Executive Summary

How many of you have heard of, or maybe even seen an OLED? An OLED or organic light emitting diode can best be described as a solid-state device composed of thin films of organic molecules that create light when voltage is applied to the device. Amazingly, an OLED is only 100 to 500 nanometers thick\(^1\) or about 200 times smaller than a human hair. OLEDs use red, green and blue diodes to produce color images that can provide brighter, crisper displays on electronic devices and use less power than conventional light-emitting diodes (LEDs) or liquid crystal displays (LCDs) that are commonly used today.

What is an OLED?

An OLED is generally made up of six parts as described below:

- **Substrate** – The base of the OLED and made of clear plastic, glass or foil.
- **Anode** – The positive terminal.
- **Conducting Layer** – Composed of organic plastic molecules or polymers.
- **Emissive Layer** – Composed of organic plastic molecules or polymers and layer where light is formed.
- **Cathode** – The negative terminal.
- **Seal** – Protective covering of glass or plastic.
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A voltage is applied across the OLED by connecting the cathode and anode plates to a power supply. This results in the cathode receiving and the anode losing electrons. Electrons in the atoms of the anode move resulting in a flow of current across the OLED circuit and causing the anode to be depleted of electrons. This can be thought of as creating positive holes or the anode receiving “holes.” The additional electrons in the cathode cause the emissive layer to become negatively charged (increase in electrons). Similarly, the conductive layer next to the anode becomes positively charged (increase in holes).

The holes jump across the boundary between the conductive and the emissive layer and combine with the excess electrons in the emissive layer. When this happens, it forms a burst of light. The process occurs continuously and generates a steady stream of light, as long as a voltage is applied to the OLED.

The type of organic molecules used in the emissive layer will determine the color of the light produced. Several types of organic films are placed on the same OLED to make the color displays. The intensity or brightness of the light can then be adjusted based on the amount of electrical current applied; the more current that is applied, the brighter the light. ³

There are a variety of OLED technologies, each with its advantages and disadvantages depending on use and application.

- **PMOLED – Passive Matrix OLED.** This type of OLED is primarily used to display text and icons on small screens found on a cell phone, PDA or MP3 player.
- **AMOLED – Active Matrix OLED.** This type of OLED provides better response and color as it requires less power than PMOLEDs and has faster refresh rates. Likely applications include computer monitors and items with larger display sizes such as large screen televisions, electronic signs and billboards.
- **TOLED – Transparent OLED.** These have only transparent components and when turned off, are up to 85% as transparent as their substrate. These are used in Heads Up Displays (HUDs) and windshield type displays. Initial applications will be for the military (aircraft HUD) with consumer applications later on.
- **FOLED – Foldable or Flexible OLED.** The FOLED is built onto a plastic substrate that is flexible so this product is lightweight, unbreakable and foldable. One unique anticipated use is sewing FOLEDs into clothing so a person can wear a computer and display content.
- **WOLED – White OLED.** This device can produce white light more efficiently than fluorescent lighting. It may eventually become a replacement for lighting used in commercial buildings and homes since it can be made into large, thin sheets.

Some of the OLED manufacturing processes are similar to those found in semiconductor or photovoltaic fabrication. OLED manufacturing tends to be less hazardous and unlikely to encounter uses of pyrophoric gases, flammable and highly corrosive gases/liquids or hazardous metals in the production process. The most critical part of manufacturing OLEDs is applying the organic layers to the
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substrate. This can be done in one of three ways with manufacturing techniques including:

- **Vacuum Thermal Evaporation** – This process is conducted in a vacuum chamber. The organic molecules are heated so they will evaporate and condense as a thin film onto a substrate. This is the most expensive manufacturing process.

- **Organic Vapor Phase Deposition** – This process is conducted in a low pressure, hot-walled reactor chamber. An inert carrier gas such as nitrogen transports the evaporated organic molecules onto a substrate so they can condense into thin films. This manufacturing process is more efficient and less costly than Vacuum Thermal Evaporation.

- **Inkjet Printing** – The polymers for the OLEDs are sprayed onto a substrate similar to a conventional inkjet printer. This manufacturing process is currently the least costly and can allow OLEDs to be printed onto very large films for large television screens and electronic billboards.

From a risk management and insurance perspective, consider the following issues:

- Property values may be very high due to the clean room exposure, expensive production equipment and their support systems, and the storage of raw materials and finished OLED products.

- There may be some complex business interruption considerations to analyze and evaluate due to the clean room manufacturing environment, use of specialized production equipment and possible need for unique raw materials from a limited number of suppliers.

- With regard to workers compensation, certain chemicals and processes used in manufacturing may be hazardous to the worker’s health. Employee safety should be assessed and appropriate controls need to be in place.

**Projected Growth Trends**

Global shipments of OLEDs totaled $3.2 billion in 2011 and are projected to reach $4.9 billion in 2012. The increase in demand is primarily due to displays used in tablets, computers and televisions, with some growth in white-emitting OLED panels for lighting. By 2017, BCC Research has forecasted that global shipments of OLEDs will exceed $20 billion. That would be a five-year compound annual growth rate of 33%. Displays will continue to be the largest segment and account for 96% or $19.6 billion by 2017. Lighting currently accounts for minimal revenue but is expected to grow to $700 million by 2017.
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LCD is currently the primary display technology for small electronic devices, monitors and large televisions, while LEDs are commonly used to form the digits on digital clocks and other electronic devices. Some of the advantages and disadvantages OLEDs have over LCDs include:

Advantage OLED:
- **Materials** - OLEDs are extremely thin and can be made on plastic, flexible materials. This could allow new applications such as roll-up displays that can be embedded in fabrics or clothing. In contrast, LCDs have a glass substrate and can be prone to breakage resulting in repair or replacement.
- **Wider Viewing Angle and Brightness** – OLEDs have a greater contrast ratio and viewing angle compared to LCDs because OLED pixels emit light directly. The OLED pixel colors appear true and correct at viewing angles approaching 90 degrees, which is almost perpendicular to the display screen.
- **Power** - Since an OLED doesn't use a backlight like an LCD, it has better power efficiency. Most of a LCD's power goes into the backlighting, which consumes more power.
- **Response time** – The OLED response time or refresh rate can be up to 1000 times faster than LCD. This allows for crisper displays, especially where there is significant change from one frame to another in events such as sports or gaming. This can eliminate the jitter problems currently present in LCD displays.

Advantage LCD:
- **Cost** - Today LCDs are less costly to produce. This may change, however, due to the OLED's simpler design and ongoing advancements in the materials and manufacturing techniques used to produce OLEDs.
- **Shelf life** - OLEDs have a limited lifetime due to the organic materials. In particular is the blue color, which has a lifetime of about 14,000 hours. This is nearly equivalent to five years of use at eight hours a day. In comparison, the LCD and LED displays have a lifetime that is two to three times longer than the blue OLED.
- **Water damage** - Since an OLED uses organic materials, water can readily damage it. Therefore, improved sealing processes are important during manufacturing. Moisture intrusion could be a concern for OLEDs used indoors and outdoors in devices such as a digital camera, cell phone or tablet.
- **Display** - OLEDs may be difficult to view in bright ambient light such as the outdoors.

Current Uses

OLED technology has many current uses and offers a wide range of opportunities in the years ahead. OLEDs have already been used for digital displays in common electronic devices such as television screens, computer monitors and digital cameras, and can be found in portable systems like mobile phones, handheld game consoles and PDAs. In addition, the automobile industry may be one of the more proactive industries regarding use of OLEDs. Potential uses for OLED displays and lighting in cars include dashboard displays, windshield transparent OLED, internal lighting, digital rear-view internal mirror and back-window alerts, and messaging.

In September 2011, Kia introduced a new concept car that used a very smart system for the dashboard display. It consisted of three layers of transparent OLED panels to create a unique 3-D display presenting the instrument data, entertainment information and navigation system. Then in March 2012, Audi...
displayed a concept car that uses OLED lighting panels to create rear lights, turn indicators, external lighted “decorations” and even a large display to show information to the driver behind you.\(^7\)

In the field of medical devices, Sony is now marketing the first and only OLED monitor with FDA approval for use in surgery. The higher contrast and quality color reproduction of the OLED monitor versus the LCD is intended to help surgeons finish operations faster and with fewer mistakes.\(^8\)

Consumers are still waiting for the first big screen OLED display to make it to the consumer electronics retail stores. LG and Samsung have planned to launch 55 inch OLED panels in 2013.

On June 25, 2012, Sony Corporation and Panasonic Corporation announced their agreement to jointly develop next generation panels and modules for televisions and large-sized displays. They plan to jointly develop printing method-based OLED technology that will be suitable for low cost mass production of large, high resolution OLED panels and modules, Sony and Panasonic aim to establish the mass production technology in 2013.\(^9\)

In addition, LG has been chosen by Korea’s Ministry of Knowledge Economy to develop a 60-inch flexible OLED by 2017. These flexible window displays could display information in public places like a subway station, retail store or other commercial businesses. The initial focus appears to be commercial applications, but we may one day be able to roll down a giant OLED screen where most people would expect a television monitor or projector screen. There are claims that eventually, an entire television could be made from a flexible OLED mat that can be unrolled, positioned, plugged in, turned on and viewed. The mat’s size could be limitless.\(^10\)

OLED based lighting for both residential and commercial applications is another anticipated future use right around the corner. OLEDs may end up being the preferred illumination source due to the following desirable characteristics:

- Energy efficiency
- Low-heat generation
- Slim and lightweight
- Flexibility if used with a plastic substrate
- Environmentally friendly

There are sample OLED lighting panels and an OLED desk lamp on the market today but they are currently very expensive. Actual commercial production is expected within the year.

**Conclusion**

Advancements in the field of OLEDs are rapidly leading to new applications in heads-up displays, automotive dashboards, billboard type displays, home and office lighting, flexible displays, and yes, even a newspaper\(^11\). Since the OLEDs...
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can refresh almost 1000 times faster than LCDs, a device with an OLED display can provide text, graphics and images with much better contrast and color reproduction so the term “high definition” may take on a whole new meaning. Stay tuned as new applications of this fascinating technology continue to be discovered and introduced.

To learn more about how OneBeacon Technology Insurance can help you manage online and other technology risks, please contact Dan Bauman, Vice President of Risk Control for OneBeacon Technology Insurance at dbauman@onebeacontech.com or 262.966.2739.

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