DROPLET MANIPULATION USING AC EWOD-ACTUATED ANISOTROPIC RATCHET CONVEYORS

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Introduction

We demonstrate an AC electrowetting-on-dielectric (EWOD) based platform to manipulate water droplets using anisotropic patterning of electrodes, without the need of complex control circuits. Only two electrodes are required to transport the droplet. Different droplet sizes (5~15 μL) have been tested and the droplet transport speed can reach 20 mm/s for 15 μL at 20 Hz external AC frequency. By introducing DC EWOD electrodes, we can perform multiple droplet manipulating functionalities including droplet synchronizing, merging, and mixing, which provides potential applications including active self-cleaning surfaces and lab-on-chip instruments.

AC EWOD System Design

- ❖ Periodic arc or chevron shaped electrodes (metal or ITO) were patterned on the glass substrates
- ❖ Dielectric: SiNx / Top hydrophobic coating: Cytop

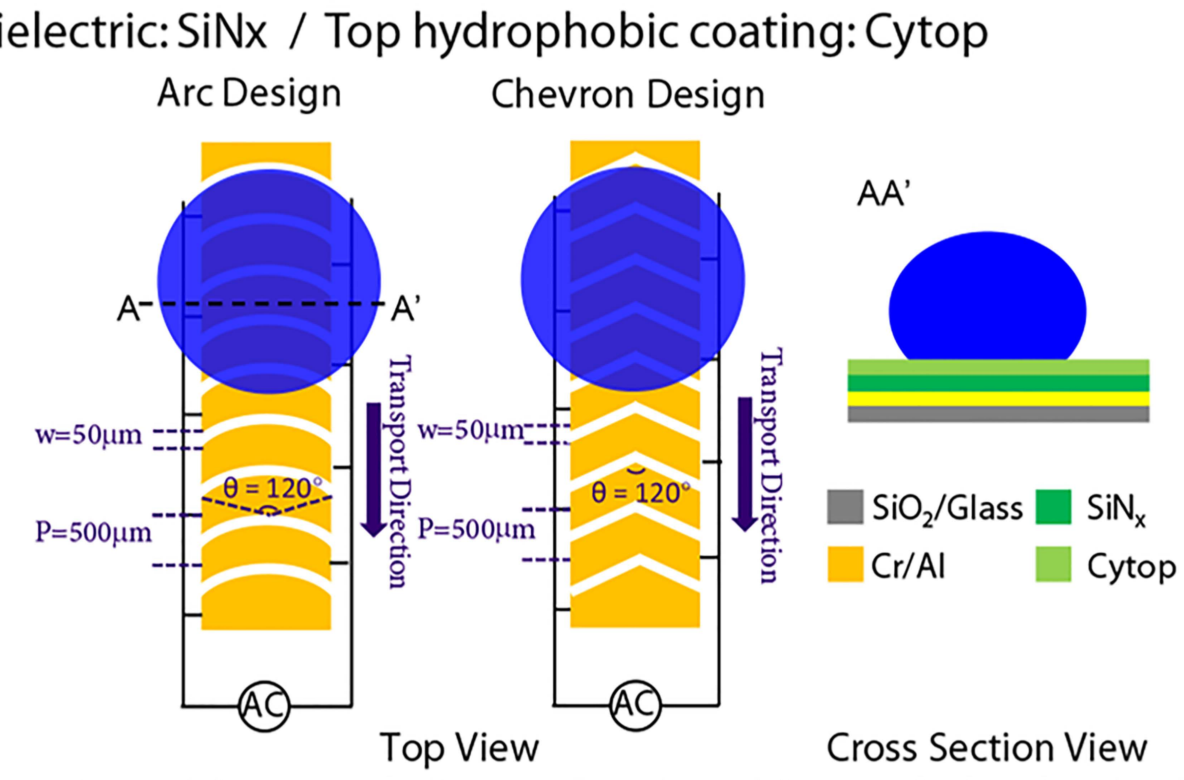

Figure: Top View and **Cross Section View** of the basic AC EWOD system with anisotropic rachet conveyor electrodes.

Droplet Transport Characterization

- ❖ Water droplet size: 15 μL
- ❖ AC voltage: 160V_{pp} 20 Hz sine
- ❖ High speed camera: 1000 fps

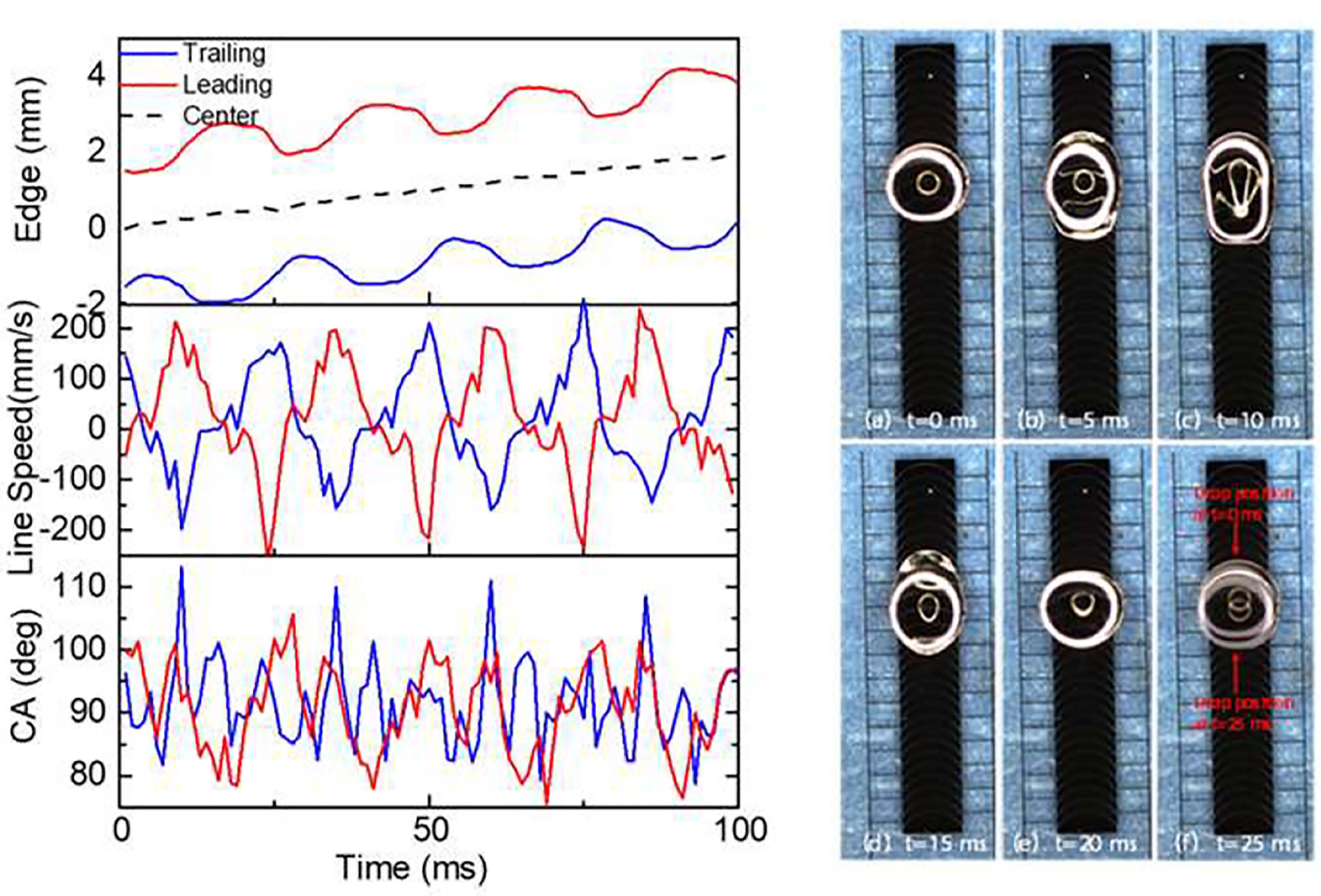

Figure: [Left] Droplet leading edge, trailing edge, edge center, edge line spreading speed, and contact angle change with time; **[Right]** Top view of the droplet (10 μL) transport on ARC surface.

Droplet Transport on Inclined Surface

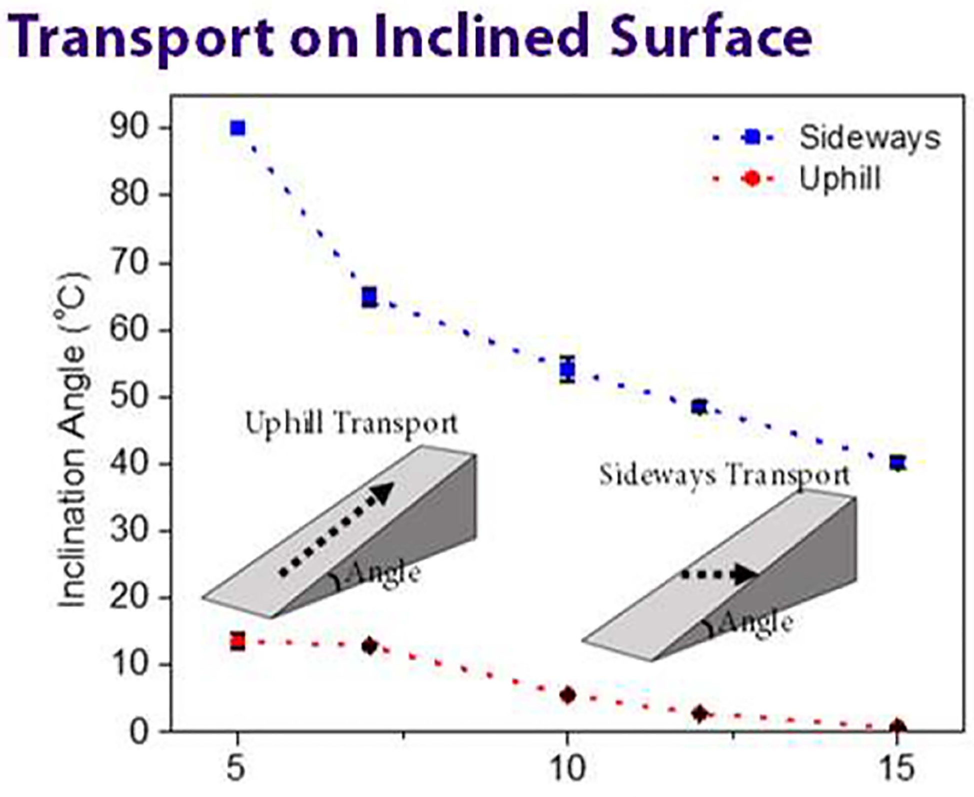

Figure: Test on all-terrain droplet actuation. Maximum surface inclination angle for different volumes (5~15 μL) of droplets to transport on EWOD-ARC electrodes with 240 Vpp 30 Hz sine wave. The droplet can also be transported on and upside down surface.

Frequency Response Analysis

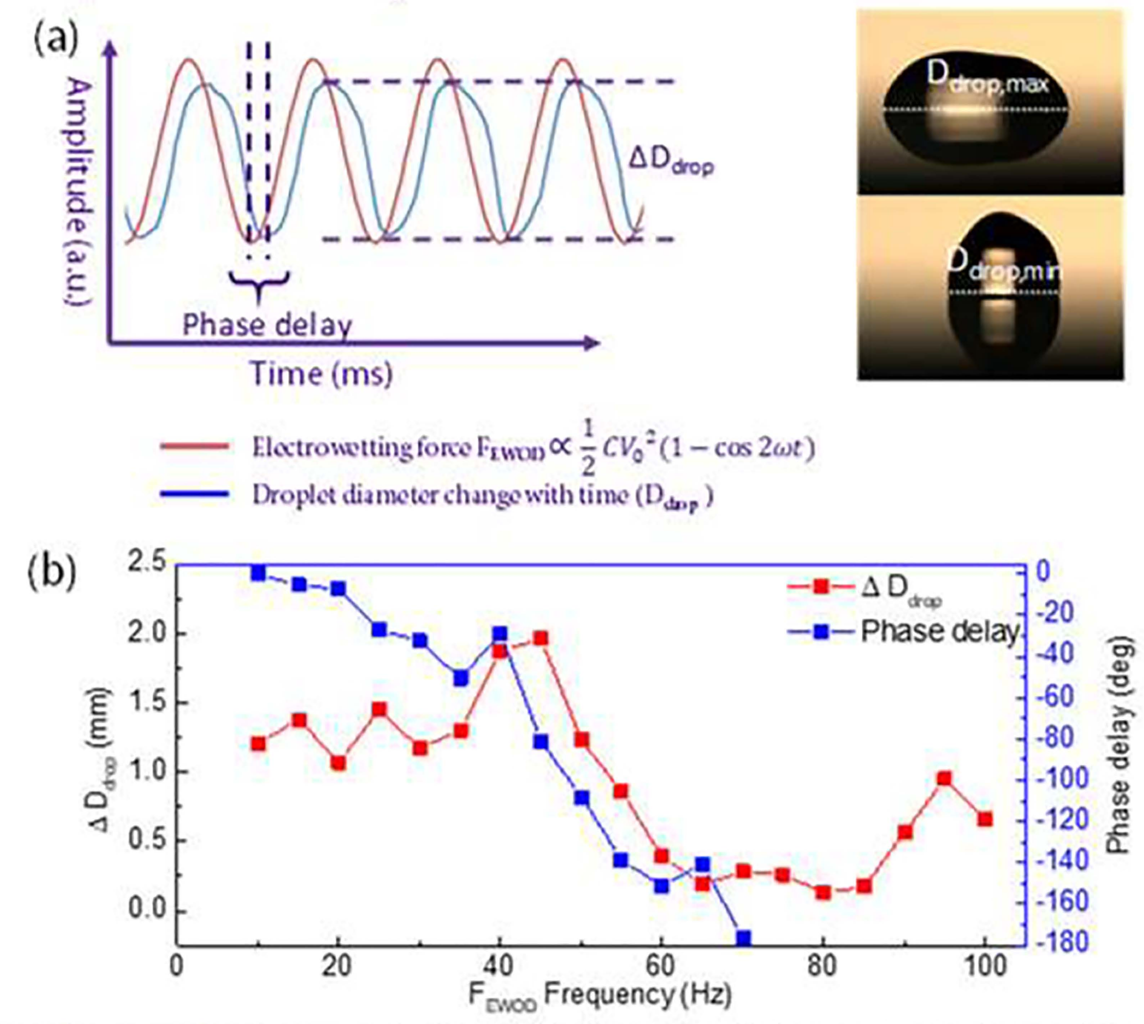

Figure: Frequency Response. (a) Simultaneous plot of change in droplet total width and electrowetting force F_{EWOD}. The pictures on the right show 15 μL droplets when D_{drop} was at maximum and minimum. ΔD_{drop} is the difference between $D_{drop,max}$ and $D_{drop,min}$. (b) ΔD_{drop} and phase delay of the 15 μL droplet plot with time. The resonance frequency corresponds to maximum change in droplet width and a the phase delay close to -90°.

Demo: Lab-on-Chip

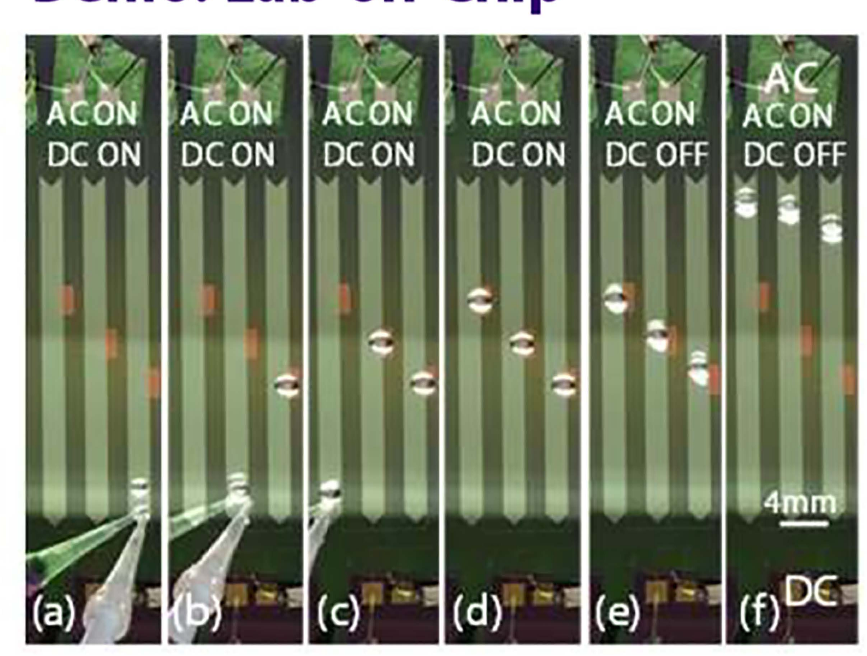

Figure: Droplet Movement Synchronization. DC electrodes were at the bottom layer, separated from the top AC electrodes with a 350 nm SiN_x dielectric layer. Another SiN_x layer and a Cytop layer were coated on top of the AC electrodes.

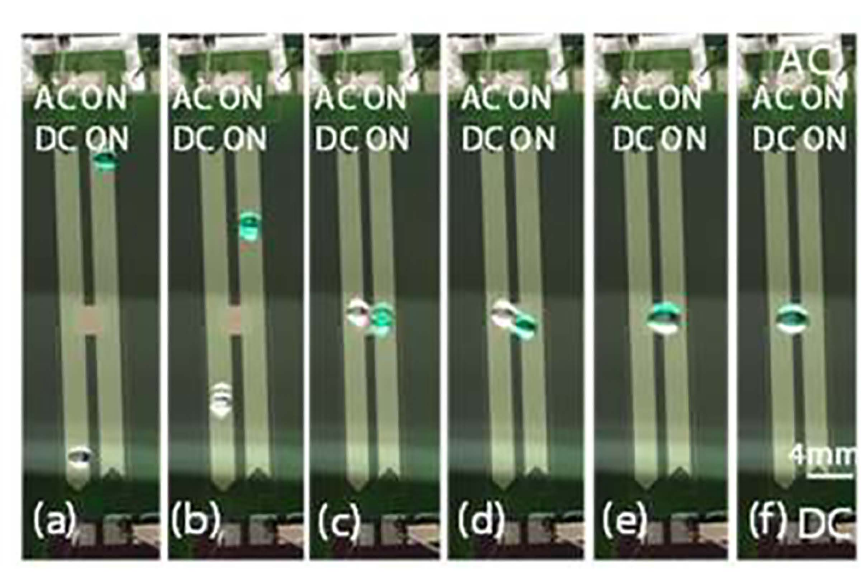

Figure: Droplet Merging and Mixing. The two droplets were first transported by the EWOD-ARC tracks and moved in the opposite direction (Fig. 6(a)-(b)). Then the droplets were trapped and merged at the center by the DC electrodes (Fig. (c)-(d)). The merged droplet continued to be agitated and mixed by the AC signal (Fig. 6(e)-(f)).

Demo: Self-cleaning Surface

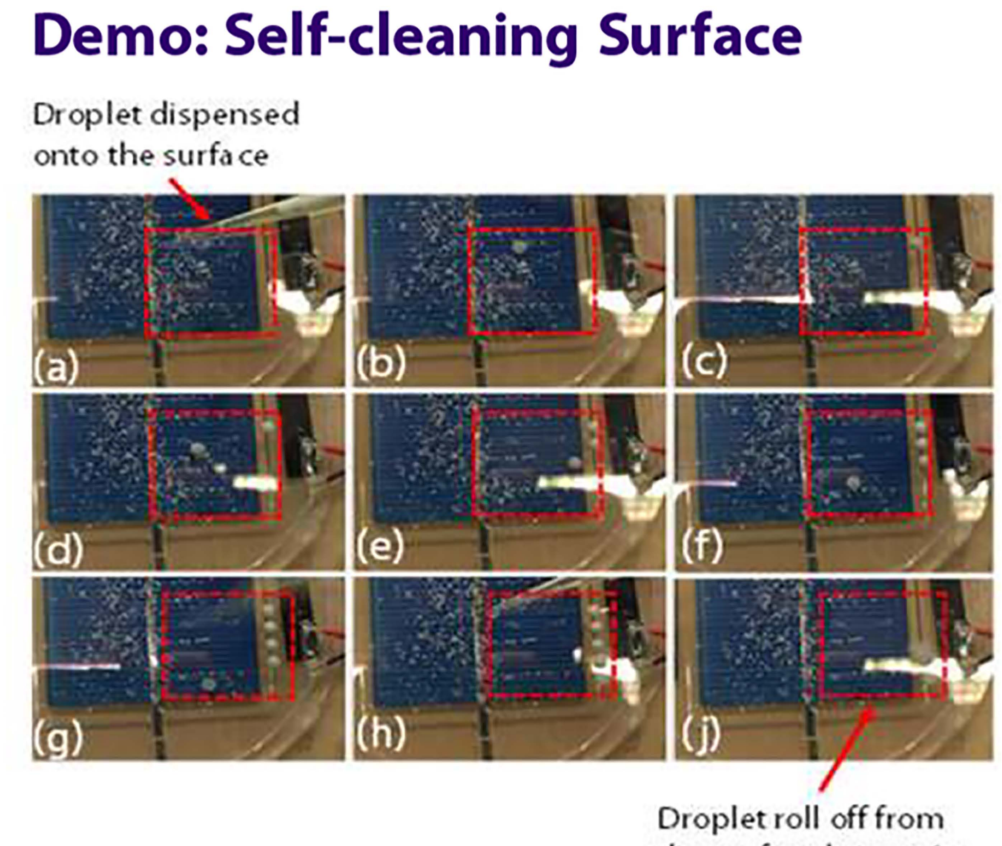

Figure: Self-cleaning Surface Design. (a)-(j) shows sequential images of patterned ARC-EWOD tracks on the solar panel cover glass surface. The red dotted square region (size 1" by 1") is patterned with ARC-EWOD tracks. The entire solar panel sample is mounted on a 30° inclined surface.

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