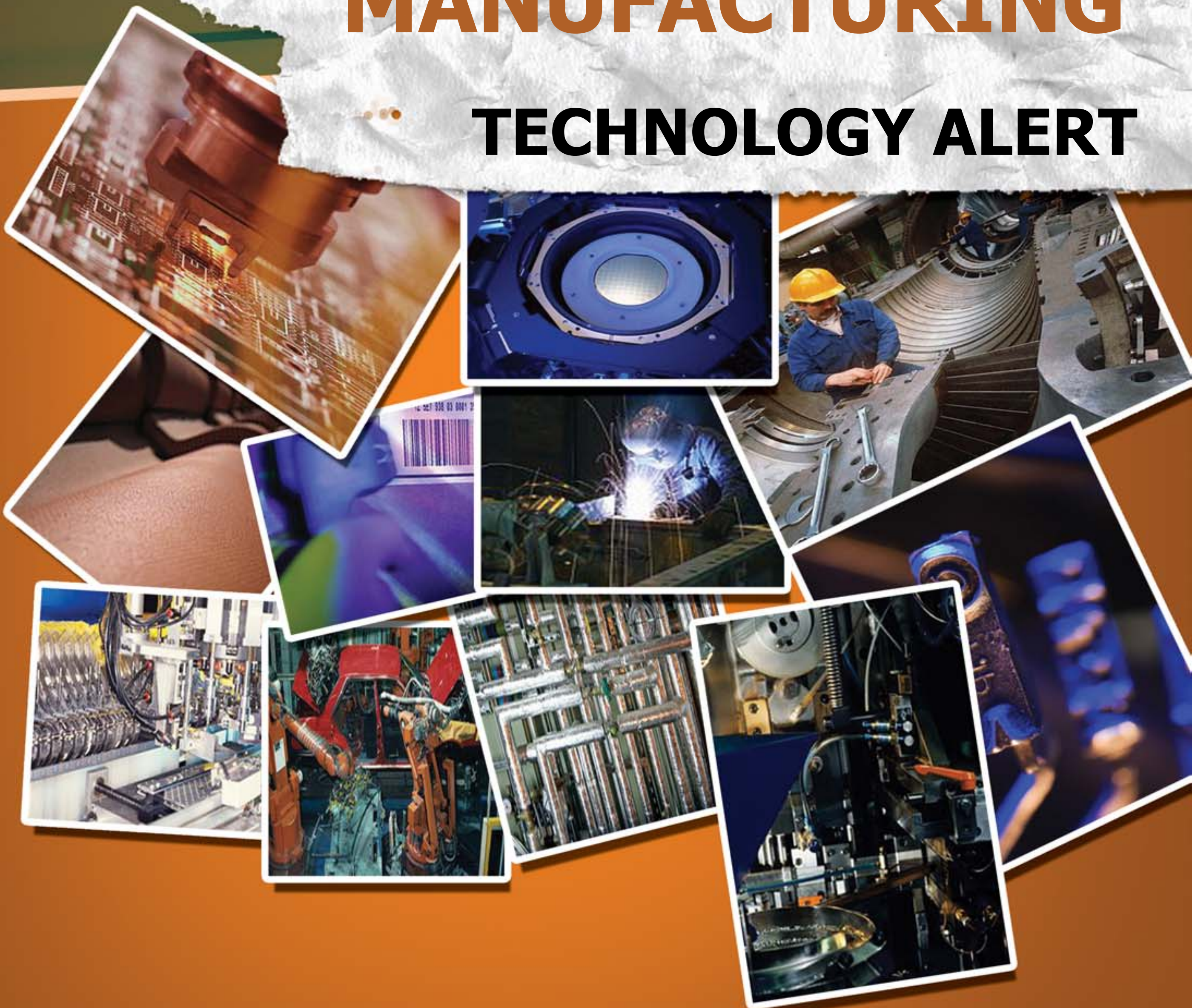
TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT



21st March 2014

1. METHOD TO MANUFACTURE SMALL-SIZED ELECTRONIC COMPONENTS

Electronic component manufacturers are looking for innovative ways to downsize their products. Manufacturers are trying to achieve this without having to compromise the thermal conductivity of the materials that are used in their products.

Researchers from the Bourns College of Engineering, University of California, Riverside, USA and University of Manchester, UK, have found that by creating a sandwich between graphene and copper, it would be possible for manufacturing small-sized electronic products. From the various experiments that were carried out by the researchers, it was found that by adding a layer of graphene, which has thickness of one atom with high electrical, thermal, and mechanical properties, to both sides of copper, the heat conducting properties were increased by almost 24%. The researchers believe that this enhancement of the ability of copper to conduct heat more when sandwiched with graphene could become a key development in the formation of hybrid copper that can be used for manufacturing electrical chips that are becoming increasingly smaller of late. The researchers were able to see from the experiments that there was significant improvement in the thermal properties of graphene coated copper films even with the thickness of the graphene being only one atom. It was also found that the improvements in the thermal properties were largely due to the changes in the nano and micro structures of the graphene when compared to graphene's heat conducting channel. When the grain sizes of copper were examined before and after adding the graphene, it was seen that the chemical vapor deposition of graphene conducted at high temperature stimulated the growth size of the copper films. Hence, with larger grain size of copper that was coated with graphene, better heat conduction was observed. In addition to the above-mentioned results, the heat conduction rate by adding graphene was seen more prominently in thinner copper films. The results have been seen as a major breakthrough as further improvements will be enabled in the future when the copper interconnects are scaled down to ranges of nanometers, which is 1/1000th of the micrometer range.

The research team is currently working on investigating the changes of heat conducting properties in copper films that are coated with graphene. They are also planning to develop a theoretical model that is even more accurate in order to provide an explanation for the thermal conductivity changes in accordance with the changes in grain size. The National Science Foundation and STARnet Center for Function Accelerated nanoMaterial Engineering (FAME), a Semiconductor Research Corporation (SRC) program sponsored by Microelectronics Advanced Research Corporation (MARCO), and Defense Advanced Research Projects Agency (DARPA) have supported the research. Electronic products manufactured using this novel model developed by the researchers could commercialized around 2016.

As this novel innovation enables the downsizing of electronic products, it is seen as a key advantage in electronic product manufacturing. Due to this advantage, various manufacturing companies can adopt this novel method once it is commercialized on a large scale.

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2. INNOVATIVE SOFT ROBOT WITH INCREASED CAPABILITIES

Extensive research being carried out in the field of soft robotics is aimed at making robots safer for human-robot interaction. An advantage of soft robots is that they are equipped with soft machines, which change the entire planning system, thereby preventing collisions at the workplace. In many robotic motion planning systems, avoiding collisions within the working environment is given highest priority.

Researchers from the Massachusetts Institute of Technology (MIT), USA, have developed a novel robotic fish that is designed in such a way that it explores one of the key advantages of soft robots; their capability to deform continuously. This deformation capability gives the soft robotic systems various configurations which are not usually achievable with machines that are hinged. For instance, the continuous curvature of the novel fish robots body when it flexes allows it to change direction at a significantly faster speed. According to the researchers, this soft robotic fish can maneuver and change direction in a fraction of a second, similar to the movements of real fish. The findings of the research on this self-contained autonomous robot that has been developed have been published in the March, 2014 edition of the journal *Soft Robotics*. Each side of the robotic fish's tail has been bored through with a long tightly rolling channel. Carbon dioxide released into the container kept in the abdomen of the fish causes inflation of the channel which in turn reflects in the bending of the tail in the opposite direction. Each half of this robotic fish tail has been equipped with two control parameters--the diameter of the nozzle that releases the gas into the channel and the amount of time that it is left open. In the various experiments that were conducted by the researchers, it was found that the angle at which the fish changes direction could be in the order of 100 degrees, based on the duration of inflation. The rate of speed at which the robotic fish moves is based on the diameter of the nozzle. The researchers have used 3D printers for building the mold of this robotic fish in which the tail and the head were made from silicone rubber and polymer, thereby protecting the various electronic parts that are used in the robot.

This innovation from the researchers at MIT could help in the development of soft robots. Soft robots could have opportunities in varied areas, such as reconnaissance, mines, factories, biomedical, material handling, and so on.

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3. ROBOTIC SYSTEM FOR SPACE APPLICATIONS

One area where researchers are continuously developing newer robotic technologies entails making space applications more sustainable and efficient.

In this vein, researchers from the Satellite Servicing Capabilities Office (SSCO) at NASA's Goddard Space Flight Center, USA, have successfully completed and tested an innovative Remote Robotic Oxidizer Transfer Test (RROxiTT). The success of this research has given NASA the confidence that advanced satellite refueling technologies could be realized in the near future. The researchers have devised the ground-based RROxiTT with capabilities to test the efficiency with which the robots would be able to transfer hazardous oxidizers at flight-like pressures and flow rates. The hazardous oxidizers have been transferred through the propellant valve into the mock tank of a satellite for testing purposes. By developing and enabling robotic capabilities for repairing and refueling GEO satellites, NASA believes that it would be able to significantly reduce the time taken for operations that require immediate attention. It is also believed that these new robotic technologies would boost the commercial satellite servicing industry, which is experiencing a spike in growth recently. In addition to helping the GEO satellites, these novel robotic technologies would also help in making space repairing processes greener and more sustainable.

RROxiTT has been tested with integration of a number of novel robotic technologies and procedures that have been jointly developed by Goddard and Kennedy Space Center, USA. Some of the key technologies include a flexible propellant hose, a novel Oxidizer Nozzle tool, and a propellant transfer system (PTS), which have been developed with the collaboration of different teams at SSCO. This novel PTS is said to consist of oxidizer tanks, sealless pumps, and flow metering devices. In addition to the above- mentioned components, the PTS also contains a maze comprising of critical components, such as a servicer satellite, which is required for replenishing the propellant of the orbiting spacecraft, thereby significantly increasing its life. Currently, the researchers are focused on designing the RROxiTT technologies for space applications. They believe that in the future it could be used for robotic replenishment of satellites before being launched. An oxidizer is a chemical that is mixed with the satellite's fuel, causing instant combustion required for providing the necessary thrust for a satellite. This liquid, which is present in the fuel tank has an intense pressure of almost 300 pounds per square inch and is extremely toxic, corrosive and compressed. By employing the newly developed RROxiTT technologies, it would be possible to robotically fill up the satellites that are present on the ground, keeping humans safe from extremely hazardous operations. The research team is currently working on expanding its research in order to include xenon transfer technologies which are the propellants used by satellites having electric propulsion systems.

This technology can significantly reduce the time required for fueling and carrying out repair tasks for satellites in space.

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4. PATENT ANALYSIS OF CO-INJECTION MOLDING PROCESS

The co-injection molding process is the most frequently used among the various multi-material molding processes. This type of molding process is employed for a wide range of applications in different industrial sectors. Some of the commonly used materials in the co- injection molding process are polyamides, nylon, polyacetal, polycarbonate, polyesters, polysulfone, polyethersulfone, polypropylene, polyethylene, ABS, PBT, polybenzimidazole, and polyamide-imides. The co-injection molding process produces plastic parts having a skin and a core laminated structure. The skin material is first injected into the mold which is then followed by the core material. Once the core material is injected into the mold, the skin material is pushed inside the mold which encapsulates the core. By doing so, the end product can be manufactured with a desired appearance of the outside skin material. The above-mentioned feature allows this process to be employed for enabling regrinding and reprocessing the core material which gives advantages in terms of cost reduction. The other advantage of this process is that it also provides significantly high product strength and performance when high impact plastics are used as the core materials.

From the patents that have been exhibited, it can be seen that research has been carried out to increase the range of products that are being manufactured using this molding process and also in the parts and components used in co-injection molding machines.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Gas-assisted co-injection molded chair	March 4, 2014/ US 8663514 B2	Knoll, Inc.	Adam Daniel DESKEVICH, Hendrik Richard VAN HEKKEN, Richard A. Wolfe	The invention is directed to an article made from co-injection molding using gas-assist. The article has an inner material and an outer material. The inner material has a blowing agent uniformly distributed throughout the inner material. The outer material surrounds the inner material. The use of the blowing agent in the inner material produces a repeatable and consistent structure, as the blowing agent is uniformly activated through the product. The use of the gas-assist the heat and pressure associated with the blowing agent is allowed to out gas, thereby insuring that the finished molded chair or other item is aesthetically pleasing while providing increased strength and reduced weight compared to traditional plastic chairs formed with known methods.
High thermal conductivity co-injection molding system	August 29, 2013/ WO 2013126667 A1	The Procter & Gamble Company	Charles John Berg, Gene Michael Altonen, Ralph Edwin Neufarth, Emily Charlotte Boswell, Joseph Moncrief LAYMAN	A low constant pressure co-injection molding machine forms molded parts by injecting molten thermoplastic material into a mold cavity at low constant pressures of 6,000 psi and lower. As a result, the low constant pressure injection molding machine includes a mold formed of easily machineable material that is less costly and faster to manufacture than typical injection molds. Co-injection of thin-walled parts having an L/T ratio >100, with embedded sustainable materials, such as polylactic acid (PLA), starch, post-consumer recyclables (PCR), and post- industrial recyclables (PIR) isolated from surfaces by barrier layers of leach-resistant material having a thickness less than 0.5mm, is possible. The co-injection molding machine is provided with a screw comprising a material having an average thermal conductivity of more than 30 BTU/HR FT °F.
Co-injection molding process and parts formed thereby	May 14, 2010/ WO 2010054188 A1	Illinois Tool Works Inc.	Frank J. Villari, Glenn Poyer	A co-injection molding system incorporating two or more injection gates feeding a common mold cavity to provide multiple cores surrounded by a skin material within the final finished part. An injection molding system including one or more slug traps disposed along the conveyance path between the injection nozzle and the injection gate and/or at remote portions of the mold cavity to collect and retain vestigial slugs that may form at the injector nozzle and/or at injector gates.
Coinjection molding cooled shooting pot cylinder and injection moulding method	September 30, 2009/ EP 1765563 B1	Husky Injection Molding Systems Ltd.	Abdeslam Bouti	Coinjection molding shooting pot cooling apparatus and method are configured to cool a shooting pot cylinder which, in combination with a shooting pot piston, injects a melt through a coinjection nozzle having at least two melt channels ending at the same gate. Preferably, a heat sink sleeve is disposed to contact an outer surface of a rear portion of the shooting pot cylinder. The heat sink sleeve is configured to remove sufficient heat from the shooting pot cylinder to increase the viscosity of the melt therein, thus reducing melt leakage between the shooting pot piston and the shooting pot cylinder.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Co-injection apparatus for injection molding	December 13, 2005/ US 6974556 B2	Bemis Manufacturing Company	Peter F. Bemis, Steven J. Kolste, Daniel Cykana, Stephen R. Fiacchino, Michael P. O'Grady	A co-injection nozzle pin (**20**) having downstream and upstream ends. The nozzle pin has therein a central bore (**30**) including an upstream end (**32**) adapted to communicate with a first material and a downstream end (**34**) exiting at the downstream end of the pin. The nozzle pin also has an outer surface (**36**) including a first portion (**38**) having a diameter D_1, a second portion (**40**) having a diameter D_2, wherein D_2 is less than D_1 and the first portion is rearward of the second portion. The pin further includes a channel (**46**) spiralling around the outer surface and being adapted to communicate with a second material. The channel (**46**) includes a first segment (**52**) defined in the first portion (**38**) of the outer surface and increasing in depth as it travels in a downstream direction and a second segment (**54**) defined in the second portion (**40**) of the outer surface and decreasing in depth as it travels in a downstream direction.
Co-injection manifold for injection molding	August 16, 2005/ CA 2147458 C	Peter F. Bemis, Daniel Cykana, Loren C. Albrecht, Gerald W. Swart	Peter F. Bemis, Daniel Cykana, Loren C. Albrecht, Gerald W. Swart, Bemis Manufacturing Company,	Injection molding apparatus comprising a platen, a die which is fixed to the platen and which defines a mold cavity having an inlet, a co-injection manifold mounted on the platen, the manifold including a nozzle housing having forward and rearward ends, the nozzle housing including an outlet which is located adjacent the forward end and which communicates with the mold cavity inlet, first and second spaced apart inlets which are located adjacent the rearward end and which are respectively adapted to communicate with first and second injection nozzles, a first passageway communicating between the first inlet and the outlet, and a second passageway communicating between the second inlet and the outlet.
Process and device for co-injection molding multilayer products	November 5, 2002/ US 6475413 B1	Johnson Control S.P.A.	Dante Siano	Multilayer products, such as vehicle trim panels, provided with an external skin layer and an internal core layer are co-injection molded by injecting external material (P) through a first plurality of points of injection (**3** *a*- **3** *c*) and injecting the core material (C) through a second plurality of points of injection (**4** *a*- **4** *g*), the points and nozzles of injection of one material being physically distinct from those of the other material.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Use of co-injection molding to produce composite parts including a molded snowboard with metal edges	October 30, 2001/ US 6309586 B1	Jumbo Snowboards, Llc	David Colley, Joseph McRoskey, Olaf Mjelde	The present invention comprises products of and methods for producing complex shapes of composite molded articles, including snowboards, that meet or exceed the aesthetic, cost and performance requirements expected of similar non-molded composite articles. The injection molded or co-injection molded snowboard comprises a top surface and a bottom surface shaped to provide a center portion, at least one tip or tail portion and edges along the sides of the center portion, wherein the bottom surface is a substantially smooth continuous surface, the center portion is cambered away from the top surface and contains metal edges along the sides of the bottom surface center portion, the tip or tail portions are curved away from the bottom surface of the snowboard and the top surface contains binding mounts or screw threads flush mounted to secure bindings. A preferred method of constructing a snowboard comprises co-injection molding, utilizing a skin polymer with a smooth finish for exterior portions of the snowboard and a core polymer that is lighter, structurally stronger and potentially cheaper than the skin polymer for the interior of the snowboard. A mold cavity is designed for the desired shape of the snowboard. In addition to providing for the shape of the snowboard, the mold cavity is designed to accommodate inserts for side metal edges and clips to secure such edges, if necessary, and inserts for top, flush mounted binding mounts or screw threads as well as the clips to secure such mounts. An additional set of metal components may be embedded within the top surface of the snowboard to compensate for warping away from the bottom metal edges due to the polymer shrink rate. The mold cavity must be designed to accommodate inserts for securing such metal components if such components are utilized.
Co-injection molding process for manufacturing complex and lightweight parts	June 19, 2011/ US 6248289 B1	Xerox Corporation	Jay lee Schneider	A method for molding relatively complex and large shapes by a co-injection molding process which results in a significantly less expensive and lighter molded product. The process steps include first injection molding a thermoplastic material highly densified with ceramic or stainless steel particulate material to form a shell structure having a homogeneous dispersion of the ceramic or stainless steel material within its matrix and then injecting a significantly less expensive material into the core of the preformed thermoplastic/ceramic or stainless steel structure and thereafter sintering the resulting molded structure. The resultant structure is a hollow shell of highly densified ceramic or stainless steel.
The use of co-injection molding to produce composite parts including a molded snowboard with metal edges	December 21, 2000/ WO 2000076831 A1	Jumbo Snowboards Llc	David Colley, Roskey Joseph Mc, Olaf W Mjelde	Products of, and methods for producing complex shapes of composite molded articles, including snowboards are disclosed. The injection molded, or co-injection molded snowboard (60) comprises a conventional shape and contains metal edges (35, 45) along the sides of the cambered bottom surface center portion, and the top surface contains threaded hols (55) flush mounted to secure bindings. A method of constructing a snowboard is disclosed comprising co-injection molding, utilizing a skin polymer with a smooth finish for exterior portions of the snowboard and a core polymer for the interior. A mold cavity (10, 20) is designed for the desired shape of the snowboard and to accommodate inserts for side metal edges (30, 40) and inserts for binding mounts or flush-mounted threaded holes (50) on the top surface as well as the clips to secure such in the mold.

Exhibit 1 depicts patents related to the co-injection molding process.

Picture Credit: Frost & Sullivan

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