TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

18th December 2015

1. NOVEL MANUFACTURING PLATFORM TO OPTIMIZE SILICON PHOTONICS PRODUCTION

Silicon photonics, which involves photonic systems that use silicon integrated circuit processes and photons to detect, process, and transmit information, is gaining prominence in the field of electronics at a faster pace due its robustness and high-speed data transmission. The prospects for commercialization of silicon photonics technology is accelerating in the US.

To be able to exploit key capabilities afforded by silicon photonics, such as very high-volume data communications, researchers are consistently involved in accelerating the commercialization of silicon photonic components in the European region.

Several silicon manufacturers and national laboratories are involved in a collaborative project called PLAT4M (Photonic Libraries and Technology for Manufacturing), which is funded by the European Union. The idea behind such a forum is to share ideas and new photonic fabrication technologies to mass produce silicon photonic components which can eventually be used to make complimentary-metal-oxide-semiconductor (circuits).

CMOS (complementary metal oxide semiconductor) circuits consume very low static power and have high noise immunity. These properties of CMOS combined with high data transfer speeds of photonics will create new and advanced CMOS devices that will be extremely useful in future applications like telecommunication, avionics, microelectronics and many more.

The basic idea of PLAT4M is to create silicon with precise sub-micrometer patterns that will serve as conducting paths for light. The PLAT4M project was launched in October 2012 to create a new revolution in silicon photonics. Today, the project has overcome many obstacles and is very close to mass-producing silicon photonics and creating a revolution in the electronics sector.

Silicon photonics provides optical inter-connects in the place of traditional connects such as copper and other metals. The optical interconnects provide very high data transfer rates when used both inside and outside of microchips. Because of this high data transfer speed, many electronics companies and research organizations have been conducting numerous experiments on silicon photonics.

Most of the research in silicon photonics is conducted on the basic physics and chemistry of silicon photonics. The research is not so focused on creating or implementing chips and integrated circuits using silicon photonics. Fabricating microchips and large electronic components is the key to ensure faster penetration of this technology into the market. Hence, PLAT4M realizes the importance of silicon photonic fabrication technology and is committed to find more cost-effective and robust methods to produce silicon photonic ICs and chips.

So far, PLAT4M has been able to get the best CMOS and R&D institutes in Europe together in a 4-year long project to create and upgrade the infrastructure of numerous companies to various silicon photonics production platforms. They have been able to streamline various production designs and processes that will be suitable to most semiconductor manufacturing platforms. This streamlining process is being done concurrently for the manufacturing requirements of various application fields like telecommunication, microelectronics and so on.

The PLAT4M project for streamlining and optimizing the silicon photonics manufacturing process is expected to be completed by September 2016. After this process is complete, the researchers are expected to focus completely on integrating the new solutions for manufacturing in volumes.

The research at PLAT4M has opportunities to impact the future of electronic circuitry. The vision of PLAT4M is to enable a seamless transition of silicon photonics from the R&D stage to industry and to benefit many in the electronics industry and academia. When the PLAT4M's vision is achieved, numerous industries such as telecommunications, sensors and microelectronics,

would have opportunities to experience a transformation that will make these areas more advanced, robust, and efficient.

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2. IMPROVED CONTROL IN PHOTONIC SINTERING

Photonic sintering is a low-thermal exposure sintering method to sinter or fuse nanoparticles (which measure between 1 nanometer to up to a few hundred nanometers) to form functional thin films. In contrast to thermal sintering, which uses sintering furnaces, photonic sintering uses pulses light (a xenon flash lamp) to provide a high intensity, short duration pulse of light to the deposited nanoparticles. The incidence of such large-area broad-spectrum light onto deposited nanoparticles results in heat generation in the nanoparticles and their densification. Photonic sintering can provide rapid densification of nanoparticle inks over large-area substrates under ambient conditions.

Due to the ability of photonic sintering to provide rapid, scalable functionality and operation under ambient conditions, there is significant interest in using this process for nanoparticle sintering in key emerging or expanding applications, such as radio frequency identification (RFID) tags, flexible electronics (which involves incorporating electronic devices on flexible substrates), solar cells, and sensors (such as wearable biosensors, chemical or gas sensors or pressure sensors). However, there is a key need to understand the physics involved in the photonic sintering process. Key issues that merit investigation include, for example, the effects of nanoparticle size on densification and the temperature of the deposited nanomaterial and substrate.

Supported by a four-year, $1.5 million National Science Foundation Scalable Nanomanufacturing Grant, focused on surmounting the scientific barriers to industry-level production of nanomaterials, researchers at Oregon State University (OSU) have achieved key insights into the physics of photonic sintering. Such knowledge has promise to lead to advancements in products such as solar cells, flexible electronics, or sensors that could be printed onto a sheet of flexible materials, such as paper or plastic.

The OSU researchers found that prior approaches to comprehending and controlling photonic sintering were predicated on an imperfect perception of the fundamental physics involved in this process. The flawed understanding has resulted in overestimating the product quality and process efficiency associated with photonic sintering. Based on their expanded knowledge of the physics of photonic sintering, the researchers conceive that they can exploit photonic sintering to devise high-quality products at considerably lower temperatures, at least twice as fast, with tenfold greater energy efficiency.

Previously, temperature change and the degree of fusion in photonic sintering were considered to not be related. The OSU researchers, however, discovered that this relationship is very important. For example, both the temperature and nanoparticle densification are found to be very dependent on nanoparticle size. Removing constraints on production temperatures, speed and cost, can enable the creation of innovative high-tech products printed onto inexpensive substrates, such as paper or plastic.

The investigation has opportunities to lead to precise control of temperature with smaller nanoparticles. Such capability can increase the speed of the photonic sintering process and enable high-quality production at temperatures at least two times lower than previously. Moreover, the researchers identified an inherent self-damping effect that strongly impacts the desired quality of the finished film. The researchers should be able to create production processes for nanotech products that are rapid and inexpensive, without loss of quality. Lower temperature processing is a key attribute. To reduce costs, it is desirable to print the nanotech products on such materials as paper or plastic, which would melt or burn at higher temperature. The researchers envision products, such as solar cells, gas sensors, RFID tags, flexible electronics, as well as biomedical sensors and innovative sensors for environmental applications.

In the next step in migrating the technology toward commercial production, the OSU researchers will work with two manufacturers in the private industry to create a laboratory-based proof-of-concept facility.

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3. OPPORTUNITIES FOR PLASTIC MATERIALS IN LASER SINTERING

High-performance plastic materials are finding key, expanding opportunities in 3D printing or additive manufacturing, which enables the fabrication of parts from a digital file via the deposition, rather than removal, of successive layers of material. 3D printing is increasingly capturing interest because it enables more efficient and environmentally friendly and less wasteful manufacturing of parts without the need for intermediate tooling.

Laser sintering is a significant, expanding type of 3D printing equipment technology, in which a laser (typically a carbon dioxide laser) is used to provide heat in order to process and fuse small particles of plastic, metal, ceramic, or glass powders into a 3D shape.

The main incumbent material used in laser sintering has been nylon (polyamide) 12 and 11. Polyamide 12 tends to be the most popular material for laser sintering due to its inherent chemical and heat resistance. Moreover, it has the lowest melt point compared to other nylon materials and low moisture absorption.

However, there is room to improve nylon 12 (which is also used in FDM) to create 3D printed parts similar to those using computer numerical control (CNC) or injection molding. Moreover, due to its superior heat resistance and stiffness compared to nylon 12, nylon 6 has opportunities in laser sintering to penetrate applications such as automotive, aerospace, electronics, and consumer goods. However, nylon 6 is relatively difficult to process via 3D printing. Nylon 6 is more brittle at low temperatures than nylon 12, but it has higher moisture absorption, which can enable better impact resistance than nylon 12 when wet.

HDPE (high density polyethylene), which can be used with aggressive media, provides chemical resistance, high toughness. HDPE has a high strength-to-density ratio and is used for products such as corrosion-resistant piping and plastic bottles. HDPE has opportunities for use in automotive and medical applications.

Ceramic materials in laser sintering have opportunities in areas involving non-complex or no-load structures, such as aerospace or healthcare (bone tissue engineering). However, there is a need for uniform temperature across the material. In carbon nanoparticles, it can be challenging to achieve solid bonding of materials at the surface. Ceramics can have processing issues; and it has been difficult to create fully dense ceramic parts.

Thermoplastic elastomers (TPE), with improved mechanical properties and easier sintering capability, have opportunities in applications, such as athletic footwear, athletic equipment, gaskets, hoses, seals, rubber parts, and so on. There are opportunities to improve the processability and durability of thermoplastic elastomers, improve their melt or solidification point, and to improve the sintering capability of TPE for rubber-like parts. TPE can provide improved (rubber-like) flexibility and functionality; but have limited mechanical durability. Moreover, TPEs lack a sharp melt or solidification point compared to polyamide semi-crystalline materials. Also, there are some sintering challenges.

High Temperature polymers (PAEK (polyaryletherketones), PEEK (polyetheretherketone), or PEKK (polyetherketoneketone) exhibit good flame retardancy, biomcompatibility, excellent mechanical and thermal properties, good creep and fatigue resistance, and low moisture sorption. Such materials have opportunities in aerospace (such as non-structural parts, air ducts, brackets), and biomedical implants, particularly if the cost of the material can be reduced.

The PAEK family of materials is viewed as a very viable, low-risk option for aerospace applications. However, there are processing issues with the PEEK/PAEK family. For example, the effort required to achieve a given viscosity with heat input is much lower for a polyamide than for a PAEK material. There is a need to improve the fracture toughness of PEEK powders.

Opportunities and adoption of PEEK/PAEK/PEKK are being driven toward high-temperature, higher-performance plastics. PEEK tubing, which has high dielectric strength, is also finding opportunities in high voltage cable conduits used in aircraft.

Carbon fiber reinforced polymer (CFRP) has opportunities to provide stronger, stiffer parts with reduced weight, high ductility, and improved thermal and electrical conductivity. Opportunities exist in such applications as aerospace, automotive, and other applications requiring high strength, stiffness, and conductivity.

However, continuous fibers are not that easy to use in 3D printing; it is complex to lay down the fibers. The 3D printed CFRP part may only be strong in one direction or not strong in the Z direction. Carbon fiber reinforced polymer (CFRP), with the ability to be oriented and strong in different directions (including having strength in the Z axis) can provide greater strength, stiffness, and conductive properties. CFRP can be used in laser sintering to produce stiffer

materials with enhanced thermal and electrical properties for such applications as aerospace.

It is important to note that, in order to advance 3D printing materials, it is beneficial to coordinate the design of materials, equipment, and processes.

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4. INNOVATIVE MATERIALS FOR FUSED DEPOSITION MODELING

Fused deposition modeling (FDM) is a widely used 3D printing or additive manufacturing equipment technology that relies on melting and selectively depositing a thin filament of thermoplastic polymer (such as acrylonitrile butadiene styrene or ABS, plastic, polycarbonate and investment casting wax) in a cross-hatching mode to form each layer of a part. In FDM, a 3D object is built one layer at a time. A plastic filament or metal wire is unwound from a coil and supplies material to a heated extrusion nozzle that controls the flow. A nozzle is heated to melt the material. Fused filament fabrication (FFF), which is equivalent to FDM, is used in very inexpensive additive manufacturing equipment for applications such as hobbyists. FDM or FFM additive manufacturing equipment is used in key industries or applications such as automotive (prototyping), aerospace, healthcare, consumer, and commercial.

Opportunities exist to improve the tensile strength, impact strength, flexural strength, accuracy, durability, stability, and jettability of FDM materials, as well as to create water-tight, less porous models with good adhesion properties and consistent extrusion and control capabilities.

Regarding some of the promising more innovative materials for FDM, plasticized copolyamide thermoplastic elastomers (PCTPE), introduced by taulman 3D (Saint Peters. MO), can offer improved flexibility and mechanical resistance. Potential applications include fashion, molds for epoxies, and carburetor transmission components.

There are also opportunities for high-strength, clear PLA (polylactic acid) that enables configuring PLA without yellowing. Such material has been aimed at use with FFF equipment (which has been driven by low-cost printer applications). taulman 3D has promulgated ARCbio clear PLA material. Clear PLA could address opportunities to improve conventional PLA, which tends to be used in applications such as home printers, hobbyists, and schools.

Moreover, opportunities exist to develop improved PLA materials, with low shrinkage, high tensile strength, a higher heat deflection temperature, and resistance to having a yellowish color. There are also opportunities to improve the mechanical properties between the layers in PLA and ABS materials to enable stronger parts.

Furthermore, potential exists to develop enhanced grade ABS (acrylonitrile butadiene styrene), a most established 3D printing material, for FDM consumer/commercial, auto, healthcare, and aerospace component applications. When printing ABS, there can be a hot plastic smell. ABS is a petroleum-based material.

In FDM additive manufacturing, there are also opportunities for parts made with carbon fiber- or carbon nanotube-filled materials, such as PEEK (polyetheretherketone), PAEK (polyaryletherketones), ABS, PLA, and so on. Carbon nanotubes may not bond well to the fiber and may have less mechanical strength than carbon fiber. Carbon fiber reinforced ABS or PLA materials have opportunities in applications requiring greater stiffness, improved dimensional stability or improved thermal resistance, and lighter parts compared to unfilled, standard ABS or PLA material.

There is also potential to increase durability of thermoplastic elastomers (TPE) for FDM/FFF; and opportunities to explore TPE for FDM/FFFF for aerospace applications, such as flexible rubber ducts for air handling.

Polyphenylene Sulfide (PPS) has tensile strength and a higher temperature range than ABS. However, due to its high tensile strength, PPS may not be conveniently wound into spools for FDM/FFF. PPS for FDM/FFF can have applications in areas such as aero, defense, and healthcare where very high tensile strength is required.

Over time, there may be opportunities for graphene-enhanced nylon in applications such as electronic devices (batteries, electronic circuits, and sensors). The addition of graphene has the potential to improve the electrical

conductivity, mechanical strength, and thermal conductivity of the polymer. However, when not fully suspended in a vacuum, graphene can have limited thermal conductivity, and graphene sheets can be brittle, lose strength, and have limited fracture toughness.

In 2014, taulman 3D and Graphene 3D Lab (Calverton, NY) agreed to co-develop a graphene-enhanced nylon material for 3D printing, In the spring of 2015, Graphene 3D Lab began selling the taulman 3D Nylon 680 filament for FDM 3D printers, which is not graphene-enhanced and is designed for use in such applications as medical and dental research, food processing, and robotics. Nylon 680, which has FDA approval for indirect food contact, has superior strength and physical attributes. Graphene 3D Lab enabled this material to be brought to the market sooner, since it is expensive to manufacture.

The CEO of taulman 3D noted they are looking into graphene-enhanced nylon; but there is the issue of safety. Graphene, nanoparticles and carbon fiber can be considered a health hazard. Furthermore, inserting something into a polymer can result in a less stronger part overall. Nylon does better with some additives and taulman 3D is looking at them with an interest in reducing shrinkage. One additive they are looking at is aluminum for printable heat sinks, but it will have less tensile strength than nylon 645. Taulman 3D has nylon 680 (not for release) with a tensile strength of 12,000 psi and they are working on two other super materials. Taulman 3D's near-term goal is to create a pure polymer that provides 19,000 psi tensile strength, 220 degrees C working temperature, 340 degrees C print temperature, a nylon alloy that allows drilling and taping directly to the part, 5-10% elongation, high chemical resistance, shrinkage on the order of t-glase (t-glase is a taulman 3D material [a polymer] that sticks to acrylic and glass print tables and has an optimum temperature of 235 degrees C to 240 degrees C.)

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5. NOVEL NANOMANUFACTURING TECHNIQUE TO PRODUCE NANOLENS

Nanomanufacturing is an emerging field of manufacturing that has potential to profoundly impact key industries and applications, for example, medical diagnostics, drug delivery systems, flexible electronics, sensors, and so on. Nanomanufacturing technology has potential to enable, for example, nano robots to emerge. New materials with high strength have been developed due to the abilities of nanomanufacturing, which is capable of manipulating properties of materials at the molecular level.

All these technological feats were possible due to a biotechnology bubble that started roughly 15 years ago. During this time, several new bio sensing technologies emerged. Bio sensing refers to a technique that is used to detect and identify substances, particles, and molecules uniquely when present in composite mixtures. For example, detecting cancer cells in blood plasma using nanobots is a bio sensing activity. One of the theoretical concepts that evolved during the biotechnology bubble is the nanolens. A nanolens is a chain of three spheres of nanoscale materials arranged in an order to focus the incident light into a minute spot that is smaller than the range possible with traditional microscopy.

In the past, researchers envisioned the potential of a nanolens (a chain of three nanoscale spheres that would focus incoming light onto a very tiny spot considerably smaller than that feasible via conventional microscopes)

Ever since the concept of nanolens was envisioned, researchers across the world have been trying to build arrays of nanolens to cover a large area. However, none of them have been successful so far. Recently, senior research scientists from the University of Chicago's institute of Molecular Engineering, along with nanophotonic experts from Air Force Research Laboratory and Florida State University, have found a new way to build large arrays of nano lenses. These nano lenses have been produced using a fabrication technique that combines chemistry and lithography.

The new fabrication technique aligns three gold nanoparticles of graduated sizes on a substrate like a string-of-pearls in order to produce the required focusing of light. The incredible feat about this new fabrication technique is its ability to place the nanoparticles at any location on the substrate precisely.

First, the research scientists used lithography to etch patterns on a chosen substrate. Lithography was chosen for its ability to produce very precise and delicate patterns on the substrate. On the flipside, lithography cannot produce three-dimensional structures on the substrate that are required to accommodate the gold nanoparticles. Therefore, the researchers resorted to chemical techniques. They used polymer chains to treat the etched surface of the substrate to build three-dimensional space through chemical bonding. The polymer chains were chosen to selectively adsorb only gold particles.

The nanolens arrangement consists of three gold nanoparticles of different sizes arranged in a particular order. To make the nanoparticle the correct size to go to its designated spot, the scientists brought in a chemical contrast in spots for nanoparticles of different sizes. In this way, the researchers were able to control the movement of gold nanoparticles on the substrate and guide them exactly to the designated spot using chemical interaction.

The resulting array consists of numerous nano lenses formed by sequential arrangement of three different sized gold nanoparticles. In each lens arrangement, the nanoparticles are separated by only a few nanometers, which produces the nanolensing effect. High focus of light is seen between the medium and small sized nanoparticles of the lens arrangement. The research scientists are now focused on making use of this hot-spot to detect molecules in chemical solutions and biological systems.

This new fabrication technology promises to open a new way for very high-precision nanophotonics and biosensing. On maturity, this technique can be expected to be employed in the production of ultra-high precision biosensing nanophotonic systems for applications in areas like organic chemistry, medicine, and diagnostic technology.

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6. PATENT ANALYSIS OF PREDICTIVE MAINTENANCE

The emergence of the Internet of Things (IoT) is impacting and transforming the manufacturing industry. Big data and predictive analytics are IoT technologies that are changing operations and maintenance in the manufacturing environment.

Predictive maintenance is one such IoT concept that combines the power of big data, cloud computing and predictive analytics to optimize the maintenance activities in a manufacturing setup. Predictive maintenance uses the present and historical data related to the health and condition of machines and other equipment and predicts the failure of machines and conducts maintenance operations of machines before any such failure actually occurs. In practice, predictive maintenance keeps maintenance frequency as low as possible to prevent unplanned reactive maintenance, without incurring costs associated with doing too much preventative maintenance.

The exhibit below shows the intellectual property activities and patents filed for predictive maintenance in various industries in recent times. One of the interesting patents in preventive maintenance belongs to Nordson Corporation (US 20150027546). The patent pertains to an adhesive melter that enables predictive maintenance of an exhaust air filter used to remove pressurized air flow that delivers solid adhesive particulate from a fill system into the melter.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
INTELLIGENT LIGHTING SYSTEM WITH PREDICTIVE MAINTENANCE SCHEDULING AND METHOD OF OPERATION THEREOF	September 11, 2015 / WO/2015/132687	KONINKLIJKE PHILIPS N.V.	FLINSENBERG, Ingrid Christina Maria	Alighting system may include: at least one controller which may be configured to: obtain lighting logging data including feature information related to features of the lighting system and obtained from a plurality of feature spaces; determine lighting prediction data which predicts at least one component failure in the lighting system at a future time in accordance with the lighting logging data and include at least one complex feature; model predicted component failures which are predicted to occur at a future time in accordance with the lighting prediction data and maintenance cost; and/or store the predicted component failures model in a memory.
Predictive maintenance and inferring patterns of solar panel cleaning systems	September 8, 2015 / US 09126341	ECOPPIA SCIENTIFIC, LTD.	Moshe Meller	System and method to predict maintenance windows, initiate and avoid cleaning cycles of robotic systems that clean solar panels. Using learning algorithms, the system and method is based on collecting, monitoring and conducting trend analysis from data received by the various robotic systems that effect the cleaning cycles, external sensors, sources and feeds.
PREDICTIVE MAINTENANCE METHOD AND SYSTEM	August 13, 2015/ US 20150227122	KONECRANES PLC	Tuomo Härkönen	The invention relates to a predictive maintenance of hoisting equipment (**102**), particularly cranes. A maintenance centre (**106**) automatically collects diagnostic data relating to least one component of the remote hoisting equipment and optionally sensor data relating the operational environment of the remote hoisting equipment (**102**). The maintenance centre (**106**) has an access to configuration data of the remote hoisting equipment and the reliability data on the at least one component of the remote hoisting equipment (**102**). The maintenance centre (**106**) is then able to generate a maintenance plan optimizing the cost of maintenance and reliability of the hoisting equipment over a life cycle of the hoisting equipment.
LOG-BASED PREDICTIVE MAINTENANCE	August 13, 2015/ US 20150227838	Zhuang WANG	Zhuang WANG	A method of building a model for predicting failure of a machine, including parsing (41) daily machine event logs of one or more machines to extract data for a plurality of features, parsing (42) service notifications for the one or more machine to extract failure information data, creating (43) bags from the daily machine event log data and failure information data for multiple instance learning by grouping daily event log data into the bags based on a predetermined predictive interval, labeling each bag with a with a known failure as positive, and bags without known failures as negative, where a bag is a set of feature vectors and an associated label, where each feature vector is an n-tuple of features, transforming (44) the multiple instance learning bags into a standard classification task form, selecting (45) a subset of features from the plurality of features, and training (46) a failure prediction model using the selected subset of features.
PREDICTIVE MAINTENANCE NOTIFICATIONS BASED ON MOTOR VOLTAGE AND MOTOR CURRENT	August 13, 2015/ WO/2015/116161	HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.	LOPEZ MATOS, Emilio	In examples provided herein, a voltage circuit is to be coupled in parallel with a motor to identify a motor voltage. A current circuit is to be coupled in series with the motor to identify a motor current that is to pass through the current circuit. The current circuit is to identify the motor current independently of the motor voltage identified by the voltage circuit. A controller is to provide a predictive maintenance notification based on a first status of the motor voltage and the motor current.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Method for evaluating and predicting maintenance work load of open source software (OSS) based on code quality	July 29, 2015 / CN 104809066	Chongqing University	Yang Mengning	The invention relates to a method for evaluating and predicting the maintenance work load of open source software (OSS) based on code quality. The method comprises the steps of firstly, acquiring all indexes representing the code quality of the OSS; after that, introducing a variance inflation factor, and removing the indexes with higher degree of association to obtain an available index set; carrying out linear regression analysis on the available indexes in the available index set to obtain a functional relation between the maintenance work load of the OSS and the available indexes; predicting the maintenance work load of the OSS according to the functional relation. According to the method, the indexes representing the code quality of the OSS can be easily obtained, so that the prediction result is accurate, and the method is suitable for being popularized within a large scope.
Method for predicting clearing maintenance time of self-help electricity selling terminal	July 22, 2015/ CN 104794536	Jiangsu Linyang Electronics Co., Ltd.	Zhang Bing	The invention discloses a method for predicting the clearing maintenance time of a self-help electricity selling terminal. The method is characterized in that the method is sequentially divided into three continuous prediction stages including an initial stage, a data accumulation stage and a standard stage after the terminal is mounted, and the prediction stages correspond to different algorithms. A system can automatically select the stages according to the accumulation process of business data. The system simultaneously predicts the clearing time results in one day, two days and three days, experience data, seasonal change and business volume increasing optimization prediction models are introduced in different stages, and the problem that prediction cannot be performed or prediction is inaccurate caused by data incompleteness is solved. The system replaces electricity using quantity data with cash charging data, interference, caused by non-cash charging manners, on prediction calculation is avoided, and system predictability and predication accuracy can be increased greatly.
SYSTEMS AND METHODS FOR PREDICTIVE MAINTENANCE OF CROSSINGS	July 9, 2015 / US 20150192636	General Electric Company	Jeffrey Michael Fries	A method for predicting failure of a crossing warning system is disclosed. The method includes monitoring an electrical characteristic of a first route when an electric current is injected into the first route. The first route has a crossing intersection with a second route and a crossing signal at the crossing intersection. The electrical characteristic is monitored to detect when a vehicle is approaching the crossing intersection on the first route and to determine when to activate the crossing signal at the crossing intersection. The method also includes identifying one or more changes in the electrical characteristic of the first route, and, based on the one or more changes that are identified, predicting a failure mode of the first route that interferes with detection of the vehicle approaching the crossing intersection.
Method for predicting clearing maintenance time of self-help electricity selling terminal	July 22, 2015/ CN 104794536	Jiangsu Linyang Electronics Co., Ltd.	Zhang Bing	The invention discloses a method for predicting the clearing maintenance time of a self-help electricity selling terminal. The method is characterized in that the method is sequentially divided into three continuous prediction stages including an initial stage, a data accumulation stage and a standard stage after the terminal is mounted, and the prediction stages correspond to different algorithms. A system can automatically select the stages according to the accumulation process of business data. The system simultaneously predicts the clearing time results in one day, two days and three days, experience data, seasonal change and business volume increasing optimization prediction models are introduced in different stages, and the problem that prediction cannot be performed or prediction is inaccurate caused by data incompleteness is solved. The system replaces electricity using quantity data with cash charging data, interference, caused by non-cash charging manners, on prediction calculation is avoided, and system predictability and predication accuracy can be increased greatly.

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SYSTEMS AND METHODS FOR PREDICTIVE MAINTENANCE OF CROSSINGS	July 9, 2015 / US 20150192636	General Electric Company	Jeffrey Michael Fries	A method for predicting failure of a crossing warning system is disclosed. The method includes monitoring an electrical characteristic of a first route when an electric current is injected into the first route. The first route has a crossing intersection with a second route and a crossing signal at the crossing intersection. The electrical characteristic is monitored to detect when a vehicle is approaching the crossing intersection on the first route and to determine when to activate the crossing signal at the crossing intersection. The method also includes identifying one or more changes in the electrical characteristic of the first route, and, based on the one or more changes that are identified, predicting a failure mode of the first route that interferes with detection of the vehicle approaching the crossing intersection.
Adhesive Melter and Method Having Predictive Maintenance for Exhaust Air Filter	January 29, 2015/ US 20150027546	Nordson Corporation	Bondeson Benjamin J.	An adhesive melter and a method for operating the melter enables predictive maintenance of an exhaust air filter used to remove pressurized air flow that delivers solid adhesive particulate from a fill system into the melter. To this end, the fill system repeatedly actuates to refill a receiving space, and a controller monitors a duration of each fill system cycle. When changes in a calculated average duration of a plurality of fill system cycles exceed a maintenance threshold, an alert is emitted at a user interface to prompt maintenance or replacement of the exhaust air filter before a complete shutdown of the fill system is caused by clogging of the exhaust air filter. Consequently, unplanned downtimes caused by clogged exhaust air filters in the adhesive melter can be minimized, regardless of any variable conditions occurring at the melter.
MAINTENANCE PREDICTION DEVICE AND MAINTENANCE PREDICTION METHOD	December 15, 2014/JP 2014234726	EDWARDS KK	OKADA TAKUYA	PROBLEM TO BE SOLVED: To provide a maintenance prediction device for a vacuum pump for discharging gas under rotation of a rotary body and other devices to be maintained that can inform necessity of maintenance in a highly accurate manner. SOLUTION: A maintenance prediction device 1 comprises a sensor part 2 for outputting a shock generated at a device to be maintained as a sensor signal S and a signal processing part 3 for the sensor signal S. The signal processing part 3 performs a measurement calculation processing and a maintenance prediction processing. An interval between rise and fall of the sensor signal S is measured as a contact time, an interval time between a rise of the sensor signal S caused by a shock of n-th times and a rise of the sensor signal S caused by a shock of n+1 time is measured as a shock interval or a shock rate. The maintenance prediction processing includes a threshold of a contact time, shock interval or shock rate and outputs maintenance information of the device to be maintained on the basis of a result of comparison between the threshold and the contact time, shock interval or shock rate. COPYRIGHT: (C)2015,JPO&INPIT

Exhibit 1 lists some of the patents related to predictive maintenance.

Picture Credit: Frost & Sullivan

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