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Application News

No.V18

High-Speed Video Camera

Observing the Fracture of Unidirectional CFRP in Static Tensile Testing

Introduction

Carbon fiber reinforced plastic (CFRP) is a composite material with a particularly high specific strength. It is used in aircraft and in some transport equipment to reduce fuel costs by reducing weight. While it has some excellent mechanical characteristics as a composite material, when in-plane damage occurs it displays brittle failure behavior, with fracture propagating instantly from the point of damage. Consequently, CFRP development involves not only material testing, but also observation of material failure to check for fracture locations at weak points. Furthermore, material failure is observed to evaluate the validity of computer aided engineering (CAE) recently. As mentioned above, a CFRP fracture event occurs extremely quickly and cannot be observed by the naked eye, so a high-speed video camera is used. Shimadzu has published an Application News on this topic in the past (No. V017 Observing the Failure of CFRP Materials in High-Speed Tensile Tests). High-speed tensile testing involves an instantaneous testing time. To accommodate this, a strobe capable of emitting very intense light instantaneously is used to achieve an image capture speed of over 1 million frames/second. Meanwhile, static testing involves longer testing times with a metal halide lamp used as a light source for continuous lighting (a relatively weak light source compared to a strobe), which cannot produce enough light to capture images at more than 500 thousand frames/second.
The newly developed HPV-X2 camera is 6 times more sensitive than the previous HPV-X camera, which allows it to capture over 1 million frames/second using even a metal halide lamp as a light source. In this article, we demonstrate the observation of unidirectional CFRP failure in static testing.

Measurement

The AG-Xplus precision universal testing machine and HPV-X2 high-speed video camera were used in experiments. The equipment used is shown in Table 1. Observing material failure during tensile testing requires a signal to trigger the high-speed video camera in time with material failure. Since cracks propagate in the direction of the unidirectional fibers when failure occurs in unidirectional CFRP, we attached aluminum foil perpendicular to the direction of the fibers with adhesive. A specimen with the aluminum foil attached is shown in Fig. 1. A break in conduction through the aluminum foil caused by a break in the specimen triggers observation of the failure event.

Results

A view of the test is shown in Fig. 2 and Fig. 3. As shown in Fig. 3, aluminum foil is also attached to the jigs around the specimen in order to focus light onto the specimen. Test conditions are shown in Table 2.

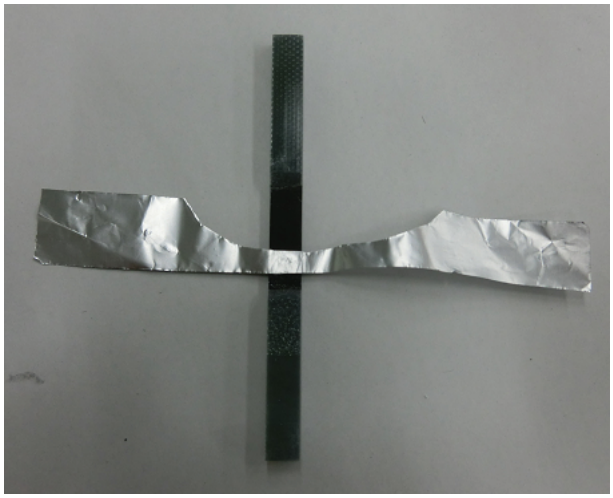

Fig. 1 Test Specimen

Table 1 Testing System

High-Speed Video Camera	: HPV-X2
Lens	: 105 mm, F1.8
Lighting	: Two metal halide lamps
Testing Machine	: AG-Xplus
Load Cell	: 50 kN
Grip	: 50 kN non-shift wedge-type grips
Grip Face	: Trapezoidal file teeth for composite materials
Software	: TRAPEZIUM X (Single)

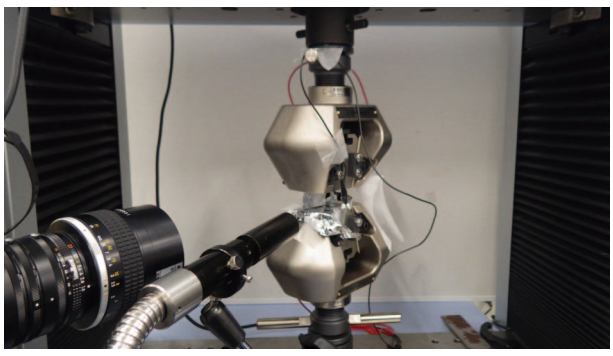

Fig. 2 View of the Test

Table 2 Test Condiions

Test Speed	: 5 mm/min
Recording Speed	: 5 million frames/sec
Specimen Size	: Width: 6 mm, thickness: 0.4 mm
Lamination Method	: $[0]_2$

The failure of unidirectional CFRP is shown in Fig. 4. Longitudinal cracks can be seen on the left side of the specimen in image (2) of Fig. 4. In image (3), these cracks have propagated as far as the upper tab. Longitudinal cracks can also be seen on the right side of the sample in image (3). Image (6) is a later view of the sample as it is breaking apart. Using the HPV-X2 allows for the observation of CFRP failure during static tensile tests, which is useful for future CFRP development.

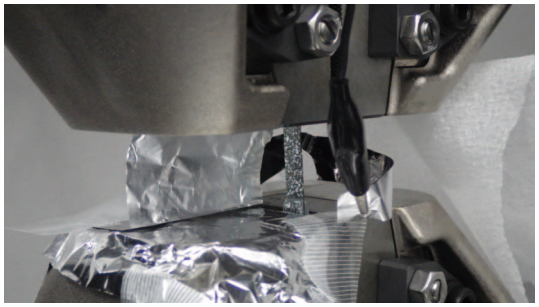

Fig. 3 View of the Test (Magnified View)

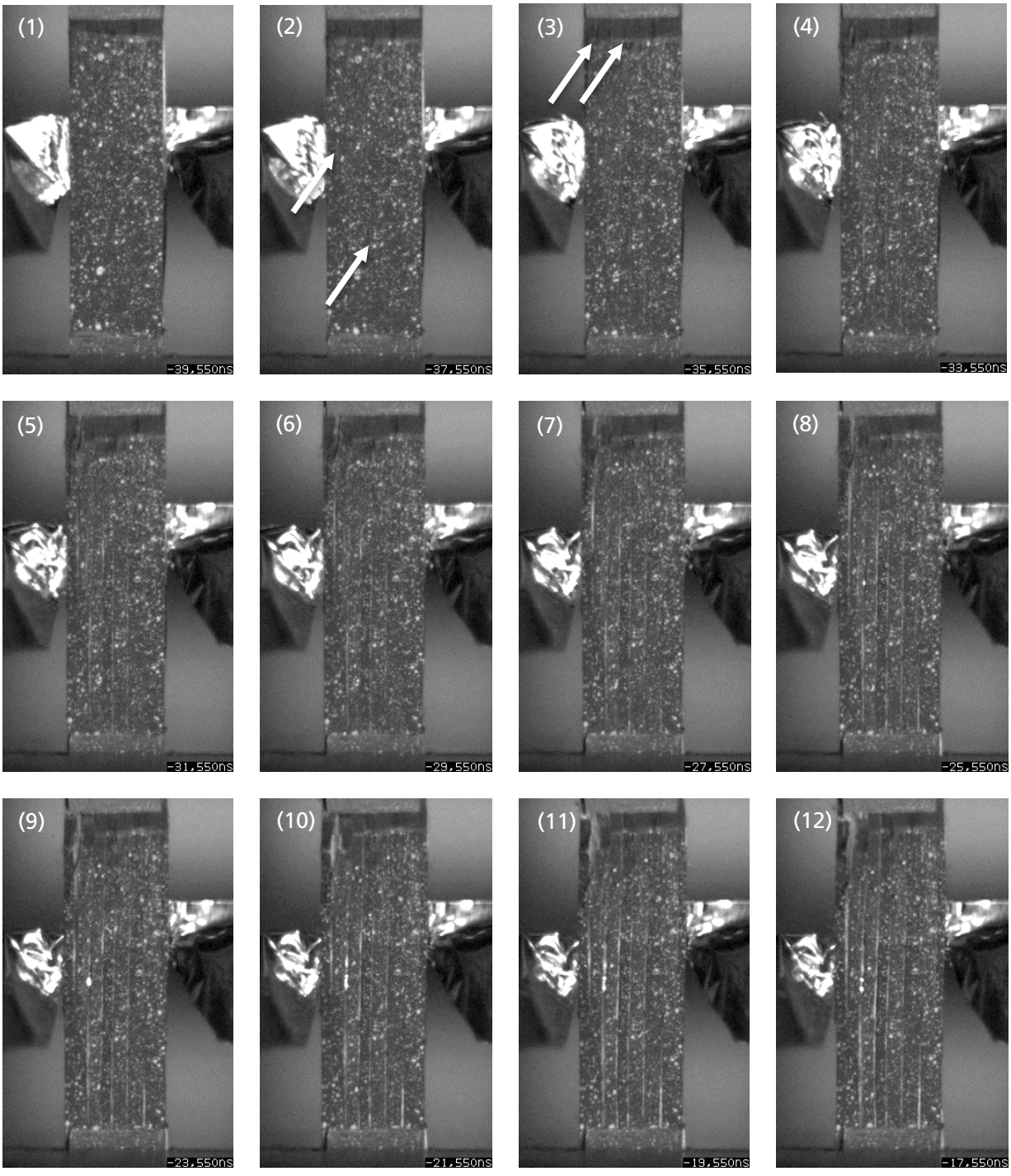

Fig. 4 Captured Images (Interval between captured images is 2 µs.)

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