Scoring of AMLCD Glass

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Abstract

The scoring process is often used for sizing of glass sheets, the score wheel generates a small crack on the glass surface, which is then propagated through the glass for complete separation. This report will present a description of the scoring process and an interpretation of the marking found on the substrate edges from the point of view of AMLCD fabrication.

Introduction

The scoring process is often used as a reliable and inexpensive method for sizing of glass sheets. Glass substrate manufacturers use it for removing undesirable portions of their formed sheet and for sizing of the glass (mother sheet) to the customers specifications. AMLCD manufacturers use the scoring process to do the final separation of the individual display panels.

Fundamentals of Scoring

In the scoring process, a score wheel is used to generate a median or vent crack in the glass surface. As the wheel rolls on the glass, the median crack is pushed downward and ahead of the wheel. The wheel rides on top of an open crack, forcing the crack open with a wedging action. The scoring wheel penetrates into the glass surface only to a depth of 2-5 µm, yet the median crack typically reaches a depth of 50 - 120 µm. The individual panels are then separated by the application of a bending stress for driving the median crack through the glass thickness.

In addition to driving the median crack along the glass surface, the scoring process results in other changes to the glass surface. The contact stresses imposed by the rolling wheel creates a damage zone 3-7 µm deep. The glass responds to the creation of this region through a combination of plastic flow and brittle failure[1]. The former results in densification of the glass, while the latter results in the formation of microcracks either on, or slightly below, the glass surface. These microcracks can, in turn, form the nuclei for larger cracks known as lateral cracks. Recent work has shown that the presence of these cracks have a significant impact on the edge strength[2]. Extensive lateral cracks may also result in the creation of glass chips. Figure 1 schematically illustrates these principles.

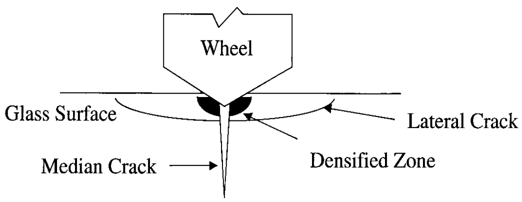

Figure 1. Schematic diagram of a scoring process

For the purposes of cleanly separating the glass sheet, it is the goal of the scoring process to maximize the median crack depth, while minimizing any other damage to the glass. This allows the glass to be separated under the minimal amount of external stress. Unfortunately not all glasses behave the same with respect to the scoring process. Historical conditions, mainly derived from the processing of soda lime glass, are inappropriate for many of the high tech glasses used in the AMLCD industry. Critical parameters to control include geometry, size, and finish of the score wheel, scoring pressure, and scoring technique. Each glass composition will often respond quite differently, even among the relatively closely related glass used for AMLCD substrates.

Much of the crack formation history can be reconstructed from a detailed examination of the glass surfaces created during the scoring and separation processes. This history is an invaluable resource for the identification and correction of process problems.

Characterisitc of a Properly Scored and Separated Edge

Figure 2 is an isometric view of the separated sheet which defines some of the critical features found on a typical scored sheet edge. The contour of the median cracks is created by the texture of the score wheel tip. As the wheel tip wedges the crack open, the non- uniform ground surface pushes on alternate sides of the crack, in essence, turning the crack. This feature, and the orientation of the surface checks, provide a history of the scoring direction. In this figure, the score wheel ran left to right.

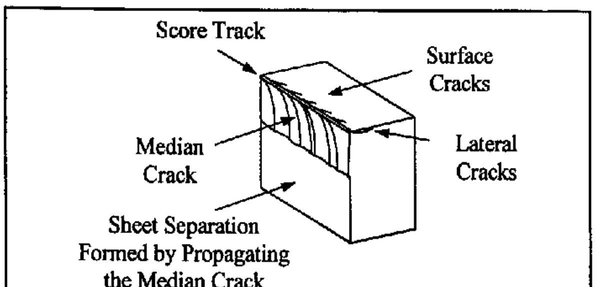

Figure 2. View of the separated glass sheet showing some of the common scoring features.

In an optimum score, the bottom of the median crack should be straight, continuous, unwavering, and parallel to the face (top) surface of the glass. Such a feature indicates the wheel is running freely and true in its holder, and that it has sufficient force and time to complete its wedging action. Below the median crack is the smooth break surface. This region was formed as the sheet was separated. A smooth surface is characteristic of a good quality break.

Characteristics of a Poorly Scored Edge

Poor technique can result in any of a number of scoring problems. Some of the more common include loss of median crack, unstable median crack, off axis median crack, and lateral cracks.

The loss of a median crack can either be temporary or permanent. When it occurs, the score wheel climbs out of the open crack and rolls across the glass surface. Surface cracks then become the dominant defect, which can direct the break off its intended path during sheet separation. Some of the common causes for loss of the median crack include: insulf;cient scoring load, normal wheel aging, binding of the wheel in its tool holder, and glass surface stress. In two axis scoring, the median crack stops and must be restarted at every score intersection of the second axis scores.

Instability of the median crack is a condition where the crack does not propagate uniformly with the score wheel, but instead suddenly jumps forward and stops. An instability condition is caused by an external impact or a sudden break down of the glass under the score wheel. Figure 3 is a schematic diagram of this effect. The instability markings shown in this figure are also called “crack arrest lines” and are indications of this sudden changes in the crack velocity.

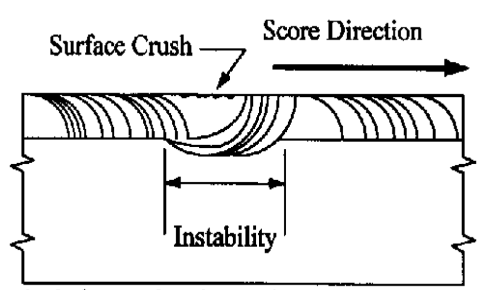

Figure 3. Schematic view of the separated glass sheet showing the condition of median crack instability.

An off-axis median crack occurs whenever the score load is not applied perpendicularly to the sheet face. Whenever this condition occurs a broad shadow is seen below the median crack. In such cases further investigation is an appropriate action to understand the cause.

Lateral cracks occur as a result of residual stress generated in the scoring process. The lateral cracks may remain as a crack in the glass or break out and be seen as glass chips from the scored edge. Their presence is always an indication of scoring problems.

Separation Signatures

The normal technique for separating a glass sheet along a score line is by flexural bending of the sheet. This process applies tensile stress at the top surface of the glass and compressive stress on the bottom surface. This stress drives the median crack through the glass for separation.

As the sheet is separated, the break crack moves from the tensile surface toward the compressive surface. Under these conditions, there is a tendency for the break direction to change and turn as it moves toward the compressive layer. This can create a line of defects on the backside of the glass sheet forining a glass hook. This effect is seen very frequently at the beak initiation and termination points. To keep these defects to a minimum, it is desirable to drive the median crack from one edge of the sheet to the other under the minimal amount of applied stress.

A second defect may be observed when the breaking stress is not perpendicular to the score line. These defects are known as twist hackle[3]. Under these conditions, the median crack is not uniformly loaded and may result in a condition where the separating crack is intermittently twisted away from the line of score. This occurrence will genrate lots of loose chips.

Conclusions

The scoring process is an integral part of the manufacture of AMLCD panels. Optimization of the scoring and separation processes is important to balance possible yield losses from inadequate scoring conditions with the extreme surface damage found on excessively scored glasses. This latter condition can result in a degradation of the glass sheet edge strength by up to 50%. This loss of edge strength, coupled with the severe mechanical stresses encountered in the laptop computer application, could result in field breaks of AMLCD panels. Fortunately, a record of the scoring and separation conditions are maintained on the separated glass face. Careful examination and understanding of this record can aid in the optimization of the scoring and separation process

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