Atlas Application Note 112

UV-Durability Testing of LCD and OLED Displays

Xenon Instruments for Outdoor/Indoor UV Durability Testing

Atlas Material Testing Technology

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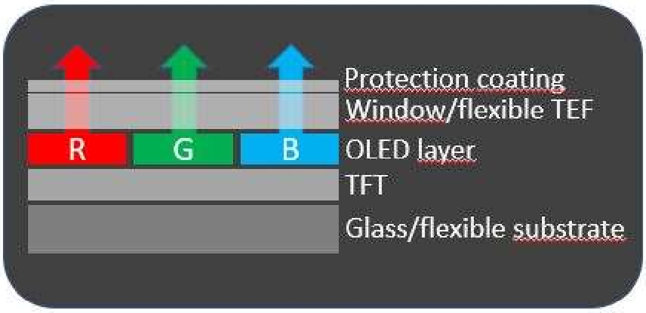
Introduction

Digital displays are embedded in almost every electronic device or piece of machinery available today. They typically come as LCD and OLED technology-based displays. The market has shown large growth over the past few years. One statement from BusinessKorea about OLED displays for vehicles is particularly impressive: “The market for OLED displays for vehicles is expected to grow fast from 240,000 units in 2020 to 4.4 million units in 2025.” [1]



Schematic OLED display structure

Individual materials used to manufacture displays, as well as the completed displays themselves, undergo numerous quality and performance tests including temperature/power cycling, scratch resistance, mechanical stress tests, and UV durability. Display developers are aware that LCD and OLED displays are sensitive to UV. Flexible polymer films that are used to protect displays, polythiophenes used in OLEDs, charge carriers in blue-fluorescent OLED emitters, and organic/metal contacts are all known to be particularly sensitive to UV radiation. Additionally, the touch sensors used in the polymeric layer of touchscreens may also be affected by UV.

LCD displays often come with an optical coupling film layer between the LCD and the superstrate for improved readability. Under UV exposure, this film can prematurely degrade. Furthermore, the laminate structure of the display is held together with a polymer known as Liquid Optically Clear Adhesive (LOCA) which is also UV-sensitive and can have yellowing or hazing occur as a result of exposure.

Solar UV Stress

Solar UV radiation and product temperature are the two major drivers of polymer degradation via photo-oxidation reactions. Natural solar UV radiation ranges between 295 - 400 nm and is known to be the most critical factor in polymer degradation due to the initiation of the formation of radicals. Therefore, UV testing is a critical part of any product durability test program. It is important to choose a UV test that is appropriate for your materials as different environments will have different amounts of UV radiation depending on the location and time of the year. For this reason, Atlas maintains databases of benchmark climates across the world providing annual average values for global radiation, temperature, and humidity. Be sure to consider indoor applications as well, as most window glass blocks UV transmittance below 320 nm which means products used solely indoors might not need to be tested using short-wavelength UV-B.

High temperatures accelerate the photo-oxidation processes initiated by UV exposure. To our experience, displays that are installed outdoors rarely see temperatures beyond 65°C. Inside a vehicle, display surface temperatures heavily depend on the type of window glass used, the location of the display, and the provided shading design. Nevertheless, temperatures may get up as high as 50 to 60 °C on a sunny day for displays at unfavorable solar beam angles. Vehicle manufacturers must carefully check the potential peak temperatures achieved by the display in the foreseen installed position ideally by means of drive-in solar environmental chambers.

Xenon Instruments for UV-Outdoor/Indoor Durability Testing

Xenon instruments, also used for weathering testing, are ideal for realistically testing the outdoor/indoor UV durability of displays. Today, they provide the best spectral match to natural outdoor/indoor sunlight. Filter systems, such as the Atlas Right Light™, can be installed to adjust the spectral power distribution to be a close match to outdoor daylight. Window glass and Store Light™ filters are also available for indoor light simulation. Test temperature and relative humidity are automatically controlled. Furthermore, water sprays to simulate rain are available, too. Rotating rack xenon instruments, such as Atlas Ci Weather-Ometers®, can test multiple small displays up to approximately 6 - 8''. Static flatbed-types, like the Atlas SUNTEST XXL+, test either multiple small or two large displays up to 20''.

Atlas SUNTEST XXL+: (1) Touch screen user interface, (2) Ethernet, USB, SD Card, RS232, (3) Light Cassette incl. xenon lamp, optical filter, (4) Water spray nozzles, (5) Light monitors, (6) Black Panel Temperature sensor, (7) Specimens

Xenon Test Methods

The scope of xenon testing of displays is to support suitable material selection and help to understand the long-term durability of displays for outdoor or indoor use. Often, this means finding the right type, mix, and content levels of UV-stabilizer. To do this, many major display manufacturers have developed proprietary xenon test methods. They often refer to the international xenon weathering test standard for polymers, ISO 4892-2. [2] Parts of IEC 60068-2-5 for solar stress testing of electronics have also been adopted. [3] ISO 4892-2 is useful as it provides options for both outdoor and indoor testing applications. Additionally, a hot lightfastness test for simulating vehicle/automotive interiors is included.

Typical parameters for outdoor UV-durability testing are a continuous irradiance level of 60 W/m^2 (at 300-400 nm), air temperature of 38 °C, and a Black Standard temperature of 65 °C. The use of water spray depends on the display's application. Xenon weathering tests such as this are designed to encourage faster degradation than that which occurs from natural processes which include plenty of dark hours and long periods of lower temperatures. Therefore, this type of testing is also known as accelerated weathering.

Test durations depend on the product, its end-use environment, and its expected service life. Even with this information, test durations can only be estimated. For example, the outdoor test at 60 W/m^2 delivers UV energy of ~ 5.2 MJ/m^2 (at 300 - 400 nm) every 24 hours. If we estimate that a product will see 100 MJ/m^2 during its lifetime, the estimated test time is 460 hours. This test duration can be considered as an initial guideline as it refers only to the approximate amount of UV radiation received by the product. Further test fine-tuning can be done by comparing the amount of product change with parallel controlled real-world exposures.

Accelerated UV-durability testing is a significant part of the product development process of a display. Early-stage xenon testing allows for screening and selection of the right materials for each part. Final product testing then provides additional safety to meet user expectations and avoid premature failures.

References

[1] Businesskorea, Michael Herh, LG Display Dominating Global Market for High-end Vehicle OLEDs, February 18, 2021. (http://www.businesskorea.co.kr/news/articleView.html?idxno=60698)

[2] DIN EN ISO 4892-2:2021, Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps (ISO 4892-2:2013 + Amd 1:2021).

[3] DIN EN IEC 60068-2-5:2019, Environmental testing - Part 2-5: Tests - Test S: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering.

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