TECHNICAL INSIGHTS

ADVANCED MANUFACTURING

TECHNOLOGY ALERT

19th November 2010

1. ADVANCED INDUSTRIAL LIGHTING SYSTEM FOR HAZARDOUS ENVIRONMENTS

Varied manufacturing processes are performed in hazardous or explosive environments. many of them can be remotely controlled, but for monitoring and vigilance reasons, or for emergency response, a light source is needed. Lighting applications in dangerous locations are a key safety concern where flammable or explosive fuels, fumes, gases, or liquids are present. Typical commercial remote source lighting systems are limited to distances of approximately only 15 m. In addition, traditional electrical lighting distribution systems, and electrical light fixtures, can be a spark source, generate significant heat, emit electromagnetic and radio frequency interference (EMI/RFI), and in some cases can cause electrocution. Those unwanted properties can cause failure of manufacturing process and in the worst case scenario cause explosion and environmental disaster.

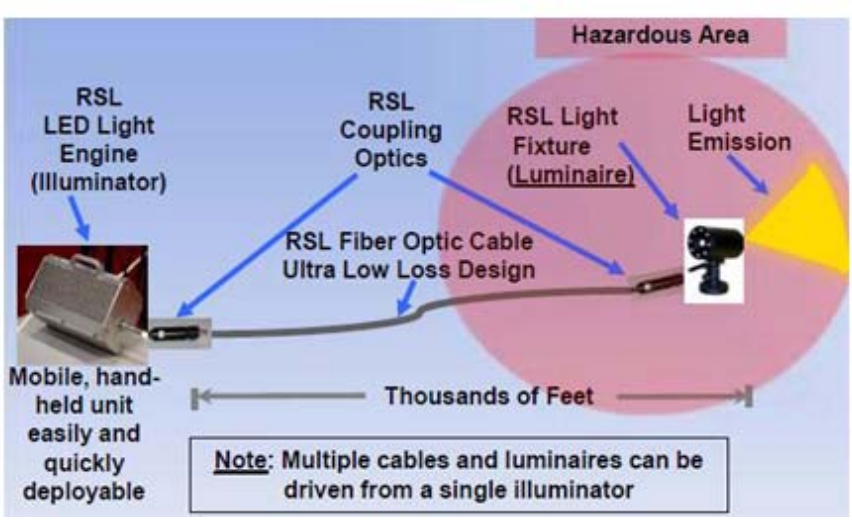

Figure 1 depicts the RSL system's potential applications.

Picture Credit: Peter Gladis, Director of Marketing, RSL Fiber Systems

RSL Fiber Systems LLC, headquartered in East Hartford, Connecticut, USA, came up with the solution to meet those hazardous or explosive environments requirements.

Remote source lighting (RSL) is a technology where light is generated at one location from an illuminator, then coupled directly into optical fiber for transmission over a distance to a specifically designed reflecting device called a luminaire. RSL consists of a set of illumination systems utilizing high-performance, long-distance optical fiber to deliver light non-electrically to a passive, non-electrical illuminator where it is critically needed. The technology is the innovative, creative, and efficient design of a full illumination system, utilizing modern, highly-efficient optical fiber, illumination, and coupling technologies.

RSL has the ability to drive bright illumination efficiently over long distances, such as 300 m or even longer when necessary. Optical fiber light distribution systems and passive illuminators are not a spark source, do not generate significant heat, and do not emit any kind of interference.

RSL systems are already implemented in three broad application areas: where the light delivery point is remote and hard to reach; where sensitive electronic equipment is co-located with lighting systems; and where light is needed in hazardous areas where explosive gaseous fumes or liquids are present.

In applications where the light delivery point is remote and hard to reach, traditional lighting fixtures are difficult to implement, costly, and maybe even dangerous to replace. RSL significantly reduces maintenance and downtime, while

increasing safety by eliminating the need for maintenance personnel to access remote lighting locations. RSL is very useful in applications where light is needed in areas where explosive gaseous fumes or liquids are present. It is because the light delivery and illumination system is non-electrical--the fiber optic cable and the reflective luminaries carry no electricity, they do not spark and they generate very little heat. Specific applications include shipbuilding, towers, complex architectures, mining, refinery, chemical, oil, and gas facilities, offshore oil/gas rigs, first responder applications, and other industrial applications. RSL implemented their solution in the US Navy applications, but they predict that about 50% of their revenue will accrue from commercial, non-military markets.

RSL Fiber Systems is willing to collaborate with others to continue their work with respect to technology and market partners with mutual synergies. They would also be willing to discuss licensing areas to identify mutually-beneficial opportunities.

The use of fiber optics and optical components for illumination systems has the same promise as fiber optics provided for communications systems in the past. With the rapid evolution in capability and price reduction of the raw light sources, such as light-emitting diodes (LEDs), lasers, and so on, the market potential for RSL's technology is significant.

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2. DIAMOND-LIKE CARBON COATINGS TO INCREASE BEARING EFFICIENCY

On the wave of trends toward energy efficiency and environmental footprint reduction, numerous R&D work has been undertaken to reduce the friction and wear of sliding surfaces.

The conventional way to reduce wear and friction are based on lubrication systems. Nevertheless, bearing lubricants might be expensive and cause environmental issues as they utilize rare materials. One of the ideas to address the concerns is to limit the amount of the lubrication oil used. Such an approach, though, exposes bearings to increased wear. Therefore, engineers started to look at sliding surface modifications in order to improve tribology characteristics of

bearings. Diamond-like carbon (DLC) coatings are among those films that attract highest attention of tribology scientists and engineers. The following article presents some engineering consideration on applicability of DLC films in bearings.

DLC coatings are amorphous carbon material structures that show specific features of graphite and diamonds. Characteristics, such as hardness number, Young's modulus, and the electrical characteristics make the DLC film similar to diamond, whereas its thermal conductivity makes DLC similar to graphite. DLC films are formed with physical vapor deposition and chemical vapor deposition techniques. They are considered as hard coating materials.

As a hard coating, DLC can be compared with films such as titanium nitride (TiN), zirconium nitride (ZrN), chromium nitride (CrN), titanium carbide (TiC), titanium carbonitride (TiCN), and titanium aluminum nitride (TiAlN). The comparison of characteristics, such as hardness, corrosion resistance, oxidation resistance, seizure resistance, and adhesion, showed that DLC can show extremely high hardness and very good seize resistance. However, DLC films pose challenges when it comes to adhesion to a substrate. Carbon atoms do not readily adhere to a dissimilar material and in the presence of high stresses in the DLC layer, poor adhesion occurs. There are though some specific techniques to improve the substrate-DLC film adhesion: higher substrate hardness through operations, such as nitriding or shot peening; surface pre-treatment through etching or abrasive blasting; adoption of an intermediate layer that shows high affinity to both substrate and DLC layers. With such operations the DLC-to-substrate adhesion is improved, which makes DLC layers applicable.

DLC films are typically applied to cutting tools, dies, and functional films. An exemplary use would be coating of tungsten carbide dies used for molding works of sintered copper (Cu) alloy parts. With a DLC coating, the dies show reduced wear and increased lifetime. Increased lifetime is also an advantage experienced by manufacturers of bearings; DLC coated surfaces of bearing components reduce friction and require less lubricant, which translates into less environmental footprint and increased efficiency of machines.

The above article is based on an NTN Technical Review No. 77 report titled "Characteristics and Applications of DLC films," authored by Kouya Oohira from the NTN Elemental Technological R&D Center.

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3. AUTOMATED LASER MATERIAL PROCESSING FOR PRECISE AND FLEXIBLE MANUFACTURING

Automated laser material processing apparatus can include a scanning laser for focusing a laser beam onto a work surface along a pre-programmed path. The apparatus also includes a work table that provides a precisely planar support surface for supporting the material during a work operation performed by the laser. There is a need to increase the precision of the operation and efficiently use the floor space so that both laser cutting as well as laser welding operations can be accommodated and make the plant more flexible and dynamic.

Fraunhofer Institute for Laser Technology (ILT) has created new system solution for higher component precision and process stability. The researchers combined laser cutting and laser welding in a single processing head to create a system that leads to higher flexibility in plant dimensioning, optimizing the processing sequence and reducing the clamping, storage and transport times. To achieve this, ILT has developed a combi-head which is produced and manufactured by the cooperation partner Laserfact GmbH in Aachen. The tool center point (TCP) is common to both the laser cutting and the laser welding process and has been instrumental in increasing the component precision and process stability during the laser cutting process.

The signals generated by the capacitive distance sensor system of the combi-head are used for normal distance control as well as for component measurement so that the subsequent weld-seam can be predetermined. In this way, the sheet metal component parts can be cut to size, measured, welded, and cut again, as in an integrated process chain. The connection of combi-processing and capacitive component measurement is not only suitable for concealed t-joints in structural components of automobile construction, but can also offer new solutions wherever curved or deep-drawn sheet metal parts need to be joined together to create a precise sheet metal group in spite of their geometric tolerances.

The TCP and processing heads were also used to develop an image processing system that observes the laser processing position of the workpiece

directly through the processing optics. The direct surroundings of the processing position are analyzed by a camera system with downstream image processing. The system measures only the area of the processing position and not at the head or in the robot axes. No measurement errors are made since the process gauges the ongoing measurement accuracy. The current process speed is recorded by the measuring system and any deviations from the preset values are detected. It ensures that the processing head follows the contours of the workpiece exactly. The system gives precise feedback to the user on how the process parameters comply with the track that was previously programmed into the machine control system. With this process, the tracks of any processing system can be measured.

Fraunhofer ILT, in collaboration with Fraunhofer IPT, has also developed a coaxial process control (CPC) for laser brazing. The process zones are taken under the magnifying glass in the visible and near infrared spectral range (NIR). The visible images transmit data on feed speed, wire position, and geometric measurement of the braze seam. The NIR images keeps the users informed about the heat distribution in the work piece, the emergence of pores or about single-sided moistening. Process monitoring during the laser process renders the time-consuming and expensive quality control step redundant.

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4. INTELLIGENT ALARM TO ELIMINATE COSTLY PRODUCTION DELAYS CAUSED BY LATE RESPONSE

Large- or medium-sized process plants can suffer from significant amounts of losses due to extra production costs caused by production delays. These delays are mostly due to faulty equipment in a process plant or due to maintenance shut down. These delays not only increase the product costs, but also decrease the efficiency of the process or manufacturing plant. While key manufacturers and process plant leaders were exploring the solutions to this issue, industrial alarming systems were introduced in the market, but these commonly used

SCADA architecture-based alarming systems were unable to address the needs of the large process and manufacturing plants.

The basic architecture of an industrial plant alarming and messaging system is based on either an industrial wireless or on wired network system. A data acquisition system, a programmable logic controller (PLC), a router and central data center (RTU) form the alarming system. Two-way voice communication through wireless has been used in manufacturing industry messaging, but these technologies have had some limitations. The software-based messaging engine can be applied to any plant operation in any industry, especially in high-noise environments where traditional alarms or two-way voice communication are not effective.

To initiate a perfect operation of a manufacturing plant, the faults should be indicated by alarms at the right time. Therefore, to trigger an alarm at the right time, the messages from PLCs, master controllers, and sensors should be instantly relayed. However, an alarm system with such facilities and efficiencies has not been readily available in the market.

Canamex Communications' (Ontario, Canada) patented product "PageRouter" addresses most of the industry shortcomings. The easy-to-install PageRouter software delivers messages within seconds. Messages from PLCs, master controllers, sensors, and even wireless panic buttons, are relayed instantly to alert staff of machine breakdowns, fire, spills, power failures, or medical emergencies. PageRouter can receive plain ASCII text from factory equipment; transmit programmable canned messages triggered when PLC relays open or close; receive e-mails from equipment and send them to staff; deliver programmable messages when wireless panic buttons are pressed. PageRouter can be integrated to any plant operation. The product includes a wall-mounted antenna, a small on-site paging transmitter and cables from the PLCs and/or the production control computer. Canamex delivers as many pocket pagers as required. These units boast heavy duty construction, a very strong vibrator and a four-line display. Patented product allows user to use a "dynamic map" that shows all user assignments and create unlimited departments and groups each with unlimited members. PageRouter is integrated with a patented WebPager, which enables message sending from any browser easily. PageRouter delivers text messages from unlimited network computers to on-site pagers in very quick time and hence minimizes the response time significantly.

Commercially available alarming systems in the marketplace are mostly data acquisition systems along with monitoring facility (supervisory system). They may not enable a facility to initiate alarming technology, messaging and reporting, which the "PageRouter" does. This product has the potential to significantly penetrate the global automation and process control market.

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5. INK-JET PRINTING TECHNIQUE FOR STEM CELLS CONTROL

Currently, cell biology research studies are conducted under the light of better understanding on the behavior of stem cells. This understanding/knowledge relies on the fact that stem cell are likely to be implemented in stem cells-based therapies, due to the possibility to generate pluripotents cells, which leads to the improvement in human life, by the application/use of stem cells in cancer management, and so on.

In order to perform *in vitro* experiments to study stem cells behavior, there are several methods for creating protein-based arrays, including pen spotting, soft lithography, photolithography, and drop-on-demand ink-jet printing.

Scientists at the Institute for Complex Engineered Systems, Carnegie Mellon University, chose to use the ink-jet bioprinting method because of several advantages--it is programmable, there is no contact with between the substrate and the mechanical parts of the device, and it does not require any modifications to the proteins or substrates. They are using this approach to engineer cell fate toward the osteogenic lineage in register to printed patterns of bone morphogenetic protein (BMP) 2 contained within a population of primary muscle-derived stem cells (MDSCs) isolated from adult mice.

It must be noticed that growth factors (GF), such as bone morphogenetic proteins (BMPs) and fibroblast growth factors (FGFs) are essential for basic developmental mechanisms. BMPs are also potent osteoinductive factors and stimulate differentiation of osteoprogenitors via cooperative mechanisms with extracellular matrix (ECM) components.

The set-up for the chips bioprinted is depicted as follows: recombinant human bone morphogenetic proteins (BMP)-2 bio-inks was labeled using cyanine 3 (Cy3) monofunctional reactive dyes, synthesized in-house following established protocols. Prior to printing, the print head was sterilized by first rinsing with 70% ethanol followed by three rinses with 0.2 micrometer of filtered deionised water prior to loading the ink in the jet. The bio-ink, consisting of 100 microgram/ml Cy3-labeled BMP-2 in phosphate buffered saline (PBS), pH 7.4, was loaded into the print head, and patterns were printed onto fibrin-coated glass slides. These relatively high-growth factor bio-ink concentrations were used to aid visualization of the patterns. The printed patterns were 2X2 arrays of 750 square micrometers with a spacing of 75 micrometer between the printed drops and 1.75 mm between the squares.

Overall, bioprinting-based in ink-jet technology is likely to be an outstanding candidate for the production of cell and protein arrays. In the future, it can possibly be applied for organ printing. One of the main goals is to generate tools that could replicate *in vivo* conditions to the cell cultured. Moreover, this work provides proof-of-concept for engineering spatially controlled multilineage differentiation of stem cells using patterns of immobilized growth factors. This approach is very useful for understanding cell behaviors to immobilized biological patterns and could have potential applications in regenerative medicine. It must be noted that spatial patterning of hormones, including growth factors, is known to be critical in directing all aspects of cell behavior throughout life; including embryogenesis and wound repair. Simple, methods, which could be controlled, to engineer the physical placement and concentration of immobilized exogenous growth factors in a physiologically relevant manner, and for studying cell behavior are important for biological research, as well as being a logical consideration for developing tissue regeneration therapies.

Broadly speaking, the technology proposed in this alert is likely to be applied for industrial bioprocessing and sensors..

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