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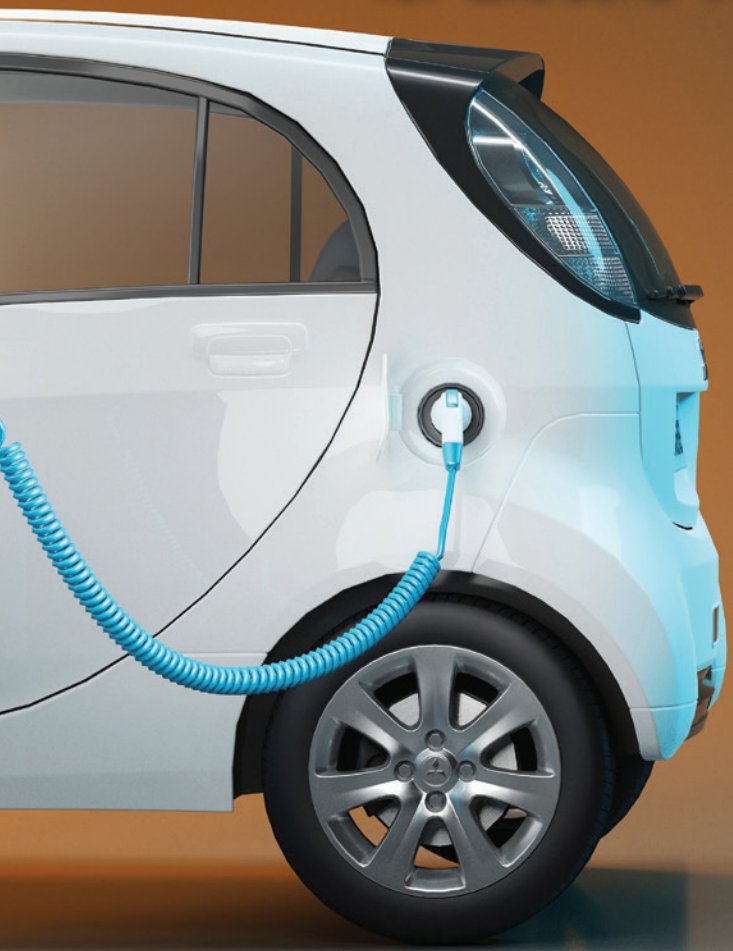

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ESD ISSUES FOR FLAT PANEL DISPLAYS

By Joshua Yoo for EOS/ESD Association, Inc.

INTRODUCTION TO FLAT PANEL DISPLAYS AND THE CURRENT STATE OF THE ART

Electronic displays have been widely adopted around the world, and information displays have become an essential part of human life. Flat Panel Displays (FPD) products like smartphones, tablets, televisions, and wearable displays use LCD and organic light-emitting diode (OLED) technologies for most current display devices. As innovation comes from many sources, it is difficult to predict or accurately forecast future display technology development. Curved and flexible displays were introduced as the most innovative display technology achievement along with OLEDs in the last ten years. Flexible displays are a different segment from traditional FPDs, using plastic base material instead of glass, or extremely thin glass, which can change shape without breaking. As in these results, we are recently seeing newly introduced foldable smartphones from several manufacturers and widely adopted by users.

The obvious changing trends in display technology are products getting thinner and lighter and flexible display devices. There is a common trend for higher resolution and pixels per inch (PPI) and increasing screen sizes for new display devices. Also, there are continuous developments for brighter, lower reflectance displays for better visibility under high ambient light conditions. Future display trends will continue to be introduced at industry trade shows including Internationale Funkausstellung (IFA) and International Consumer Electronics Show (CES). Some of the newer technologies and finished products are Quantum Dots, curved and flexible displays with higher resolution and higher pixels per inch, Low-temperature polycrystalline silicon (LTPS) and Indium gallium zinc oxide (IGZO) technology, OLED, and transparent display technologies.

Joshua (Yong Hoon) Yoo is a president of Core Insight, Inc. He served on the EOS/ESD Association, Inc. Board of Directors during 2016 – 2018. He is an active member of standard working groups for Process Assessment, EOS Best Practices, High Reliability, Ionization and was a chair of the Flat Panel Display (FPD) working group. He is an expert and technical support for micro contamination and ESD issues in the FPD industry with 25+ years of experience in the static control industry. He holds certification as a Professional ESD Program Manager and iNarte ESD Engineer.

Q: What are the FPD manufacturing details that can be a potential problem for ESD (like defects, glass material properties, etc.)?

Initially, ESD problems were not an issue until a few years ago, but ESD has now become a more significant reason for yield loss due to changes in panel technology, such as higher definitions, fast refresh rates, narrow bezel, and adopting thinner glass substrates, etc. FPD manufacturing processes are similar to semiconductor wafer processes and much simpler. But for economic reasons, the industry has adopted extremely large glass substrates that have greater capacitance and generate more energy compared with 300mm wafers.

During FPD fabrication processes, a variety of charge generation elements can cause static related issues. For example, friction from photoresist coated glass substrate and deionized water spray rinses in the cleaning process causes change generation. There is also charge generation when glass substrates transfer through conveyor rollers between processes. Most ESD damage on glass substrates resembles CDM

damage after semiconductor device testing. A major difference between legacy CDM and ESD discharge on glass substrates is the discharge energy path to ground. ESD phenomena on glass substrates have no ground path and limited current flowing; thus breakdown events occur between metal structures or between thin films that are at different potentials.

Q: How is ESD in the FPD production process controlled? Are there any gaps between ESDA standards?

Most FPD manufacturers have requirements from the Original Equipment Manufacturers (OEM) to follow ANSI/ESD S20.20 or IEC 61340-5-1 standard as factory ESD control guidelines. This is an obvious dilemma for them because their devices aren't wafer-based semiconductor ICs, but glass or plastic substrate-based. Glass substrates can't drain their charge to ground through static dissipative materials as wafers do. Their operating personnel does not touch any items during the manufacturing process. The process is a fully automated in-line system that automatically transfers substrates between processes. ANSI/ESD S20.20 does not address FPD and automated handling equipment within ESD protected areas (EPA).

The FPD manufacturers control their processes based on their own failure and control experiences, not published standard documents. There is no published standard document to describe how to test FPD panels or completed display panel modules that have repeatable results. There is no published standard for requirements for the fabrication process. There are technical gaps and communication issues between FPD manufacturers and OEMs about correct control methods.

Q: What challenges remain?

For semiconductor device qualification, HBM and CDM testing standards are globally accepted and have repeatable results for the electronics industry. IEC 61000-4-2 is a test methodology for completed electronic systems for ESD EMC compliance. For FPD, ESD damage occurs on panels only during fabrication, panels with ICs as sub-system level (module), and completed systems through various ports. None of these failure modes have a detailed explanation or can be tested with methods in technical documents. WG21 – FPD is trying to publish a second Technical Report (TR) that addresses these issues. The first WG21 TR introduced basic ESD issues on FPD. FPD damage mechanisms, testing issues, and factory control documents need to be created based on the ANSI/ESD S20.20 standard. Some of the elements in S20.20 may remain unaddressed, and there may be some additional requirement for display panels, which are glass or plastic substrates.

To create these documents and make them technically correct, the EOS/ESD Association, Inc. invites volunteers and experts who are working in FPD manufacturing organizations and interested in ESD damage on FPD devices.

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