**Introduction**

Water droplets can be transported with asymmetric lateral vibrations\(^1\) or with orthogonal vibrations using surface wettability asymmetry\(^2\)[3]. Our anisotropic ratchet conveyor (ARC) system transports droplets with micro-sized hydrophilic surface patterns on a hydrophobic background with a wide orthogonal vibration frequency bandwidth (20 ~ 500 Hz). An active self-cleaning surface is developed using an ARC system to remove surface contaminants with a single water droplet.

**ARC Surface Design**

- Periodic TMS (trimethylsilanol, water contact angle 53°) semicircular rungs are patterned on FOTS surfaces (perfluoro-octyltrichlorosilane, water contact angle 108°)
- Water droplet movement is driven by wetting anisotropic force at the hydrophilic-hydrophobic boundary of the leading and trailing edges

![Figure 1: ARC Design and Function.](image)

**Water Droplet Transport**

- Water droplet moves along the ARC track during each orthogonal vibration cycle and can climb up to 15° inclined surfaces
- Water droplet motion is captured by the high speed camera

![Figure 2: Directional Water Droplet Transport.](image)

**Water Droplet Vibration Resonance Modes**

- Water droplet resonance frequencies depend on contact angle\(^4\):
  \[
  f_j = \frac{\pi}{2} \sqrt{\frac{j^2 \gamma (\cos \theta - 3 \cos \theta + 2)}{24m^2 \cos^2 \theta}}
  \]
  where: \( \theta \) – water droplet contact angle
  \( m \) – water droplet mass
  \( \gamma \) – surface tension
  \( j \) – mode number
- Tested frequency bandwidth: 20 ~ 500 Hz

![Figure 3: Water Droplet Directional Transport under Different Frequencies.](image)

**Application: Self-cleaning Surface**

- Self-cleaning surface is being developed based on ARC surface
- Water droplet is driven in a zig-zag pattern to dislodge the surface contaminants

![Figure 4: Self-cleaning Surface Design and Test.](image)

**Table 1: Materials tested on the self-cleaning surface**

<table>
<thead>
<tr>
<th>Material</th>
<th>Sand</th>
<th>Salt</th>
<th>Sweetener</th>
<th>Pepper</th>
<th>Dry soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be cleaned or not</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

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**References**