Supporting Information


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Text S1. sensing principles of a parallel-plate capacitor and an iontronic capacitor: For a typical parallel-plate capacitive sensor (Figure 1a), its capacitance is defined as $C_p = \varepsilon_0 \varepsilon_r A / d$, where $\varepsilon_0$ and $\varepsilon_r$ are permittivity of vacuum and dielectric layer, respectively, $A$ is the plate area, $d$ is the distance between electrodes. Due to the limited variation of $A$, $d$ and $\varepsilon_r$, the capacitance of such sensor tends to be at picofarad order and is susceptible to noise. By introducing an ionic gel film to work as the dielectric layer, EDL forms at the interface between the gel film and the electrode, yielding ultracapacitance as numerous interfacial EDL capacitors are parallel connected. Specifically, the capacitance of each EDL capacitor could be expressed as $C_{\text{EDL}} = \varepsilon_0 \varepsilon_r A_{\text{EDL}} / d_{\text{EDL}}$, where $A_{\text{EDL}}$ is the EDL area and $d_{\text{EDL}}$ is in an atomic length of scale (~1nm), resulting in sharp increment of $C_{\text{EDL}}$ at least 1000 times than $C_p$. Besides, considering the full contact of the bottom electrode with the gel film, $C_{\text{EDL}}$ on the bottom is extremely huge and nearly will not change when exerted external pressure, thus the total capacitance change depends on the parallel capacitance $\sum C_{\text{EDL}}$ between the gel film and the top electrode. Finally, as $C_{\text{EDL}}$ is proportional to $A_{\text{EDL}}$, the capacitance change is determined by the contact area change between gel film and top electrode interface.
Figure S1. Diagram of the two-stage profile of HSPS (a) and contact behavior of rough-surface electrode and HSPS (R-HSPS) (b).

Figure S2. Fabrication process of HSPS.
Figure S3. Optical images of a HSPS template before(a) and after(b) carbonized residue being wiped off.

Figure S4. Optical microscope pictures (left) and laser 3D images (right) of (a) the screen-printed electrode and (b) the sputtered electrode.
Figure S5. Sensitivity of the iontronic sensor with a rough-surface electrode and a planar gel film under the applied pressure ranging from 0 to 2000 kPa.

Figure S6. Initial capacitances curve under different measurement frequency.
Figure S7. Capacitance change of the sensor fabricated by different processing parameters of (a) power ratios, (b) laser speeds, (c) scanning type and (d) line spacing.

Figure S8. Sensing results of the iontronic sensors fabricated in three different batches.
Figure S9. Simulation results showing the contact process of different electrode-gel groups under 1MPa.

Figure S10. Capacitance response under different static pressures
**Figure S11.** Compressive stress–strain property of the HSPS-based iontronic sensor under 1000 cycles of loading/unloading under a pressure of 1 MPa.

**Figure S12.** Hysteresis of HSPS-based iontronic sensor after cycling loading ranging from 0 Pa to 1MPa.
Figure S13. Real-time capacitance response of the iontronic sensor under different conditions. (a) On the index finger of a volunteer to detect three cyclic bending angles at 30°, 60°, and 90°. (b) On the wrist to detect different touching modes, including fast light pat, slow press, and step press conditions. (c) On a robotic gripper to sense a nut (~ 200mg), a weight (~ 10g) and a tomato (~ 200g). (d) In a wood-ball transport task.
Figure S14. (a) 3 × 4 laser scanning patterns for HSPS templates. The inset shows a single HSPS template, where dx and dy are the line spacing between columns and rows respectively. (b) Schematic illustration of scanning type (st) taking "12-12" for example. In specific, along x-axis (before symbol "-") and y-axis (behind symbol "-"), the odd lines and even lines will be scanned with different passes. "12-12" means that the odd columns will be scanned for one pass while even columns will be scanned for two passes along x-axis; And the odd rows will be scanned for one pass while even rows will be scanned for two passes along y-axis. Intersection-"X", i.e intersection-2,3,4, means that the intersect points of lines have been scanned "X" passes. Based above strategy, the HSPS templates obtained will demonstrate graded distributed concaves.
<table>
<thead>
<tr>
<th>Row</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pr = 80%</td>
<td>ls = 110 mm/s</td>
<td>st = 11-11</td>
<td>dx = 0.5 mm</td>
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<tr>
<td>2</td>
<td>pr = 90%</td>
<td>ls = 120 mm/s</td>
<td>st = 12-11</td>
<td>dx = 0.6 mm</td>
</tr>
<tr>
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<td>pr = 100%</td>
<td>ls = 130 mm/s</td>
<td>st = 22-22</td>
<td>dx = 0.7 mm</td>
</tr>
</tbody>
</table>

**Table S1.** Controlled processing parameters of different groups