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Application News

No.i248

Material Testing System

Mechanical Strength Evaluation of Functional Film Used in Smartphones

Introduction

Plastic film is formed into thin film using techniques such as extrusion and stretch molding of the polymer film. A wide variety of products having special characteristics, such as water retentivity, light reflectivity, and selective permeability for specific substances, can be found all around us as industrial products, construction materials, as well as everyday necessities. Recently, a wide range of multi-functional films have been developed which possess a variety of special characteristics designed to provide such functionality as enhanced protection and visibility in display screens for smartphones and LCD televisions. These multi-functional plastic films can also be designed to provide enhanced security, insulation, and light shielding for automotive and architectural glass products.
This paper introduces an example of the strength evaluation of self-repair coating film used on the functional protective film that covers the LCD screens of such products as smartphones and tablets.

Test Conditions

Fig. 1 shows an overview of the test configuration, and Fig. 2 illustrates the structure of the sample. Table 1 shows the test conditions, and Table 2 presents detailed information about the sample.

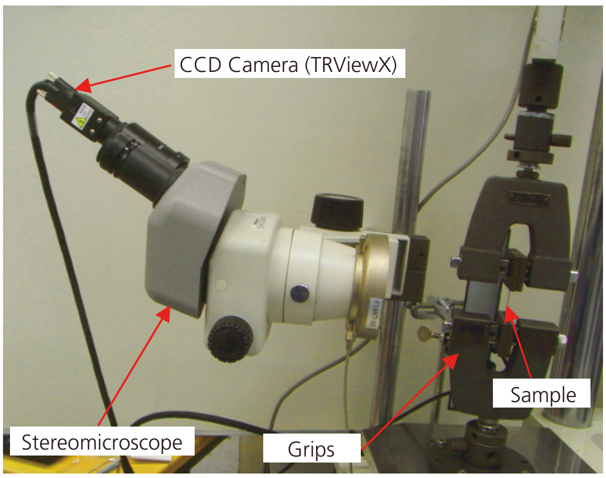

Fig. 1 Test Apparatus

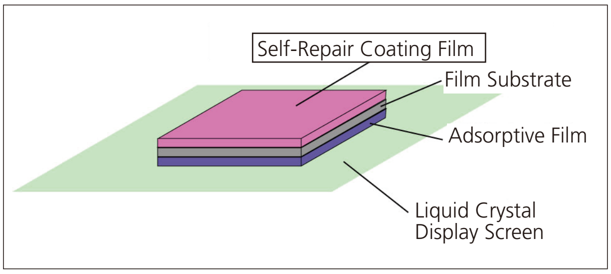

Fig. 2 Sample Structure

Table 1 Test Conditions

Instrument	Micro Autograph MST-1
Test Force Measurement	1 kN load cell
Test Speed	5 mm/min
Grips	1 kN screw type flat grips
Grip Teeth	File teeth
Video Observation	TRViewX Non-Contact Digital Video Extensometer
	Stereomicroscope
Software	TRAPEZIUM X (Single)

Table 2 Sample

Sample (dimensions)	Width 10 mm, length 40 mm (strip shape), thickness 150 µm
	PET self-repair film

To conduct this study, we used the Autograph MST-I micro strength tester with the CCD camera of a TRViewX video extensometer connected to a stereomicroscope to provide non-contact observation of state changes due to a tensile load. The samples evaluated in this study are used as protective film for liquid crystal displays in smartphones. In sequence from the top, the protective film structure includes a self-repair coating film, a film substrate, and an adhesive film for attaching the LCD screen to the protective film.
The non-contact TRViewX video extensometer can record changes in the sample state during tensile testing as an animation, making it possible to easily extract such information as the test force at the instant of deformation as well as the amount of deformation, using a built-in feature referred to as "Point Pick."
This Point Pick feature was used to quantitatively evaluate the whitening phenomenon (appearance of cloudiness in the self-repair film due to the occurrence of countless small cracks) that occurs in the self-repair film at the top of the three-layer functional film sample when a tensile load is applied.

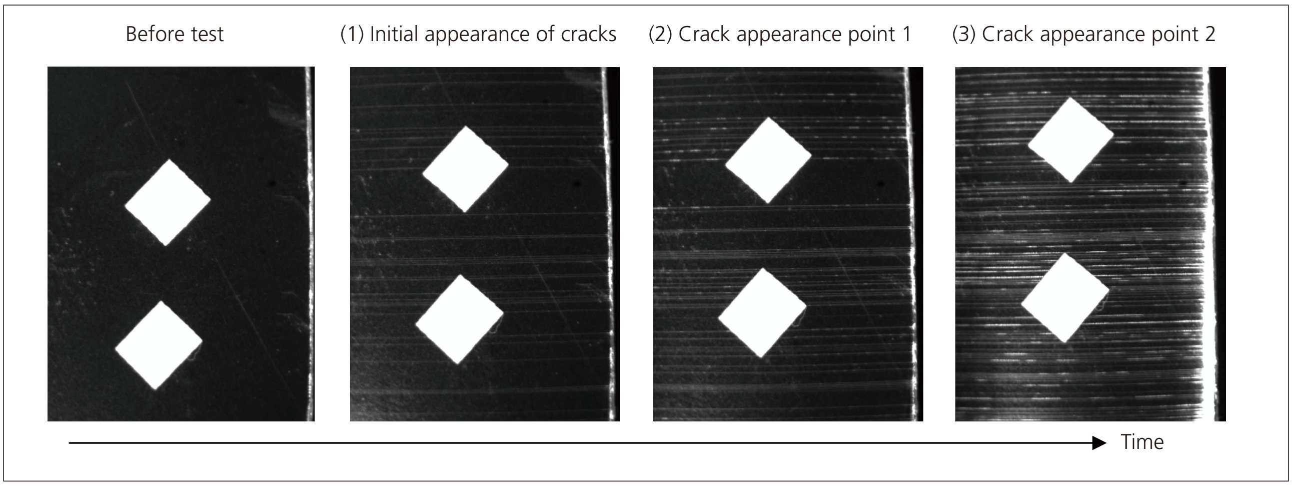

Fig. 3 State of Self-Repair Coating on Sample

Results

Fig. 3 shows the time-course changes in the self-repair coating film at the sample surface that were extracted from the TRViewX tensile test video. Here, the characteristic changes that occurred in the sample at various states during tensile loading are displayed in photographs. The captured states include: (1) Initial appearance of cracks: the point at which localized minute cracks first appear in self-repair coating film, (2) Crack appearance point 1: the point at which the cracks become clearly evident, and (3) Crack appearance point 2: the point at which the cracks become evident over the entire coating film, imparting a whitening effect.

Next, using the TRViewX Point Pick feature, we quantified the test force loaded onto the sample and the amount of deformation that occurred at states (1), (2), and (3) of the self-repair coating film. Fig. 4 shows the Test Force -Stroke curve.

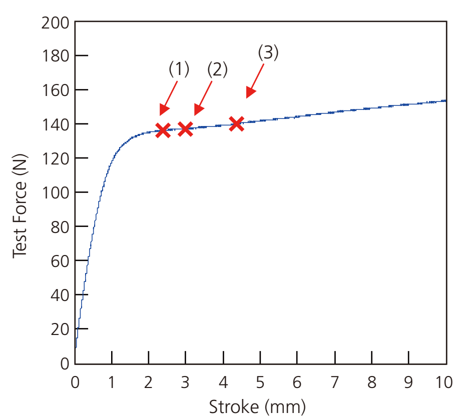

Fig. 4 Test Force - Stroke Curve

Table 3 Test Results

	Test Force (N)	Stroke (mm)
(1)	135.66	2.38
(2)	137.25	2.98
(3)	139.53	4.36

Fig. 4 reveals that the cracks occur in the self-repair coating film after the sample exhibits non-linear behavior - that is, when the plastic region has been reached. It is therefore presumed that the self-repair coating film possesses strength properties that prevent its damage in the elastic region. The cracks in the coating film appeared at about the 135 N load point, and after the cracks became clearly evident at a load point of about 137 N, the cracking suddenly became very pronounced over the range of 137 N-140 N.

From this study, we were able to quantitatively evaluate the strength characteristics of a self-repair coating film in functional film. Therefore, it is reasonable to expect that this test method for evaluating material strength in multilayer structures, previously difficult to evaluate, has the possibility of achieving widespread application, not only for functional films, but also for films coated on various surfaces.

First Edition: Mar. 2013

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