Supporting Information

for Small, DOI: 10.1002/smll.201300772

Multiscale Transfer Printing into Recessed Microwells and on Curved Surfaces via Hierarchical Perfluoropolyether Stamps

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Supporting Information

S1. Measurement of surface energy

Table S1. Surface energy measurement on various flat surfaces

<table>
<thead>
<tr>
<th>Material</th>
<th>Surface energy [mJm⁻²]</th>
<th>Polar</th>
<th>Dispersive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOA 73</td>
<td>10.4</td>
<td>42.1</td>
<td>52.5</td>
<td></td>
</tr>
<tr>
<td>PFPE</td>
<td>4.3</td>
<td>11.5</td>
<td>15.8</td>
<td></td>
</tr>
<tr>
<td>Pt</td>
<td>12.9</td>
<td>34.6</td>
<td>47.5</td>
<td></td>
</tr>
</tbody>
</table>

The surface energy (γ) of solid surface was calculated based on the Owens-Wendt method⁴. Table S1 shows the summary of surface energies on various solid surfaces used in this experiment. The measured surface energy of PFPE showed good agreement with the reported data in the literature (γ = 15 mJ/m²)⁵.

S2. Calculation of work of adhesion between Pt/NOA 73 and Pt/PFPE.

Table S2. Work of adhesion between Pt/NOA 73 and Pt/PFPE

<table>
<thead>
<tr>
<th>Interface</th>
<th>Work of adhesion [mJm⁻²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt/PFPE</td>
<td>54.0</td>
</tr>
<tr>
<td>Pt/NOA 73</td>
<td>99.0</td>
</tr>
</tbody>
</table>

The work of adhesion between two solid surfaces was calculated using the Harmonic mean equation, which is given by

\[
W_{12} = \frac{4\gamma_1^d\gamma_2^d}{\gamma_1^d + \gamma_2^d} + \frac{4\gamma_1^n\gamma_2^n}{\gamma_1^n + \gamma_2^n}
\]

Here, the superscripts d and p represent the dispersive and polar components of surface energy, while the subscripts 1 and 2 represent the object 1 and 2 respectively. Table S2 shows the summary of works of adhesion between Pt/PFPE and Pt/NOA 73 systems.
S3. Electromagnetic induction heating with multiscale metal patterns

Figure S3. Photographs showing the change of temperature in an electromagnetic induction heating process utilizing multiscale metal patterns. The inserted temperature indicator (90308-40, TERMAX) changes its color from white to black when the temperature is increased to 54°C. As shown, multiscale Cu patterns (5-μm dot arrays within 500-μm patch) were transferred onto the temperature indicator, and when heated by electromagnetic wave, the color was changed to black. This approach demonstrates the use of multiscale metallic patterns as a microheater component after transfer to a surface or potentially inside a microfluidic channel.


Figure S4. Plot of the critical compressive stress for roof collapse as a function of spacing distance for single- and dual-scale stamps. Here, a simple line-and-space pattern was used for the bottom and upper structures: a line-and-space pattern (width = 150 nm, AR = 1, width/space = 1:1) for the upper structure and a line-and space pattern (width = 100 μm, AR = 1) for the bottom structure.
References

