LAAN-A-SB-E002

SHIMADZU

Application News

Material Testing System No.i242

Endurance Testing and Dynamic Viscoelasticity Measurement of EVA Film by MMT-100N

■ Introduction

EVA (ethylene vinyl acetate) film, highly elastic, yet stress crack resistant, is widely used as a film for bonding of solar cells. Solar cells reach high temperatures in the daytime when exposed to sunlight, but cool down at night. This requires that the EVA film has sufficient durability to withstand the daily range of thermal expansion and thermal contraction.

EVA film is also gradually deteriorated with prolonged usage due to the constant exposure to ultraviolet rays during the daytime. Here, we introduce examples of tensile fatigue (endurance) testing and dynamic viscoelasticity measurement of EVA film before and after ultraviolet irradiation.

■ Endurance Testing of EVA Film

Two types of EVA film samples were used for the endurance testing. One type consisted of original film samples ((1), (2), (3)) that had never been exposed to UV radiation, and the other consisted of samples ((4), (5), (6)) that had been exposed to UV radiation for 100 hours. The samples consisted of EVA film strips measuring 40 (L) × 20 (W) × 0.5 (T) mm.
The testing machine and load jigs (grips) are shown in Fig. 1 and Fig. 3, respectively.
The load stress in the endurance testing was set based on the static tensile strength (TS = 9 MPa) of the samples unexposed to UV radiation. These un-irradiated samples showed an endurance of 100,000 cycles at a stress equal to 20 % (1.8 MPa) of static tensile strength. On the other hand, the samples that had been irradiated for 100 hours exhibited an endurance of 100,000 cycles at a stress equal to 10 % (0.9 MPa) of static tensile strength, but broke prior to reaching 100,000 cycles at a stress equal to 15 % (1.4 MPa) of static tensile strength. The results are summarized in Table 1.

Fig. 1 Microservo MMT-100N

Table 1 Results of Endurance Testing of EVA Film

UV Irradiation Conditions	Not Irradiated			Irradiated for 100 Hours		
Sample No.	(1)	(2)	(3)	(4)	(5)	(6)
Maximum load stress (MPa)	1.8	1.4	0.9	1.8	1.4	0.9
Minimum load stress (MPa)	0.9	0.7	0.45	0.9	0.7	0.45
Repetitions before break	100,000*	100,000*	100,000*	139	4,883	100,000*

The * indicates that the sample did not break.

Using the endurance test data obtained for samples (1)-(6), an SN curve was plotted with stress amplitude on the Y-axis, and the number of cycle repetitions before breaking on the X-axis, as shown in Fig. 2.
Based on the data, it can be concluded that ultraviolet irradiation of EVA film is a large factor that significantly contributes to diminished longevity with respect to loading frequency. Therefore, when evaluating the long-term reliability of solar cell products that will be used for long periods, this type of endurance testing is extremely important for assessing the parameters that include both stress due to the temperature effect (daily range of thermal expansion and contraction) and the amount of ultraviolet radiation received.

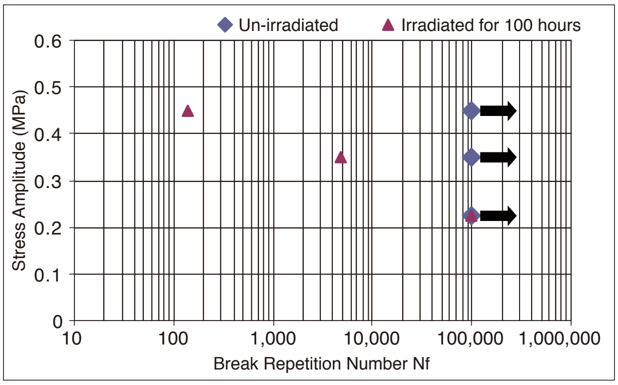

Fig. 2 SN Curve for EVA Film

■ Dynamic Viscoelasticity Measurement of EVA Film

The dynamic viscoelasticity (as indicated by absolute spring constant, storage spring constant, loss spring constant, damping factor, and loss factor) of a sample can be measured using the Microservo endurance testing software. Here, focusing on the storage Young's modulus and loss Young's modulus obtained from the test force and testing machine's piston displacement measured using the number of cycles in the endurance test,we compared the changes in these constants while increasing the number of load cycle repetitions.
Fig. 4 shows the history of the storage spring constant and loss spring constant for samples (2) and (5) from the 100th load cycle onward. At the 100th cycle, the storage spring constant of the sample (5), irradiated for 100 hours, is 25 % smaller than that of the un-irradiated sample (2), and as the number of cycles is increased, they both show a gradual decreasing trend. In addition, the loss spring constant at the early load stage is slightly less in sample (5) than in sample (2), and the degree of the gradual decrease in the loss spring constant is greater in sample (5). Furthermore, the storage spring constant and loss spring constant of sample (2) level off and exhibit a plateau region between 60,000 cycles and 100,000 cycles.

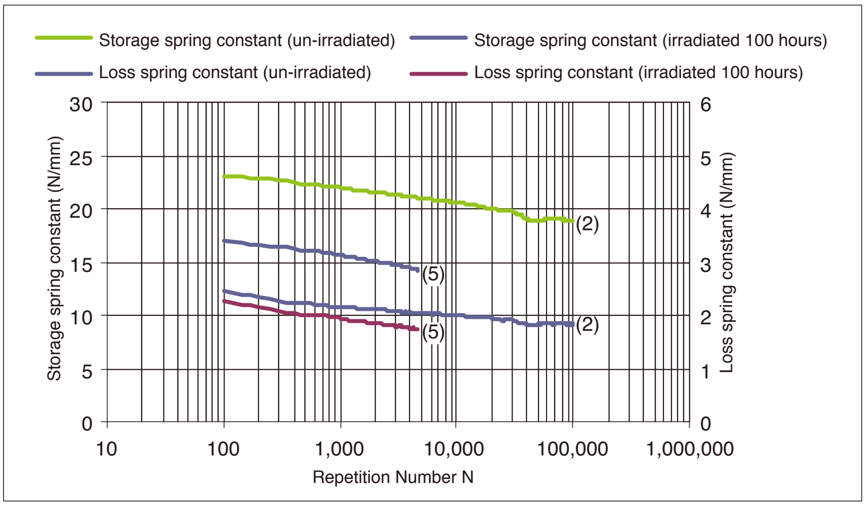

Fig. 4 Storage and Loss Spring Constants of EVA Film

Fig. 3 Grips and EVA Film

Thus, the Microservo is a material testing system that offers simultaneous endurance testing and dynamic viscoelasticity measurement of samples. Since this system adopts an electromagnetic actuator, not only is testing conducted in a green environment, but a variety of evaluations become possible using a temperature atmospheric chamber and other optional attachments.

■ Reference Information

Absolute spring constant $|K^*| = \dfrac{F_0}{x_0}$

Storage spring constant $K' = |K^*| \cos\delta$

Loss spring constant $K'' = |K^*| \sin\delta$

Damping factor $c = \dfrac{K''}{2\pi \cdot \mathrm{Frequency}}$

Loss factor $Lt = \dfrac{K''}{K'}$

The loss angle δ is calculated below using FFT based on the test force and displacement waveform relative to time.

Loss angle $\delta = 2\pi \cdot \Delta t \cdot \mathrm{Frequency}$

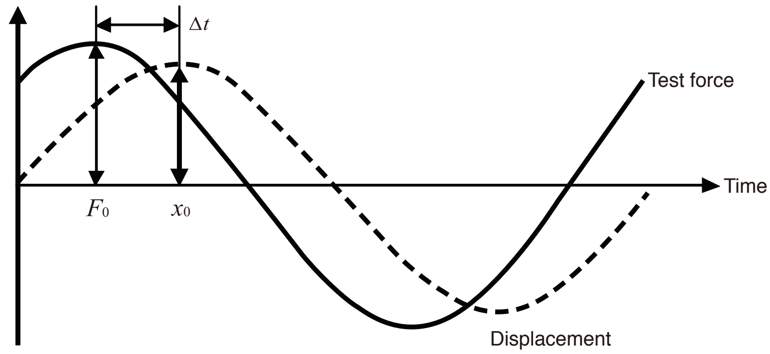

Fig. 5 Test Force and Displacement Waveform

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