Electronic Supplementary Material (ESI) for Soft Matter

Bending creep behaviour of various polymer films analysed by surface strain measurement

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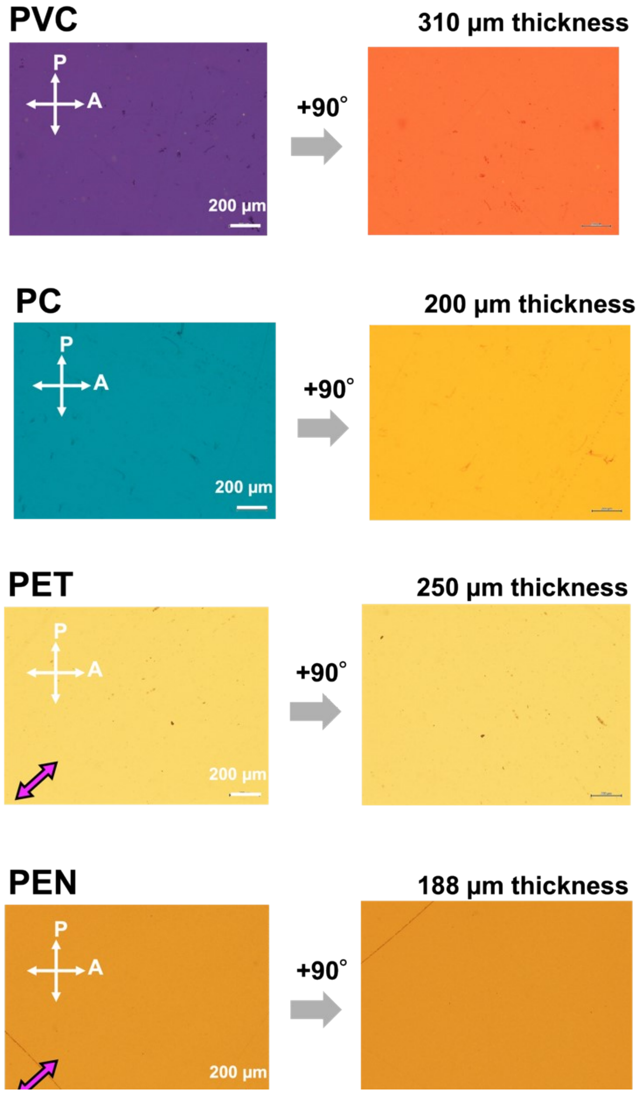

Fig. S1. POM images of polymer films. Crossed white arrows depict the direction of polarizers. Purple arrow represents the optical axis of a tint plate with a retardation of 530 nm.

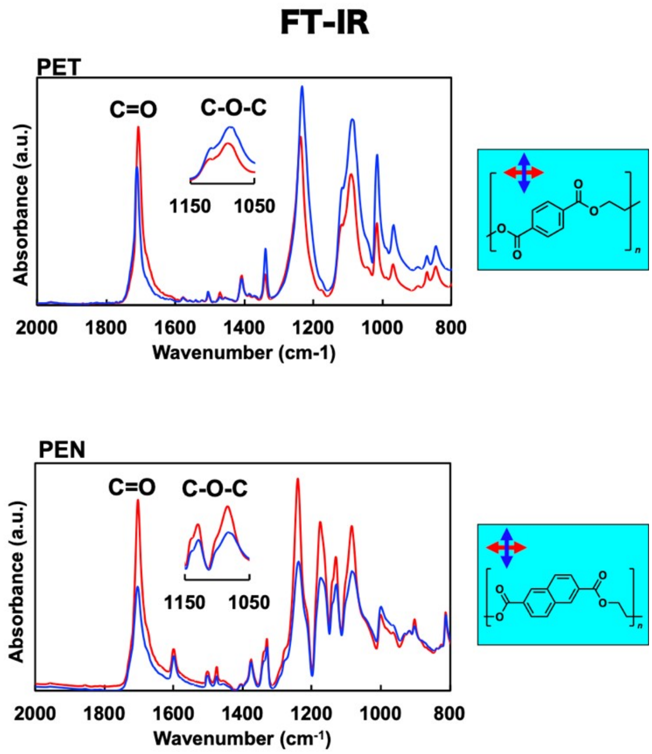

Fig. S2. Polarized IR spectra and schematic illustrations of PEN and PET films according to the optical axes. The red and blue arrows shown on the right correspond to the polarization direction in the spectra.

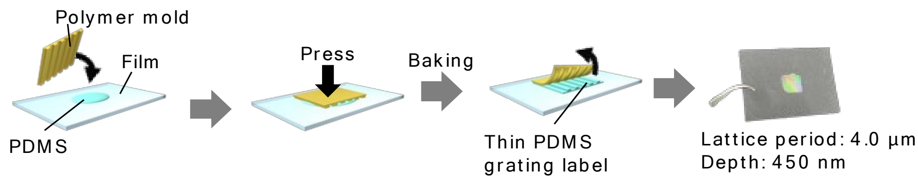

Fig. S3. Preparation of a thin PDMS grating label on polymer films.

Measurement of surface bending strain:

The change in distance between +1 and −1 diffracted beams on a screen (**Fig. S4**) was observed using a charge-coupled device (CCD) camera 2 (**Fig. 1**).

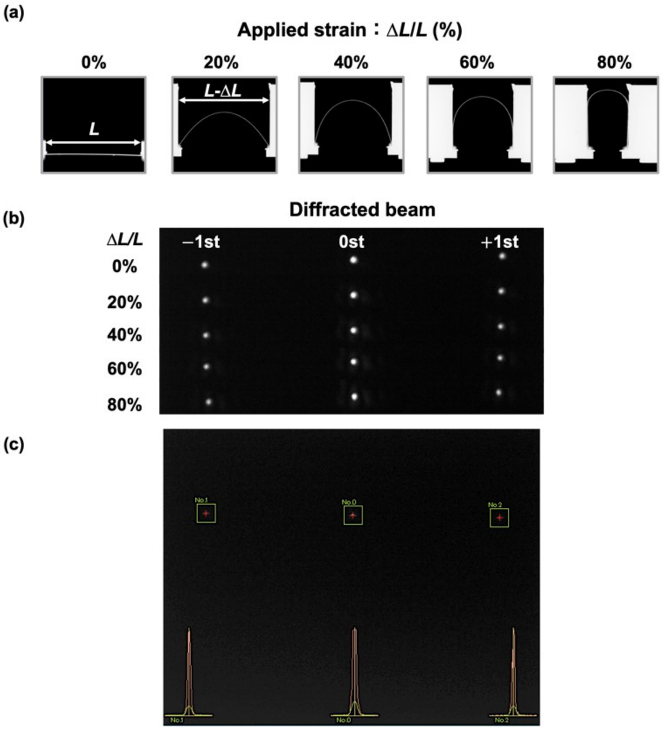

Fig. S4. Film profiles captured by CCD camera 1 during the bending process of a PET film with a 250 μm thickness. Corresponding applied strains ($\Delta L/L$) denote the change in distance (ΔL) relative to the initial distance (L) indicated on the images. (b) During the bending process, images of diffracted and transmitted beams corresponding to the applied strains are observed on a screen. (c) The distance between +1 and −1 diffracted beams on a screen are observed by CCD camera 2. The green square represents the detection area of the beam points, with the brightest point detected, illustrated as red peaks, identified as the position of the beam points.

The surface strain during the bending of the targeted film was calculated from the distances measured using Equations S1, S2, and S3:

$$\alpha = \arctan\left(\frac{D}{2l}\right) \tag{S1}$$

$$\Lambda = \frac{m\lambda}{\sin\alpha} \tag{S2}$$

$$\varepsilon_s = \left(\frac{\Lambda}{\Lambda_0} - 1\right) \tag{S3}$$

where α is the diffraction angle, D is the distance between the +1st and −1st diffracted beams, l is the distance between the films and the screen, Λ_0 is the initial grating period, Λ is the grating period during bending, λ is the wavelength of the laser beam, and ε_s is the surface strain. As the film is bent, l changes. Therefore, l is maintained constant (55.020 mm) using a laboratory-made automatic control system and employed the film profile using CCD camera 1 (**Fig. 1**) to track the changes in the distance between the film surface and the screen.

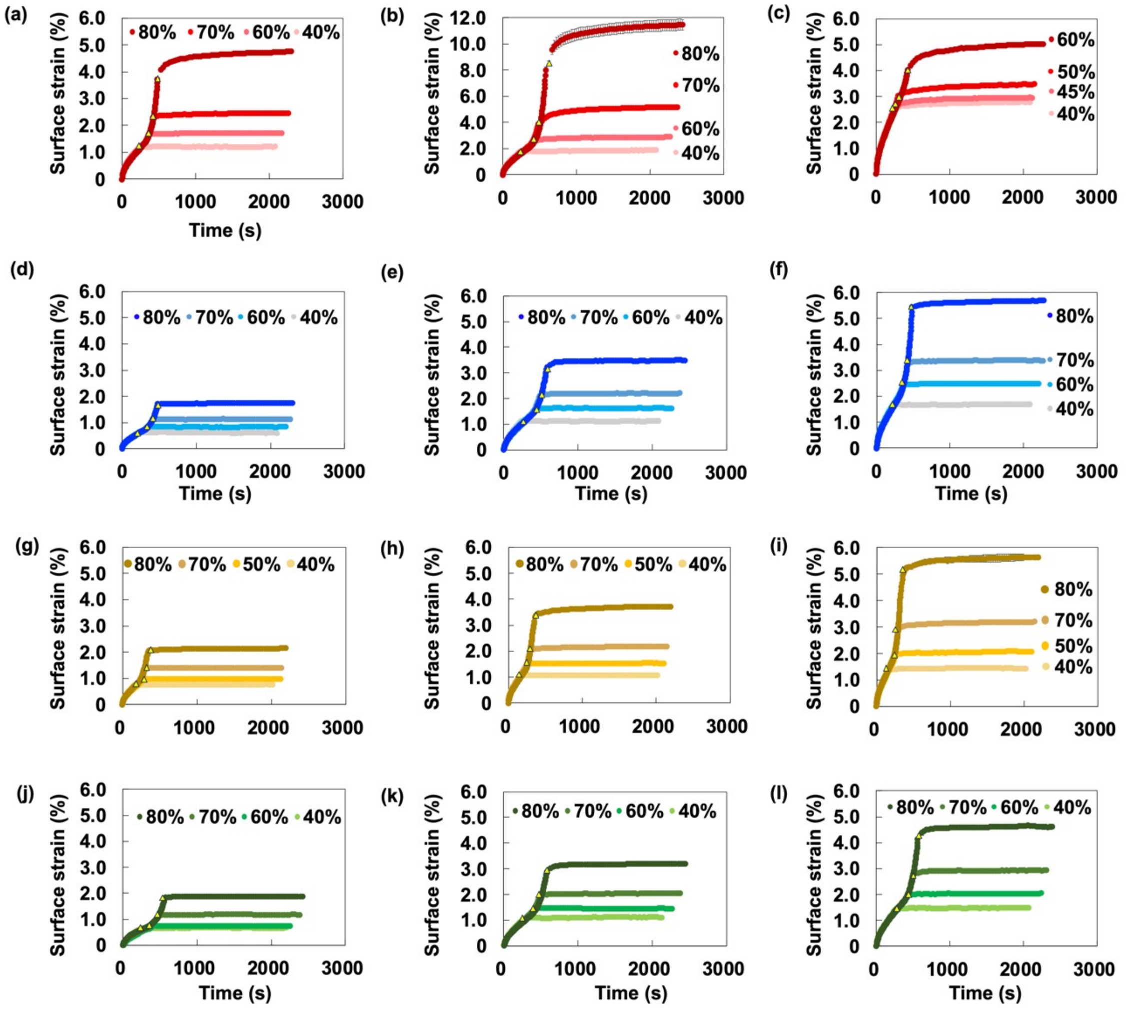

Fig. S5. Bending surface strain of various bending polymer films with different thicknesses at different applied strains. PVC, (a) 200 μm (b) 310 μm (c) 410 μm; PC, (d) 100 μm (e) 200 μm (f) 300 μm; PET, (g) 125 μm (h) 188 μm (i) 250 μm; PEN, (j) 125 μm (k) 188 μm (l) 250 μm. Yellow triangles signify the start of the constant holding state.

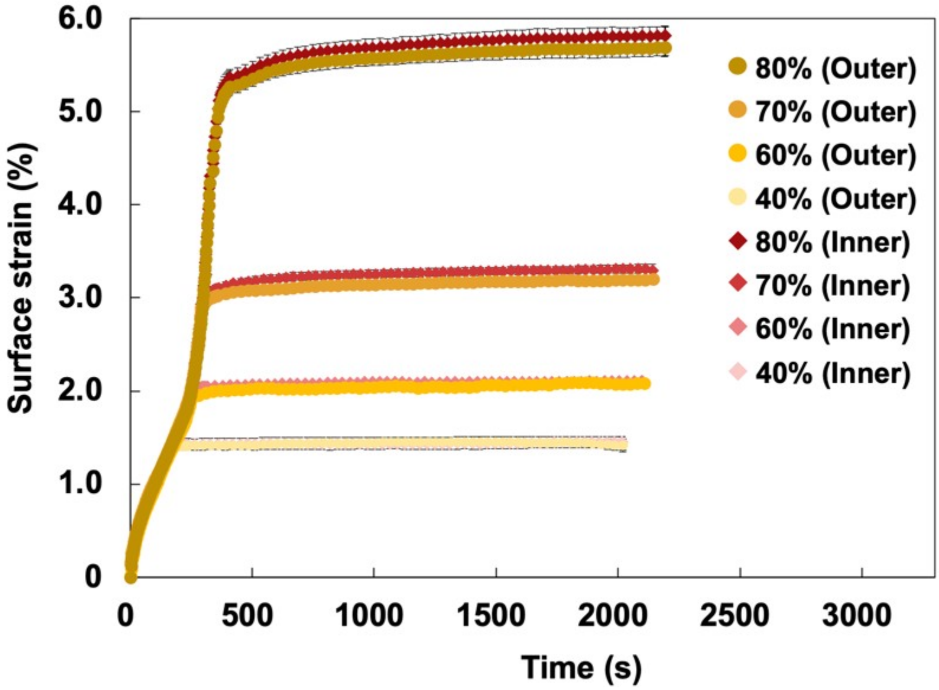

Fig. S6. Bending surface strain of 250 µm thick PET films at different applied strains, measured on both inner and outer surfaces. Circles represent outer surface strain; lozenges denote inner surface strain.

Table S1. Average values of initial surface strain ε_0 (strain immediately after bending) and parameter a (strain increase factor) obtained from the curve fitting of the four-element model on 250 µm-thick PET films at different applied strains $\Delta L/L$.

$\Delta L/L$ (%)	ε_{0_outer} (%)	a_{outer}	ε_{0_outer} (%)	a_{inner}
80	4.86	0.677	4.87	0.683
70	2.89	0.195	2.94	0.263
60	1.96	0.060	2.02	0.062
40	1.41	0.044	1.42	0.018

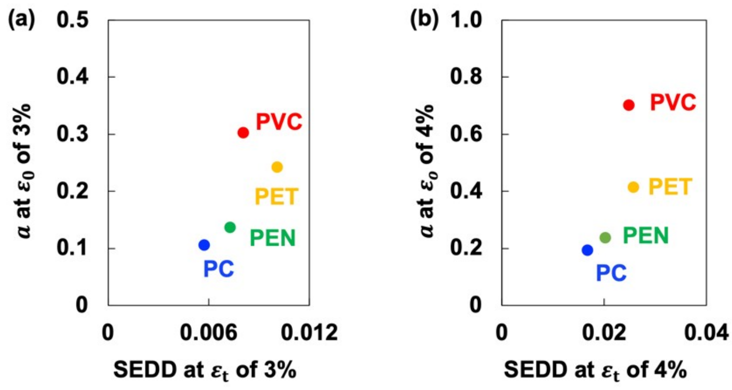

Fig. S7. Correlation between the strain increase factor a and the SEDD at different strains. (a) 4%, (b) 5%, (c) 6%. The value of ε_0 and ε_t represents bending surface strain and tensile strain, respectively.

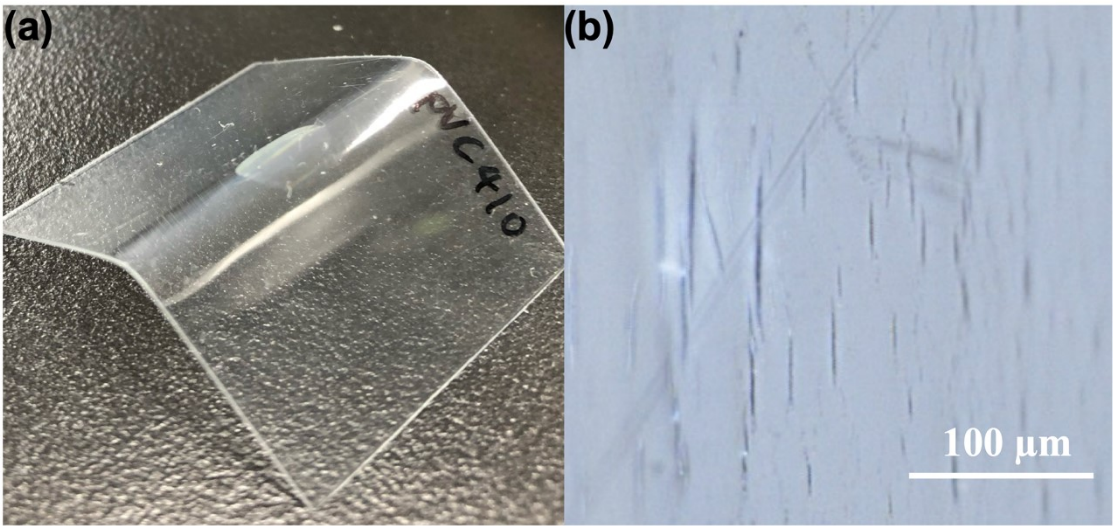

Fig. S8. (a) The bending shape of a PVC film with a thickness of 400 μm after a bending creep test under the applied strain of 70% (b) Microscope image of the center of the crazed polymer film's outer surface.