

Supplementary Materials

Table S1. Mass loss of the shell samples due to the etching. The mass values before and after the etching were averaged by three measurements. Mass loss is calculated by subtracting the mass before the etching from the mass after the etching.

Group No.	Etching site	Sample No.	Mass before etching, mg	Mass after etching, mg	Mass loss, mg
Group A	Periostracum	EA_S1	92.73	92.53	0.20
		EA_S2	100.5	99.9	0.60
		EA_S3	43.80	43.63	0.17
		EA_S4	76.37	76.47	-0.10
		EA_S5	71.17	71.16	0.01
		EA_S6	69.17	68.80	0.37
Group B	Prismatic layer	EB_S1	96.50	96.07	0.43
		EB_S2	83.33	82.87	0.46
		EB_S3	113.5	113.6	-0.10
		EB_S4	101.9	101.6	0.30
		EB_S5	122.0	121.8	0.20
		EB_S6	71.57	71.37	0.20
Group C	Nacre	EC_S1	92.03	91.40	0.63
		EC_S2	87.33	86.17	1.16
		EC_S3	53.60	53.20	0.40
		EC_S4	85.77	85.13	0.64
		EC_S5	61.73	60.40	1.33
		EC_S6	90.13	89.73	0.40

Table S2. Contact area of water droplet on the shell samples of group D before and after the etching. Contact area values before and after the etching were averaged for three measurements.

Sample No.	Contact area on prismatic surface, mm ²		Contact area on nacre surface, mm ²	
	before etching	after etching	before etching	after etching
ED_S1	2.858	2.780	2.897	2.729
ED_S2	3.777	2.869	2.801	3.273
ED_S3	3.139	2.401	3.262	3.027
ED_S4	3.206	2.809	2.765	3.262
ED_S5	2.971	3.368	2.806	2.760
ED_S6	3.250	2.418	2.734	2.985

Table S3. Contact angle of water droplet on the shell samples of group D before and after the etching. The values are averages of the angles from three measurements.

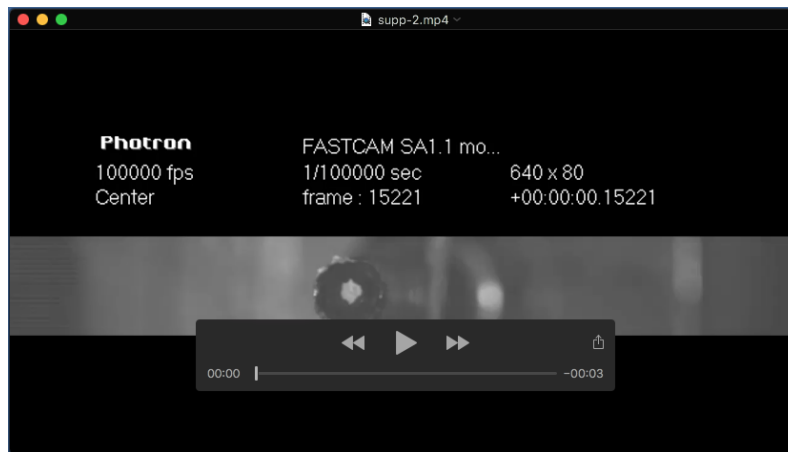
Sample No.	Contact angle on prismatic surface, °		Contact angle on nacre surface, °	
	before etching	after etching	before etching	after etching
ED_S1	61.3	75.5	71.3	73.5
ED_S2	60.1	73.5	69.0	60.8
ED_S3	65.3	76.6	71.2	72.3
ED_S4	61.0	67.8	70.3	65.8
ED_S5	54.9	67.7	63.8	70.9
ED_S6	64.7	78.6	64.1	67.9

Table S4. Static mechanical properties (elastic modulus and strength) of the beam shell samples under the out-in and in-out bending tests.

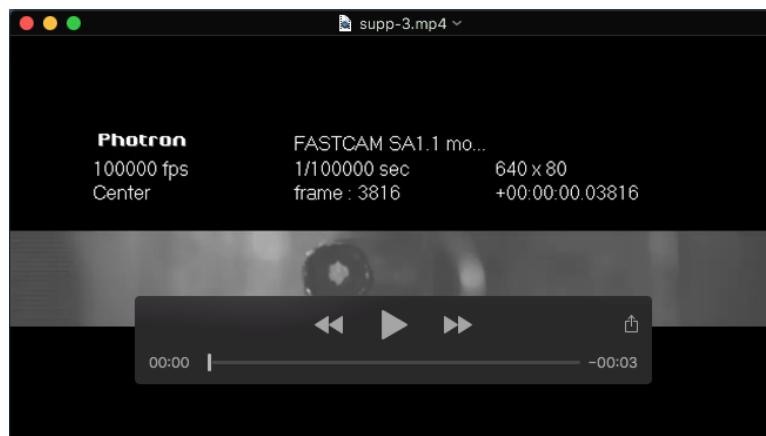
Bending type	Sample No.	Static elastic modulus, GPa	Static ultimate strength, MPa
Out-in	SO_S1	14.7	129.7
	SO_S2	23.2	161.9
	SO_S3	30.3	86.1
	SO_S4	28.4	120.4
	SO_S5	26.1	140.2
	SO_S6	21.3	108.7
	SO_S7	41.2	181.8
	SO_S8	19.3	132.9
	SO_S9	27.3	125.5
	SO_S10	45.3	163.1
	SO_S11	35.0	105.9
	SO_S12	20.0	121.3
In-out	SI_S1	29.2	147.6
	SI_S2	41.3	154.2
	SI_S3	33.2	165.0
	SI_S4	35.3	170.7
	SI_S5	39.1	128.3
	SI_S6	53.9	228.6
	SI_S7	35.2	125.8
	SI_S8	54.4	184.6
	SI_S9	28.6	124.0
	SI_S10	34.3	175.1
	SI_S11	38.2	170.2
	SI_S12	55.0	282.0

Table S5. Dynamic elastic modulus, strength and toughness of the beam shell samples under the out-in and in-out bending tests.

Bending type	Sample No.	Dynamic elastic modulus, GPa	Dynamic ultimate strength, MPa	Toughness, J/mm²
Out-in	DO_S1	3.87	9.66	0.0157
	DO_S2	2.05	12.5	0.0439
	DO_S3	3.34	16.5	0.0609
	DO_S4	2.38	10.1	0.0418
	DO_S5	2.06	8.37	0.0291
	DO_S6	2.17	10.3	0.0504
In-out	DI_S1	1.67	8.02	0.0460
	DI_S2	1.23	6.50	0.0421
	DI_S3	2.23	9.95	0.0391
	DI_S4	3.24	11.6	0.0420
	DI_S5	1.44	8.25	0.0522
	DI_S6	4.13	17.1	0.0747



Movie 1. Typical high-speed video in recording the dynamic out-in bending of shell sample from its lateral view. The shell sample was shown in the middle of the field of view. The loading part of the impact tester translated from left to right in the video. Its velocity values before bending and after sample fracture were calculated by the movement of the white marker on its top surface.



Movie 2. Typical high-speed video in recording the dynamic in-out bending of shell sample from its lateral view. The shell sample was shown in the middle of the field of view. The loading part of the impact tester translated from left to right in the video. Its velocity values before bending and after sample fracture were calculated by the movement of the white marker on its top surface.