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Application News

Hyper Vision™ HPV™-X3 High-Speed Video Camera
AUTOGRAPH™ AGX™-V2 Series Precision Universal Testing Machines

Fracture Observation in Glass Ring-on-Ring Bending Tests Using HPV-X3

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User Benefits

- The HPV-X3 high-speed video camera has a resolution three times higher than conventional models, allowing for high-resolution, high-speed imaging.
- The HPV-X3 makes it possible to observe the origin of glass fractures and the propagation of cracks while allowing high-speed imaging at a maximum of 20 Mfps.

■ Introduction

In recent years, glass is being used in a diverse range of applications, including electronics, automobiles, and architecture. For example, smartphone screens and automobile windshields demand high-strength glass, so three-point bending tests, four-point bending tests, and ring-on-ring bending tests are used to evaluate strength. In three-point and four-point bending tests, the results depend on the condition of the edges since cracks at the edge of the test piece can become the origin of a fracture. On the other hand, the ring-on-ring bending test is considered a biaxial four-point bending test, and it can evaluate the 'in-plane strength' of glass without being influenced by the edges. This test is specified in ASTM C1499, and the pass or fail judgment is determined by observing the origin of the fracture on the specimen with tape applied to the compression side. Accordingly, it is important to not only perform the test but also to confirm the origin of the fracture.

In a previous report[1)], the fracture process of strengthened glass in a ring-on-ring bending test was observed using the HPV-X2 high-speed video camera. The newly developed HPV-X3 (Fig. 1) has a resolution three times higher than the HPV-X2, allowing for more detailed observation of glass cracks.

Fig. 1 Hyper Vision™ HPV™-X3 High-Speed Video Camera

■ Measurement System

The fracture behavior in a glass ring-on-ring bending test was observed using a high-speed video camera (HPV-X3) and a precision universal testing machine (AGX-V2). The test equipment is shown in Table 1, and the recording and test conditions are detailed in Table 2. Fig. 2 and 3 show the observation setup and the testing section. The inside of the support ring-on-ring test jig was hollowed out, allowing the fracture to be observed from below the test piece using a mirror placed directly underneath. An acceleration sensor was attached to the load ring to detect changes in acceleration at the time of fracture. This was used as the trigger. In addition, a reflective sheet was placed on the upper side of the piece to facilitate observation of the crack propagation. The test piece was tempered glass, and the test speed was 5 mm/min, with the recording speed set at 10 Mfps.

Table 1 Test Equipment

High-speed Video Camera:	HPV-X3
Lens:	105 mm Macro Lens Teleconverter
Illumination:	Ultra-high output light source SLG-600V
Precision Universal Testing Machine:	AGX-V2
Load Cell:	100 kN
Test Jig:	Ring bending test jig for glass Load ring diameter: 18 mm Support ring diameter: 32 mm

Table 2 Recording and Test Conditions

Recording Speed:	10 Mfps
Test Speed:	5 mm/min

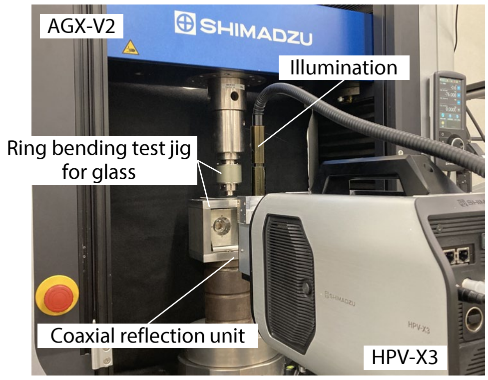

Fig. 2 Observation Setup

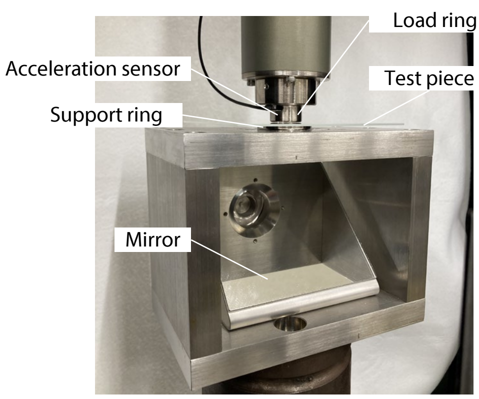

Fig. 3 Test Section

■ Measurement Result

Fig. 4 shows the results of the fracture observation in the ring-on-ring bending test. In (2), the fracture origin on the load ring can be seen, and then, from (3) to (12), the propagation of the cracks can be observed as the circle of origin expands. Fig. 5 compares the images captured with the HPV-X2 in the previous report with the newly captured images taken using the HPV-X3. The image from the HPV-X3 in Fig. 5 is an enlarged view of the crack area from Fig. 4(4). Similarly, the image from the HPV-X2 in Fig. 5 is an enlarged view of the crack area from the previous report. In the HPV-X2 image, the outline of the black circle at the fracture is somewhat unclear. In contrast, the HPV-X3 allows for the identification of cracks radiating from the fracture origin, and it can be seen that the improved resolution enables more detailed observation.

■ Conclusion

The fracture behavior in the ring-on-ring bending test of tempered glass was observed using the HPV-X3 high-speed video camera. The crack propagation speed in glass is very fast, which makes a high-speed video camera with a recording speed of over 5 Mfps suitable for these observations. The resolution of the HPV-X3 has been improved threefold compared to the conventional HPV-X2, allowing for clearer imaging of the cracks. In this way, the HPV-X3 can contribute to the development of glass.

<References>

1) Fracture Observation of Glass in Ring-on-Ring Bending Test, Application News No. V30

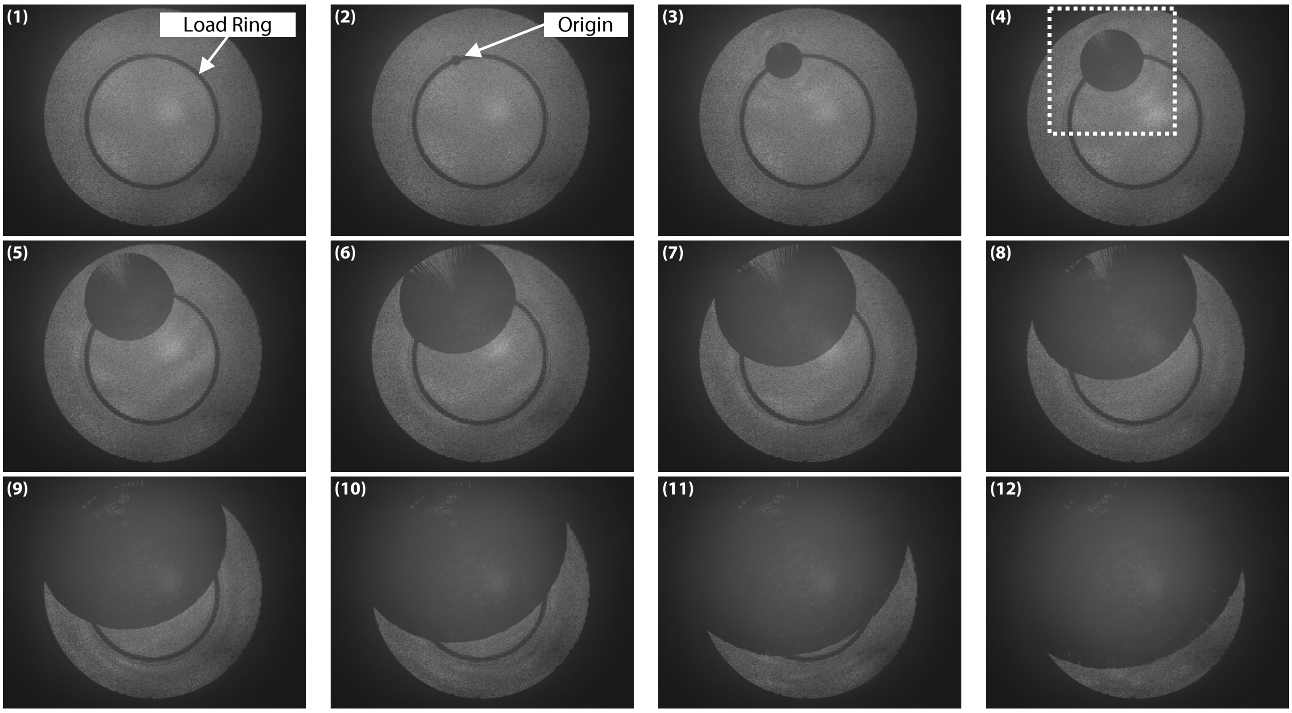

Fig. 4 Fracture Observation in the Ring-on-Ring Bending Test Captured with the HPV-X3 (Time Interval between Images: 1 µs)

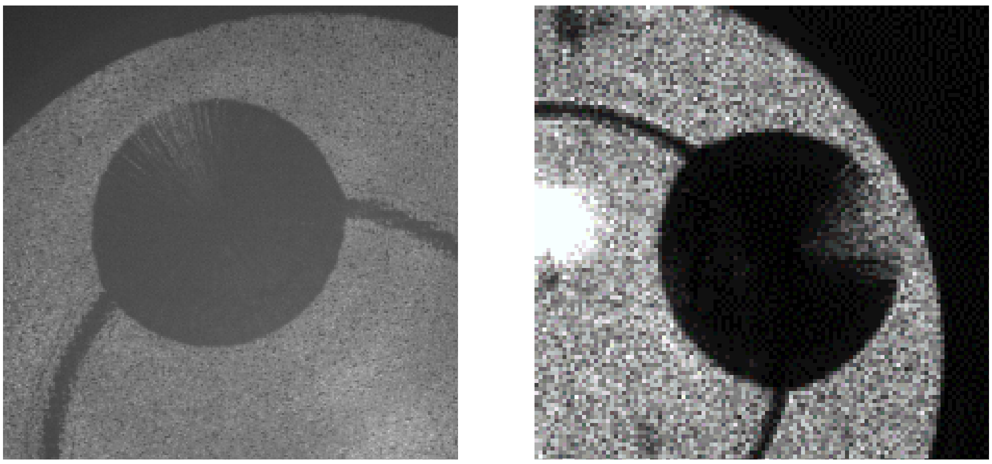

Fig. 5 Enlarged Images of the Fracture Area of the Glass during the Test Captured with the HPV-X3 (left) and HPV-X2 (right)[1)]

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