Electronic Supplementary Information for *Soft Matter* Manuscript:

Mechano-Responsive Lateral Buckling of Miniaturized Beams Standing on Flexible Substrates

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Experimental

Fabrication of 3D Printed Masters and elastomeric beams: We used 3ds Max (Autodesk Inc.) to design masters; the designs are sliced by using a commercial software (Carima Slicer). The 3D master is fabricated using a commercial DLP (digital light processing) 3D printer (Dp110E, Carima Co., Ltd.). After the printing process, constructed structures are rinsed with ethanol to remove the pre-cured resin. Cured structures are exposed to a UVO Cleaner (Model No.42-220-60, Jelight Co., Inc. λ = 253.7 nm, intensity 28~32 mW/cm^2) for 40 min (Figure S3). The mixture of polydimethylsiloxane (PDMS, Sylgard 184 elastomer, Dow Corning) elastomer base and curing agent (10:1 weight ratio) is poured onto the 3D printed master. After removing air bubbles via a vacuum desiccator for 30 min, the PDMS mixture was cured in the oven heated at 60 ℃ for 12 hours. The transparent PDMS structures detached from the master were used to observe the lateral buckling in bending experiments.

Finite Element Analysis: To examine the effect of geometry on lateral buckling, finite element analysis was performed using COMSOL multiphysics software. The original configuration of the initial body was defined as an un-deformed coordinate *X (x, y, z)* in a three-dimensional Cartesian coordinate; displacement vector *u(X)* is also introduced to represent a strain tensor. The material properties needed for calculation are obtained from literature values of PDMS as Young's modulus E = 2 MPa and Poisson's ratio v = 0.49. Assuming the flexure of a beam is under a constant bending moment M, deflection of a beam was due to pure bending. In other words, there is no shear force V at both sides of the beam because $V = \mathrm{d}M/\mathrm{d}y$, where y is the longitudinal axis perpendicular to the direction of shear force. According to the above assumptions, prescribed rotation is applied on a normal plane of bending at both sides of the beam. The rotated angle is 30 degrees and four vertices of the bottom of the beam was considered as fixed boundary conditions (u = 0). Additionally, the structure is meshed to tetrahedral-shaped subdomains for the finite element procedure.

Figures in Supplementary Information

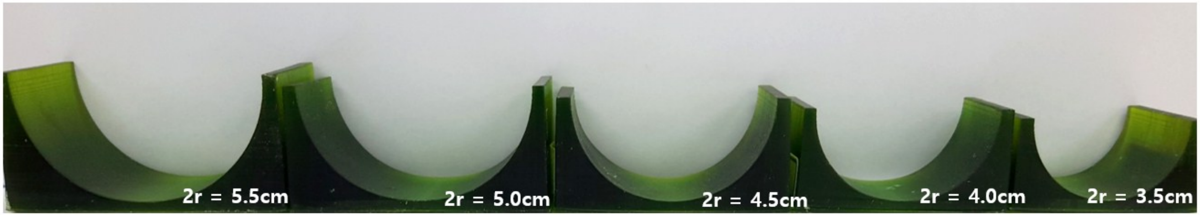

Fig. S1 3D printed recessed holders with changes of radius r.

Calculating the neutral surface of the beam

To define the position of the neutral surface, the centroid of a plane area has to be determined first because the neutral surface passes through the centroid of the cross-sectional area of the body when it is Hookian.

The first moment of inertia Q with respect to x is defined as follows:

$$Q = \int y dA \quad \text{(S1)}$$

where dA is a differential element of area in the x and y coordinate, and the total area A can be represented as $A = \int dA$.

The coordinate $\bar{y}$ of the centroid C is equal to the first moment of inertia Q divided by the total area A:

$$\bar{y} = \frac{Q}{A} = \frac{\int y dA}{\int dA} \quad \text{(S2)}$$

The T-shaped beam shown in fig S2 (a) is symmetric about an axis, so the distance to the neutral surface n_T can be represented as follows:

$$n_T = \frac{pH(H/2) + wh(H + h/2)}{pH + wh} \quad \text{(S3)}$$

To introduce the dimensionless numbers $w' = w/p$ and $h' = h/H$, divide both the numerator and denominator of the above eqn (S3) by pH. Then, we can obtain a final form of the position of the neutral surface in a T-shaped beam as follows:

$$n_T = \left(\frac{H}{2}\right)\frac{1 + w'h'(2 + h')}{1 + w'h'} \quad \text{(S4)}$$

In a similar manner, the position of the neutral surface of the ratchet structure shown in fig. S2 (b) can be derived. One thing we need to consider is asymmetry, so the top edge has to be represented as a linear function such that $f(x) = a + \frac{t-a}{w}(x)$. Thus, the distance to the neutral surface n_R can be represented as follows:

$$n_R = \frac{\int_0^w \int y\,dy\,dx}{A} = \frac{\frac{1}{2}\int_0^w f(x)^2\,dx}{A} = \left(\frac{1}{3}\right)\frac{t^2 - a^2}{t^3 - a^3} \tag{S5}$$

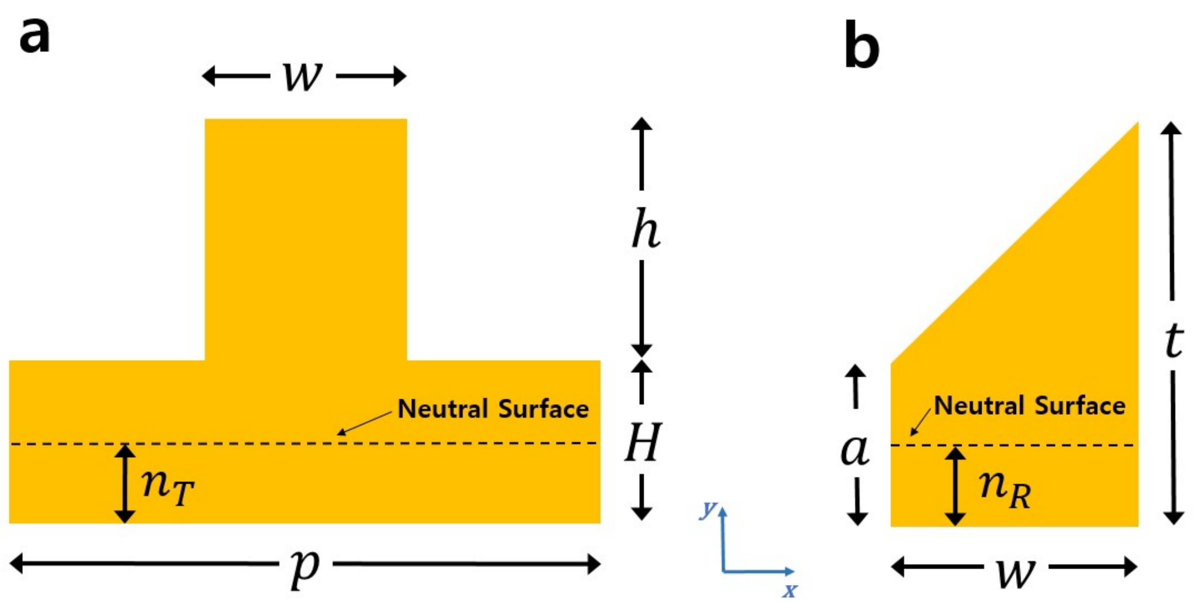

Fig. S2 Schematic illustration of the cross section of beams that are (a) T-shaped and (b) ratchet structure.

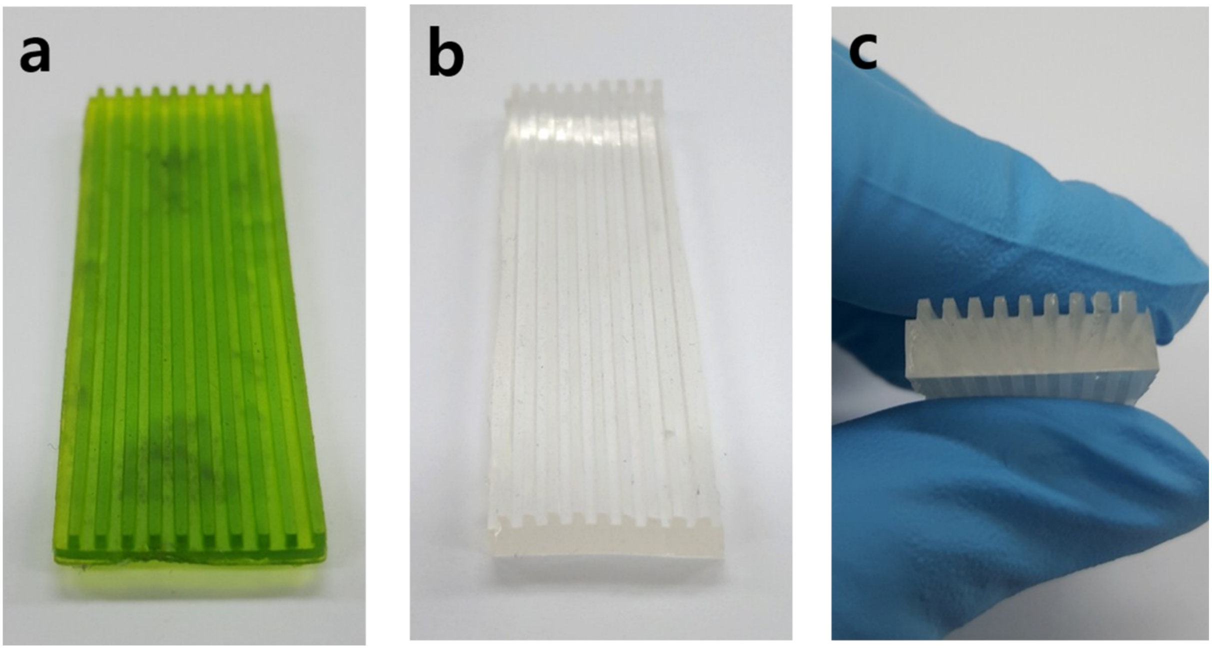

Fig. S3 Images of (a) the 3D printed master for line patterns, (b) the replicated elastomeric beam, and (c) the cross-sectional view of the elastomeric beam.