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White Paper

Rapid Strength Assessment Technique for AMLCDs

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Rapid Strength Assessment Technique for AMLCDs

Introduction

Active Matrix Liquid Crystal Displays (AMLCDs) are used throughout the world in various industries while being subjected to a range of loading conditions. Extreme changes in temperature and humidity can wreck havoc on the sensitive layered structure. A slight bend or short distance impact can shatter the paper thin layer of glass, permanently damaging the structure. Due to the constantly changing LCD industry, always moving towards a smaller, faster, and clearer screen, methods need to be developed to quickly assess the life of an LCD. This study focused on characterizing the mechanical strength of an LCD assembly in comparison to a single layer of glass used in the same LCD assembly.

Results

To assess the mechanical strength of an LCD test screen assembly a mechanical bend test was used, both applied force and displacement rate were monitored. With the use of finite element modeling, the critical strength of the LCD assembly and the top cover glass layer can be determined from the force required to break each test specimen. The resulting relationship between the critical strength of an LCD assembly and the critical strength of the top cover glass layer can assist in quickly assessing the life of an LCD.

The assembled LCD test specimens consisted of only the LCD structure without any frame or protective coating. The coating was removed with the use of a razor blade resulting in minor abrasions on the surface of the glass. The top cover glass layer was chemically separated from the LCD structure resulting in no abrasions or other damage to the glass surface. Since LCD screens are coated with a protective polymer any surface flaws, such as cracks, would have occurred during the manufacturing process and would not be the result of handling conditions. The specimens that were mechanical separated were considered to be ‘abraded’ due to the high probability of induced surface flaws.

A load was applied to the center of the test specimens while freely supporting the four corners of the specimens. The loading rate was varied between 0.5 to 50 mm/min to determine if the relationship between the LCD and cover glass strength was rate dependent. From testing, the critical strength of the specimens was found to not depend on loading rate. However the observed failure mechanism was rate dependent. The faster the loading rate the more symmetrical and uniform the cracking pattern. The uniformity of the crack propagation can be associated to the effects of the surface flaws.

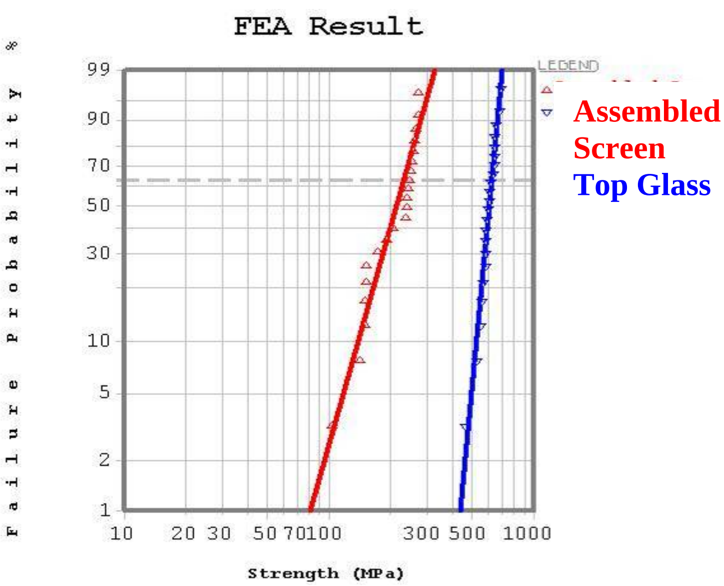

Figure 1: Strength results for assembled LCDs and glass layers.

The critical stresses determined from the finite element analysis of both the assembly specimens and the cover glass specimens are shown in Figure 1. The decrease in strength of the LCD assemblies compared to the strength of the top glass is a result of the ‘abrading’ of the assembly surface.

In a study by Corning Display Technologies[1], the mechanical reliability of the glass panel (top cover glass) was studied along with its direct impact on the LCD

[1] Gulati, S. T. et al., “Mechanical Integrity of an AMLCD Panel” SID Digest, 2005.

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module reliability. A similar loading test was conducted on various glass panels. Comparing the Corning results to results of this study yielded a relationship that can effectively analyze the strength of an LCD while only testing the top cover glass layer used in the LCD assembly. Eliminating the need to test the strength of the entire LCD structure can potentially reduce the time and resources required to test an assembled LCD structure, reducing the time needed to assess new products before public release.

Corning tested glass panels that had been 'abraded', resulting in lower mechanical strength, comparing the strength of these panels to the strength of the 'abraded' LCD assemblies resulted in a very close relationship.

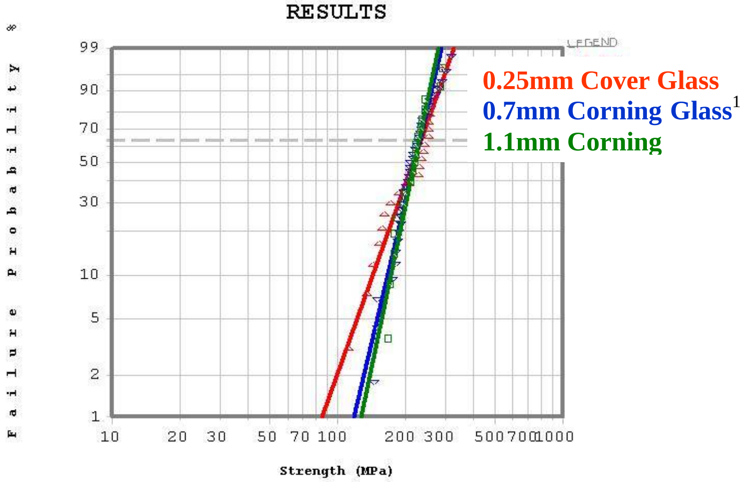

Figure 2: Corning strength analysis – 'abraded' glass

The 'abraded' assembly – 'abraded' glass comparison yielded near identical results, see Figure 2. The characteristic failure stresses range between 230 and 234 MPa, while the Weibull slope had slight variations due to the difference in the 'abrading' technique between this study and that conducted by Corning.

Summary

From the presented analysis it is possible to assess the strength of an LCD assembly or glass panel using a mechanical bend test due to the dependency of surface flaws on the glass strength. The glass thickness was also found to not interact with the critical strength of an LCD. The mechanical strength of glass can be directly related to the probability of finding a surface flaw within the stressed area of testing.

The comparison between the experimental data and the data collected from Corning yielded an useful strength relationship, allowing the strength of an LCD assembly to be compared to the strength of the glass panel used in that assembly. This type of relationship can be used to assist in quickly assessing life of LCDs, which is extremely useful in today's ever changing display industry.

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