Supporting Information

Dynamic Defrosting via Spontaneous Dewetting on Nanostructured Superhydrophobic Surfaces

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**Figure S1:** Three different nanopillar geometries were fabricated by etching into platinum masks of initial thickness (a) 5 nm, (b) 10 nm, and (c) 15 nm.

**Table T1:** Geometry of nanostructures in Figure S1

<table>
<thead>
<tr>
<th>Platinum thickness (nm)</th>
<th>Pillar height (nm)</th>
<th>Pillar diameter (nm)</th>
<th>Averaged Aspect Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>850 ± 70</td>
<td>50 ± 10</td>
<td>17</td>
</tr>
<tr>
<td>10</td>
<td>1500 ± 400</td>
<td>200 ± 200</td>
<td>8</td>
</tr>
<tr>
<td>15</td>
<td>2000 ± 700</td>
<td>500 ± 400</td>
<td>4</td>
</tr>
</tbody>
</table>
Figure S2: Top-down light microscopy of subcooled condensate forming on the chilled nanostructured superhydrophobic surfaces (a), (b), and (c) from Figure S1. The Cassie state of the condensate was the most robust on the surface with the highest aspect-ratio roughness (a), as indicated by the high frequency of jumping-drop events, low surface coverage, and delayed frosting. On surface (c), which had the lowest aspect-ratio roughness, jumping did not occur at all, indicating a much more significant extent of drop impalement. This demonstrates that robust, high aspect-ratio nanostructures are required to promote suspended condensation. Movies M9-M11 are also available in the Supporting Information.
Figure S3: Nanostructured superhydrophobic surfaces (a), (b), and (c) from Figure S1 were defrosted by heating to 12 °C. The melt-water was able to dewet most readily for surface (a), due to the suspended state of the frozen condensate (see Figure S2). On surface (c), where the condensate was more impaled, the melt-water was relatively fixed to the substrate with minimal dewetting. This illustrates that the robustness of dynamic defrosting is directly related to the robustness of the Cassie state of the initial subcooled condensate. Time zero corresponds to the beginning of melting as the heater passed 0 °C. Movies M12-M14 are also available in the Supporting Information.
Figure S4: Side-view imaging was used to grow the superhydrophobic frost sheet to a variety of controlled thicknesses before heating the Peltier stage to the desired defrosting temperature. The yellow line indicates the location of the solid interface. Frost growth always occurred at -20 °C.
**Movies M1-M4.** Top-down movies of dynamic defrosting on the nanostructured superhydrophobic surface at 0 °C for frost sheets of thickness 1.0, 1.5, 2.0, and 2.5 mm, respectively (Figure 3). The light source is periodically brought closer to the sample during melting to compensate for the surface’s reduced reflectivity. The field of view is 23 mm × 18 mm and the movies are played at 30X fast forward.

**Movie M5:** Side-view movie of a drop defrosted at 1 °C on a nanostructured superhydrophobic surface that slides off the substrate at a critical tilt angle of 10° (Figure 4). The mobilized drop collected condensate that formed on the surface, leaving behind a dry path. The field of view is 6.8 mm × 5.1 mm and the movie is played back in real time.

**Movie M6:** Side-view movie of dynamic defrosting at 25 °C on a superhydrophobic copper substrate exhibiting a 10° tilt (Figure 5). The field of view is 6.8 mm × 5.1 mm and the movie is played back in real time.

**Movie M7:** Side-view movie of dynamic defrosting at 0 °C on a nanostructured superhydrophobic surface exhibiting a 10° tilt (Figure 6). The field of view is 6.8 mm × 5.1 mm and the movie is played back in real time.

**Movie M8:** MD simulation of dynamic defrosting at 245 K (Figure 7a). The total runtime of the movie corresponds to 8.25 ns.

**Movies M9-M11:** Top-down movies of subcooled condensate forming on the chilled nanostructured superhydrophobic surfaces prior to frost formation (Figure S2). The movies correspond to surfaces with platinum masks of 5, 10, and 15 nm respectively. The field of view is 449 µm × 335 µm and the movies are played at 10X fast forward.

**Movies M12-M14:** Top-down movies of defrosting the nanostructured superhydrophobic surfaces at 12 °C (Figure S3). The movies correspond to surfaces with platinum masks of 5, 10, and 15 nm respectively. The field of view is 449 µm × 335 µm and the movies are played in real time.