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Application News

No. V30

High-Speed Video Camera

Fracture Observation of Glass in Ring-on-Ring Bending Test

In recent years, number of smartphones, tablets, and other mobile devices using glass has increased. Because these products must possess the strength to withstand external forces due to bending and dropping, adequate strength is also required in the glass. The strength of glass is evaluated mainly by the 3-point bending test, 4-point bending test, and ring-on-ring test. In the 3-point and 4-point bending tests, fracture frequently originates from damage or a defect at the edge of the specimen, and test results obtained in these tests depend on the condition of the glass edge. On the other hand, the ring-on-ring test can be considered to be biaxial 4-point bending test, and testing unaffected by the glass edge is possible. The obtained strength represents the surface strength of the glass, and is called "in-plane strength" [(1)]. The ring-on-ring bending test has been standardized in ASTM C1499. According to that standard, tape is applied to the compressive side of the glass specimen, and the condition of the specimen after the test is observed. Since the validity of the test results is decided based on the result of observation, identifying the point of origin of the fracture is considered critical for evaluation of the glass.

In this experiment, the fracture behavior of strengthened glass in a ring-on-ring bending test was observed using a Shimadzu Hyper Vision HPV™ -X2 high-speed video camera. The HPV-X2 has a recording speed of maximum 10 million frames per second (10 Mfps), which not only made it possible to clearly observe the point of origin of the fracture, but also the detailed condition of crack propagation.

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Measurement System

The fracture behavior of the glass in the ring-on-ring bending test was observed by using an HPV-X2 high-speed video camera and an AGX™-V precision universal testing machine. Table 1 shows the recording equipment. Fig. 1 and Fig. 2 show the recording setup and the condition of the test part, respectively. To enable fracture observation, the inside of the support ring of the ring-on-ring test fixture was hollowed out and a mirror was placed directly under it. The change of acceleration rate during fracture was used for a trigger. A reflective sheet was placed on the upper side of the specimen to facilitate observation of crack propagation. Strengthened glass was used as the specimen, and observation was conducted at a test speed of 5 mm/min and recording speed (framerate) of 5 million frames per second (5 Mfps).

Table 1 Recording Equipment

High-speed video camera	: HPV-X2
Lens	: 105 mm macro lens
Illumination	: Metal halide lamp
Precision universal testing machine	: AGX-V
Load cell	: 50 kN
Test fixture	: Ring-on-ring test fixture Load ring diameter 18 mm Support ring diameter 32 mm

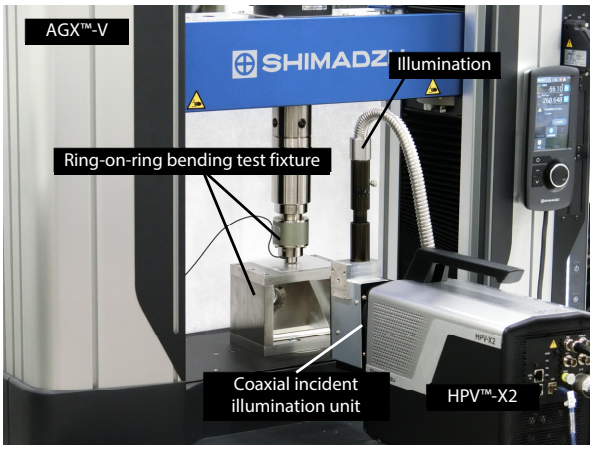

Fig. 1 Condition of Recording Setup

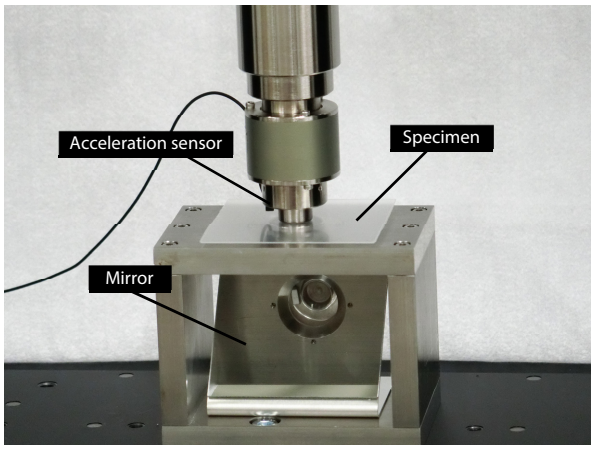

Fig. 2 Condition of Test Part

Table 2 Recording Conditions

Specimen	Recording speed	Test speed	No. of specimens
Strengthened glass	5 Mfps	5 mm/min	2

Measurement Results

Fig. 3 and Fig. 4 show the results of fracture observation of two specimens in the ring-on-ring bending test. In Fig. 3, the origin of fracture is directly under the support ring. On the other hand, in Fig. 4, a condition in which the origin of fracture is on the load ring and the crack propagates from the left to the right side of the figure was observed. In the standard, cases in which the origin of fracture is on the edge of the specimen are invalid.

Conclusion

The fracture behavior of strengthened glass in a ring-on-ring bending test was observed using an HPV-X2 high-speed video camera. Fracture of strengthened glass is difficult to observe because the fracture occurs at an extremely high speed. However, by using the HPV-X2, it was possible not only to designate the point of origin of the fracture, but also to clearly observe the condition of crack propagation.

Reference
(1) Satoshi Yoshida, New Glass, Vol. 28, No. 109, pp. 51-56 (2013)

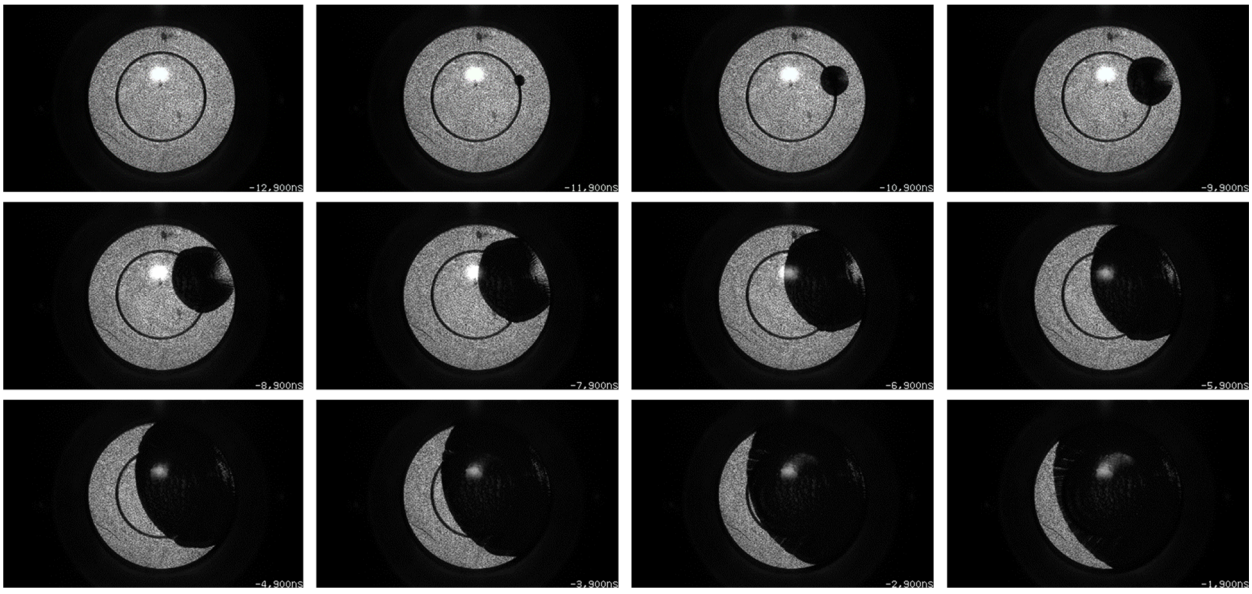

Fig. 3 Fracture Observation in Ring-on-Ring Bending Test (a) (Time Interval Between Images: 1 µs)

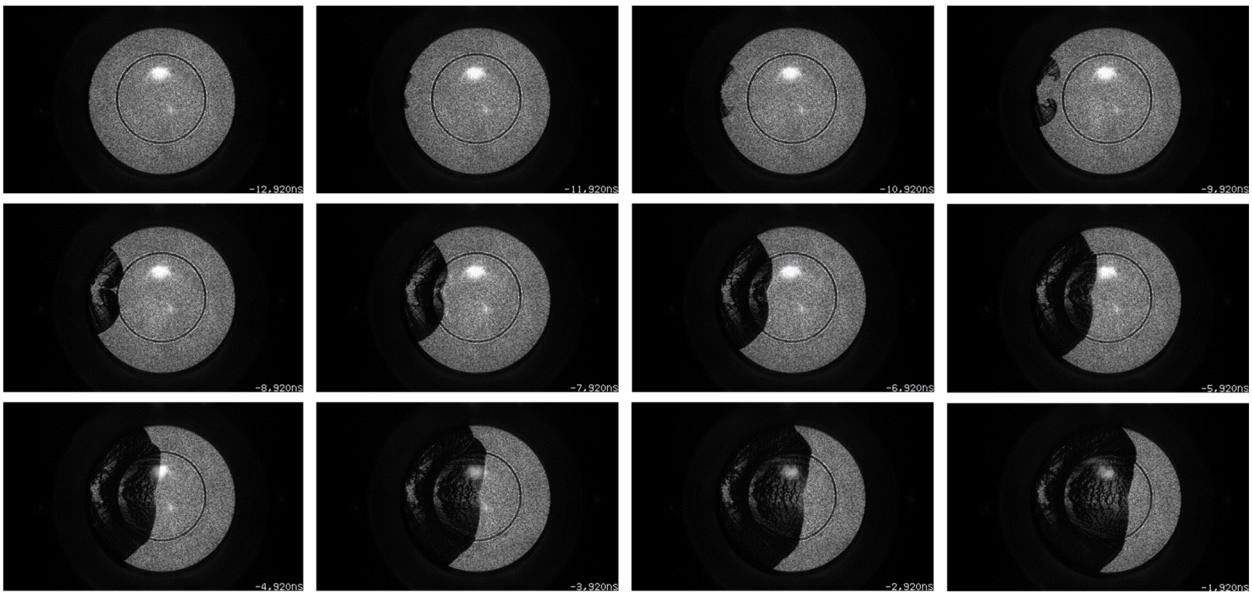

Fig. 4 Fracture Observation in Ring-on-Ring Bending Test (b) (Time Interval Between Images: 1 µs)

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