TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

28th August 2015

1. TEA TREE EXTRACT USED FOR PRODUCING GRAPHENE

Graphene is a form of carbon made of one layer of carbon atoms, which are arranged in a honeycomb-shaped lattice. The one-atom thick material is very sturdy, flexible and light. Furthermore, grapheme conducts heat and electricity extremely efficiently. Many researchers are analyzing and implementing new methods to use graphene due to its exceptional characteristics in many areas. Research is also underway to find new sources to produce graphene.

As part of the above mentioned research initiatives, researchers from Australia, Singapore, Japan, and United States have discovered a method of producing graphene from a tea tree called *Melaleuca alternifolia*. For this research, the James Cook University in Queensland (Australia) researchers collaborated with researchers in institutions from Australia, Singapore, Japan, and the US.

From the tea tree's oil, the researchers were able to fabricate defect-free graphene films in large scale. When compared to conventional graphene growing methods, it takes just a few minutes to grow graphene using this novel method. This method does not confide on methane, explosives, toxic substances, or other nonrenewable sources during the growing process and can work in very {low?} temperatures without the requirement of a catalyst.

The team used a plasma-enhanced chemical vapor deposition technique to grow graphene from the tea tree's oil. While the conventional method uses methane gas, in this method, tea tree extracts were vaporized and fed into a heated tube. Graphene films were immediately produced from the vapor as soon as the plasma containing electrodes were switched on. The graphene produced by this method had long edges and large surfaces. The edges of graphene strongly influence the overall properties of the material. The graphene produced by the researchers was found to have an edge length of 2.6 km in 1 cm^2. Long edges in graphene make it very advantageous for using in various applications such as chemical sensors and battery electrodes.

The results obtained from this method also proved that the graphene produced had hydrophobic properties. Hydrophobic properties increase the surface layers in two-dimensional (2D) graphene and makes it look like three-dimensional (3D) graphene**.** Due to the strong hydrophobicity obtained during this method, the researchers found 3D nanoscale features on the surface of the produced graphene. These features allow the produced graphene to be used for creating various superhydrophobic surfaces and coatings, which are used in medical aerospace, automotive devices, and for manufacturing water repellent textiles.

The research team placed semiconductors between the produced graphene film and aluminium, and found memristive properties being exhibited. This proves that the graphene film produced can be used for making next-generation nonvolatile memory devices called memristors. The electrical resistance of the memristor depends on how much electrical current has flowed through the device, and on the direction of the current flow through the device, in the past.

The researchers are currently focusing on optimizing and increasing the efficiency of the material properties. The graphene produced can be used for manufacturing various types of detection sensors for the medical and automation industries. Graphene's characteristics, such as large surface-to-volume ratio, optical properties, superior electrical conductivity, high carrier mobility, can benefit sensor applications, such as biosensors and diagnostics. Graphene's large surface area can enhance surface loading of biomolecules, and its excellent conductivity and small bandgap can be beneficial in the conduction of electrons between molecules and the electrode's surface. Moreover, graphene can create composites with superior qualities. Graphene composites have key opportunities in areas such as automotive or aerospace parts.

Analysis of patents shows that various companies and research institutions have been continuously working on efficiently producing graphene and using it for various purposes. The patent US20150205040 filed by Tyson York Winarski, an inventor, pertains to graphene coated fiber optics. Toray Advanced Materials Research Laboratories (China) Co. Ltd., has a patent (WO2015120785) on producing graphene composites and electrodes for a lithium-ion battery used for machines and vehicles. Most of the patents filled are by China followed by the United States and Korea. Companies such as Oceans King Lighting Science &Technology Co. Ltd., (China) and Samsung Electronics (Korea) have filled a large number of patents dealing with production methods and applications of graphene.

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2. LASER INDUCED GRAPHENE CATALYST FOR FUEL CELLS

Automobiles can benefit from fuel cells for powering purposes. Conventional fuel cells are expensive because isolating hydrogen and constructing an infrastructure that will deliver hydrogen to the automobiles is very challenging. After years of research, scientist found that materials such as graphene and hexagonal boron nitride can also be used as a catalyst in fuel cells.

Researchers from the University of Manchester proved that graphene, which was considered to be impermeable, allows protons to pass through. This characteristic of graphene enables it to isolate hydrogen in a fuel cell and deliver it for powering automobiles. A group of chemists from Rice University had developed laser induced graphene in 2014 with a polyimide plastic. The graphene developed was a flexible thin film consisting of a porous surface, which was obtained by exposing polyimide to a commercial laser scribing beam.

The same research group from Rice University has now discovered a novel method to enhance the same graphene product with reactive metals. This unique form of graphene is called metal oxide-laser induced graphene (MO-LIG), which is obtained by embedding metallic nanoparticles on graphene using a commercial laser. MO-LIG can be used an alternative to expensive metal catalysts such as platinum in fuel cell applications (for converting oxygen and hydrogen into electricity and water).

The produced graphene can be used for fuel-cell applications. It is called a super catalyst because the metal content in it is less than 1%. This laser induced method when compared with the conventional graphene electrolyte method is more efficient, takes less time, and does not require expensive carbon precursors or metals. The process involves laser treatment of commercial polymers and iron, cobalt and molybdenum metal salts at room temperature and in open air. It results in metal nanoparticles getting generated and embedded on graphene.

At the beginning of the research, commercial polyimide sheets were used to produce laser induced graphene. Then, liquid polyimide infused with boron was used to produce laser-induced graphene. They had increased superconductivity and capacity to store electric charges.

To obtain MO-LIG, the liquid was mixed with one of the three concentrations that contained cobalt, iron or molybdenum metal salts. After the mixture was condensed on a film and treated with an infrared laser, it was heated at 750 degrees C for half an hour in argon gas. The results found that 10-nanometer-sized particles were spread evenly through the graphene and it had the ability to catalyze an oxygen reduction. The material was further glazed with sulfur for allowing hydrogen evolution (converting water into hydrogen by catalytic process).

This research was supported by the Air Force Office of Scientific Research and its Multidisciplinary University Research Initiative. At present, the researchers are working on optimizing the process after several tests and trials with the help of few automotive companies for development in the manufacturing scale. This method is expected to be commercialized by the beginning of 2018; and fuel cells with MO-LIG can be expected to have potential to impact the automotive fuel cell market by the second quarter of 2019.

Patent analysis of graphene's applications in fuel cells shows wide patenting activity on use of graphene coating in fuel cells. For example, in patent WO2015101773 filed by INTELLIGENT ENERGY LIMITED (UK), the first layer of a fuel cell will be coated with an electrically conductive hydrophobic layer and the second layer will comprise of a graphene coating. The same company has another patent (WO2015101772), which relates to a membrane electrode assembly and a fuel cell assembly. It also relates to a method of manufacturing a fuel cell assembly. Most of the patents are from China followed by Korea and the United States.

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3. INNOVATIVE 3D METHOD FOR PRINTING TEN DIFFERENT MATERIALS

Three-dimensional (3D) printing, or additive, layered manufacturing, has been used to print different kinds of objects with various types of plastic or metal materials for a wide range of industries and applications, such as healthcare, aerospace, automotive, consumer/commercial. A multi-material 3D printing method would enable printing products that would not be possible with traditional 3D printing techniques. Multi-material 3D printing capability also can allow for producing new, innovative composite materials.

Many companies have been working to produce a multi-material 3D printing platform with many different functional items, but these inkjet-based platforms have been mostly limited to only three materials. A group of researchers from the Massachusetts Institute of Technology (MIT) have found a novel method and device that can print ten different materials at once by using 3D-scanning techniques. This machine, which is called as ' MultiFab,' integrates both traditional manufacturing and modern 3D printing technologies, including inkjet print heads, to create a whole new range of objects, which could not be printed before. The technique is also less expensive and more efficient when compared to conventional multi-material 3D printing techniques.

The MultiFab 3D printer works by using 3D-scanning techniques from machine-vision and has a resolution of 40 micrometers. The printer can also self-correct and calibrate and does not require any manual fine turning. Inexpensive hardware can be used in the printer to ensure print accuracy since the printer first generates a correction mask showing the errors in each layer of the design by performing 3D-scan loop. The printer can also print complex and finished products with components such as circuits and sensors embedded directly on the object being printing.

In conventional printers, different materials have to be printed as individual pieces while factors such as pressure and temperature and assembly must be considered separately. MultiFab deals with the above technical challenge by using a platform were the component is placed and scanned for its 3D geometries. The information gathered is used to program the system to print around the scanned object.

Some of the multi-material printers work using extrusion process, which most of the time leads to printing an object that looks unrealistic and very low in resolution. To deal with this problem, the researchers have used a computationally-intensive process in MultiFab. This method sends microscopic droplets of photopolymers, which are mixed well through the inkjet print heads. This method allows the user to print multiple materials and large scaled objects very easily, since many gigabytes of visual data are processed simultaneously and sent through the print heads.

The main advantage of MultiFab is that companies can quickly design prototypes and parts with different materials. Many researchers are finding new techniques and implementing new methods to use 3D printers in various fields, such as automotive and aerospace for printing parts or other prototypes, which will help in increasing the overall efficiency of the vehicle or aircraft. MultiFab can be used by researchers, manufacturers, and companies for printing small- to large-scale

parts, which require more than one material. It can also be used to print parts that require sensors and circuits to be embedded in them. Currently, the researchers are working on optimizing the device for large scale manufacturing and analyzing ways to improve the overall efficiency of the printer. MultiFab is expected to be commercialized by the start of 2018, and to have opportunities to impact the 3D printing market by the end of 2019.

From the patent analysis done on multi-material 3D printing, It is evident that a lot of research has been taking place on developing a multi-material 3D printer using different methods and processes. Patent WO2015120538 filed by Structur3D Printing Incorporated (Canada) deals with a 3D printer, which prints by extrusion method using a multi-material extruder. The patent US20150201499 by Zohar Shinar, an inventor deals about using numerous 3D printing heads for achieving various processes at different stages of a process. Most of the patents filed in this area are from Japan followed by United States, China, and Europe.

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4. NOVEL OPTIMIZATION ALGORITHM FOR INDUSTRIAL ROBOTS

Robotic arms have been a boon for the automotive industry. They work efficiently and produce consistent parts and products with good quality, are cost-effective, and improve overall production. These robots can work around the clock without any supervision and can manufacture various parts with accurate engineering, closer tolerance, and precise/quality welds**.** Using robots in the manufacturing sector has also improved the quality of the vehicles manufactured. One of the main disadvantages in using robots in the automation production sector is that the energy consumption is very high.

To address this is issue, a group of researchers from Chalmers University of Technology has developed a new optimization algorithm. This algorithm reduces energy consumption of an industrial robot up to 40% by minimizing the robot's acceleration.

An industrial robot consumes energy when it is in motion doing work and even when it is in a stand-still position. In this instance, the researchers made the motion of the robot slower while it was waiting for other machines and robots to finish work and start the next sequence. By using the developed algorithm, the acceleration and deceleration properties of the robotic arm--while in motion--

were optimized. This allowed the researchers to minimize the overall energy consumption of the robots without affecting the time taken for execution of a process by the robot. The optimization algorithm only changes the speed and sequence of the robot to perform efficiently without making any changes to the robot's process path.

The algorithm starts by mapping the motion and sequence of the robots during various different operations. The information obtained is processed and optimized by the algorithm, and a new efficient control instruction for the robots to follow is generated. The new control information can be directly executed by the robots to reduce energy consumption and improve efficiency of the robots' motion and overall efficiency of the manufacturing process. A new optimization is conducted by default even when a small adjustment takes place in operating sequences of the robots.

Results obtained from preliminary tests conducted in test robots showed that the optimization algorithm was able to reduce 15% to 40% energy consumed by conventional robots. To determine the precise percentage of energy reduced, the algorithm must be tested in a proper automation industry. The researchers are presently trying to collaborate with automotive manufacturing companies to test the results of the algorithm on a large scale. This novel method is expected to be commercialized and impact the automotive and other manufacturing industries by the end of 2018.

In 2014, Siemens collaborated with Volkswagen and Fraunhofer-Gesellschaft as part of the Green Carbody Technologies (InnoCaT) innovation alliance to reduce power consumption of manufacturing robots in the automotive industry. As part of this alliance, Siemens and its partners are developing a simulation model that calculates and optimizes the best motions and trajectories for robots during the manufacturing process. Tests conducted by Siemens proved that optimized movement patterns of an robot can lower the energy consumed by robot up to 50%. Siemens is still working on integrating such a module in its manufacturing software.

Companies such as Sony, Rockwell Automation, KUKA Industrial Robots, Nash Robotics, and ABB Robotics are also working on a similar module and algorithm for reducing energy consumption of manufacturing robots. From a patent analysis done, it is evident that most of the patents filed in the area are from China, Korea, followed by United States and Japan.

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5. RECENT PATENTS IN THE FIELD OF LOWER CONTROL ARM

The two main control arms in a car suspension are the lower control arm and the upper control arm. The lower control arm has a pivot on both ends. Both pivots have bushes pressed inside them in a particular load using bush pressing process according to the design specification of the vehicle. The control arms are part of the suspension system and are attached to the chassis of the car to control the wheels and body of the car in a synchronized manner. The bushes help to attach the lower control arm to the front cross member of the suspension system. The lower control arms are placed between the frame and rear axle of the car along with the front cross member. These control arms differ in size and load carrying capacity according to the vehicle's design.

From the patent analysis on lower control arms, it is evident that most of the patents filed are from China,, followed by Korea and the United Sates. Key automobile companies such as Hyundai Motors have filed the most number of patents. Most of these patents are about the structure and manufacturing methods of lower control arm. Patent number CN103407340 filed by Chery Automobile Co. Ltd., pertains to the structure and the manufacturing methods for the lower control arm for the front suspension of an automobile. Patent US20140265206 filed by GM Global Technology Operations LLC pertains to a front lower control arm attachment system, which includes a sleeve locator stamping and a one threaded sleeve extending to secure the stamped sleeve locator. The lower control arm is basically a stamping system which then goes through milling, bush welding, and rubber bush pressing processes. Patent CN103920808 by Taizhou Huangyan Dedao Mold Co. Ltd., pertains to a progressive-die forming die to create for an automobile suspension control arm lower piece.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Lower control arm structure	April 08,2015/ CN 104494385	Anhui Technical College of Mechanical and Electrical Engineering	Ni Jinting	The invention discloses a lower control arm structure, comprising a lower control arm body formed by metal plate stamping, the rear end of the lower control arm body is provided with a screw bolt through hole, a lower control arm upper body is fixedly welded in the middle of the lower control arm body, a lower control arm casing pipe is fixedly welded at the front end of the lower control arm body, and a strengthening plate is arranged in the middle of the lower control arm upper body and the lower control arm body. For the lower control arm structure, as the lower control arm body, the lower control arm upper body and the strengthening plate constitute a complete sealing structure, the rigidity of the lower control arm body is improved effectively, the force applied to the whole lower control arm is guaranteed to be more reasonable through the application of the strengthening plate, the appearance of high stress concentration is avoided, and the reliability of the lower control arm is increased. The whole structural mass is light, the rigidity is high, the bearing capacity is strong, the strengthening plate can be molded by adopting the processed leftover materials of other components, the cost is low, and the economic benefit is good.
Progressive-die forming die for automobile suspension control arm lower piece	July 16,2014/ CN 103920808	Taizhou Huangyan Dedao Mold Co. Ltd.	Xiao Liyong	The invention belongs to the technical field of progressive dies and relates to a progressive-die forming die for an automobile suspension control arm lower piece. The progressive-die forming die comprises an upper die, a lower die, an inclined punching tool and a drawing tool, the inclined punching tool and the drawing tool are arranged between the upper die and the lower die, a plurality of feeding guide components are fixed on two lateral sides of a material belt moving track on the upper surface of the lower die at intervals along the material belt moving direction respectively, and stable and quick conveying of a material belt is realized; a nitrogen cylinder is arranged on each of an upper die seat and a lower die seat, so that buffering effect during drawing is enabled to be better; a wedge driving block is arranged on the lower die and matched with a sliding block with a punching head, so that side punching of a side hole punching process is realized. The progressive-die forming die is suitable for a progressive die processed by completing a series of different punching processes in a stroke of a punching machine each time.

Lower control arm of front suspension of automobile and method for manufacturing lower control arm	Nov 27,2013/ CN 103407340	Chery Automobile Co., Ltd.	Li Cheng	The invention discloses a lower control arm of a front suspension of an automobile and a method for manufacturing the lower control arm. Two bush mounting holes and ball stud mounting holes are formed in the lower control arm, the bush mounting holes are used for mounting bushes, the ball stud mounting holes are used for mounting ball studs, the lower control arm is of a hollow structure, and aluminum alloy is cast to form the hollow structure. Compared with the prior art, the lower control arm and the method have the advantages that the lower control arm is a hollow cast aluminum control arm manufactured by a casting process, is light and is high in structural rigidity, fast in production takt and low in production cost and rejection rate.
Vehicle front suspension lower control arm attachment system	Sept 18,2013/ US 20140265206	GM Global Technology Operations LLC	Stockard Michael L.	A number of variations of the invention may include a method including providing a front lower control arm attachment system including a sleeve locator stamping and at least one threaded sleeve extending there through, and attaching the front lower control arm attachment system to a vehicle engine cradle. A number of variations of the invention may include a front lower control arm attachment system including a sleeve locator stamping and at least one threaded sleeve extending through the sleeve locator stamping and secured thereto
A front lower control arm assembly for a	June 22,2011/ GB 2481880	Ford Global Tech LLC	Hopson Steven C	A front lower control arm assembly includes a front lower control arm 14 and a bushing 100 attached to the arm 14. The bushing 100 has a first central axis Y. A ball joint 10 is also attached to the arm 14. The ball joint 10 has a second central axis X oriented substantially perpendicularly to a plane including the first central axis Y. The ball joint 10 comprises: a mounting portion 50 defining an opening therein; a central portion 60 within the opening; an elastomeric portion 52 interposed between the mounting portion 50 and the central portion 60 to secure the central portion 60 within the opening; and at least one void 56a, 56b formed in the elastomeric portion 52.
Suspension device for a vehicle, capable of dualizing a caster angle while using a knuckle and lower arm integrated into a body in common because the caster angle can be controlled	April 05,2012/ Kr 1020120032347	Hyundai Motor Company	Jung, Dae Woo	PURPOSE: A suspension device for a vehicle is provided to maintain the driving stability and improve the ride comport by controlling a caster angle fit to a vehicle because a caster control unit controlling a mounting location of the lower arm is included in a stabilizer bar installed by the lower arm. CONSTITUTION: A suspension device for a vehicle(100) comprises a knuckle(101), a strut assembly(107), and a stabilizer bar(113). The knuckle supports wheels to be rotated. The strut assembly is composed of a shock absorber(103) and spring(105) in the upper part of the knuckle. One end part of the lower arm is connected to the lower part of the knuckle so that the lower arm and knuckle are used in common. The other end part of the lower arm is connected to a vehicle body. COPYRIGHT KIPO 2012

Lower control arm of a suspension for a vehicle, capable of arranging a reinforcing member made of a steel plate or steel rod in a neck part of a lower control arm	March 29,2012/ Kr 1020120030852	Hyundai Motor Company	Seo, Min Jwa	PURPOSE: A lower control arm of a suspension for a vehicle is provided to prevent a secondary accident because a neck part of a lower control arm is buckled due to a malleable reinforcing member in case that the neck part of the lower control arm made of the aluminium is cut by a strong impact due to a material property. CONSTITUTION: A lower control arm of a suspension for a vehicle comprises a body(32) and a reinforcing member(30) formed in a neck part connecting a wheel side connecting unit(20). The reinforcing member is composed of a steel plate surrounding the outer circumference of the neck part and fixing. The reinforcing member is composed of several steel rods forming to be recessed into the inner part of the neck part. The lower control arm is arranged toward a width direction of a vehicle, thereby connecting the lower end part of a knuckle to a vehicle body. The upper end part of the knuckle is connected to a strut assembly. COPYRIGHT KIPO 2012
Lower arm for a vehicle capable of reducing assembling time and costs by controlling the direction of a vertical penetrating bush	May 18,2011/ Kr 1020110051685	Dong Hee Industrial Co., Ltd.	Oh, Se Chan	PURPOSE: A lower arm for a vehicle is provided to improve the performance of a suspension by improving the assembly structure by controlling the direction of a vertical penetrating bush. CONSTITUTION: A lower arm for a vehicle comprises a vertical combination end part(13) and a vertical penetrating bush(30). The vertical combination end part comprises a bush hole(17) and a projection combination groove(19). The bush hole is penetrated in vertical upward and downward direction toward a sub frame. The projection combination groove is formed n the bush hole along the columnar direction of the bush hole. The vertical penetrating bush comprises a plurality of outer tube protrusions(39). The outer tube protrusion is integrally formed in the outer tube along the outer circumference of an outer tube(33). The outer tube protrusion is inserted in the projection combination groove. COPYRIGHT KIPO 2011
Preforging die for automobile rear lower control arm and forging method thereof	Oct 20,2010/ CN 101862802	Shanghai Huizhong Automotive Manufacturing Co., Ltd.	Feng Hailin	The invention discloses a preforging die for an automobile rear lower control arm and a forging method thereof. In the preforging die chamber of the preforging die, a first clearance is arranged between the inner side face of the lower die and the position on the periphery of a upper die, which is corresponding to the forge piece crotch bottom of the automobile rear lower control arm; the two sides of the position are respectively provided with a clearance which is between an upper die periphery and the inner side face of the lower die and gradually decreases from the first clearance to a second clearance, thereby forming a first transition section and a second transition section; the clearance between the rest of the upper die periphery and the inner side face of the lower die is the second clearance; the first clearance is 7-7.5 mm, and the second clearance is 1.6-2 mm; and the height of the bridge part of a closed extrusion cavity is 2.2-2.6 mm. Since adopting the preforging die, the forging method of the invention can be used for manufacturing the automobile rear lower control arm

				only through preforging and finish forging, thereby reducing the production cost and enhancing the quality of forge pieces.
Spherical hinge type metal rubber support of front axle lower control arms	June 06,2010/ CN 101746413	Shanghai Volkswagen Automobile Co., Ltd.	Gao Qiujin	A spherical hinge type metal rubber support of front axle lower control arms solves the problems that the existing metal rubber supports are unsafe to use due to easy aging, fatigue and damage. The spherical hinge type metal rubber support consists of an inner sleeve, an outer casing and a rubber body, wherein the outer casing is arranged outside the inner sleeve, and the rubber body is arranged between the inner sleeve and the outer casing; the inner sleeve is in a spherical hinge type tubular structure of which the middle section is spherical and the two ends are straight; a spherical bushing is tightly sheathed on the outer surface of the spherical section of the inner sleeve, an inner casing is wrapped on the outer surface of the spherical bushing, and the inner casing, the rubber body and the outer casing are combined by vulcanization; a dust cover is respectively arranged on the upper and the lower ends of the inner casing, and the inner sleeve, the spherical bushing, the inner casing and the dust covers form a spherical hinge structure. As the spherical hinge type metal rubber support adopts the structure, the torsion deformation of the rubber body is largely reduced when the rubber body swings up and down on the support. The metal rubber support resists aging, fatigue and damage, the service life of the support is largely improved, and the use safety of the whole vehicle is increased.

Exhibit 1 lists some of the patents related to lower control arm.

Picture Credit: Frost & Sullivan

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