patents related to plasma-enhanced atomic layer deposition.

Picture Credit: Frost & Sullivan

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