Supplementary Information for:

Weakly charged droplet fundamentally changes impact dynamics on flat surfaces

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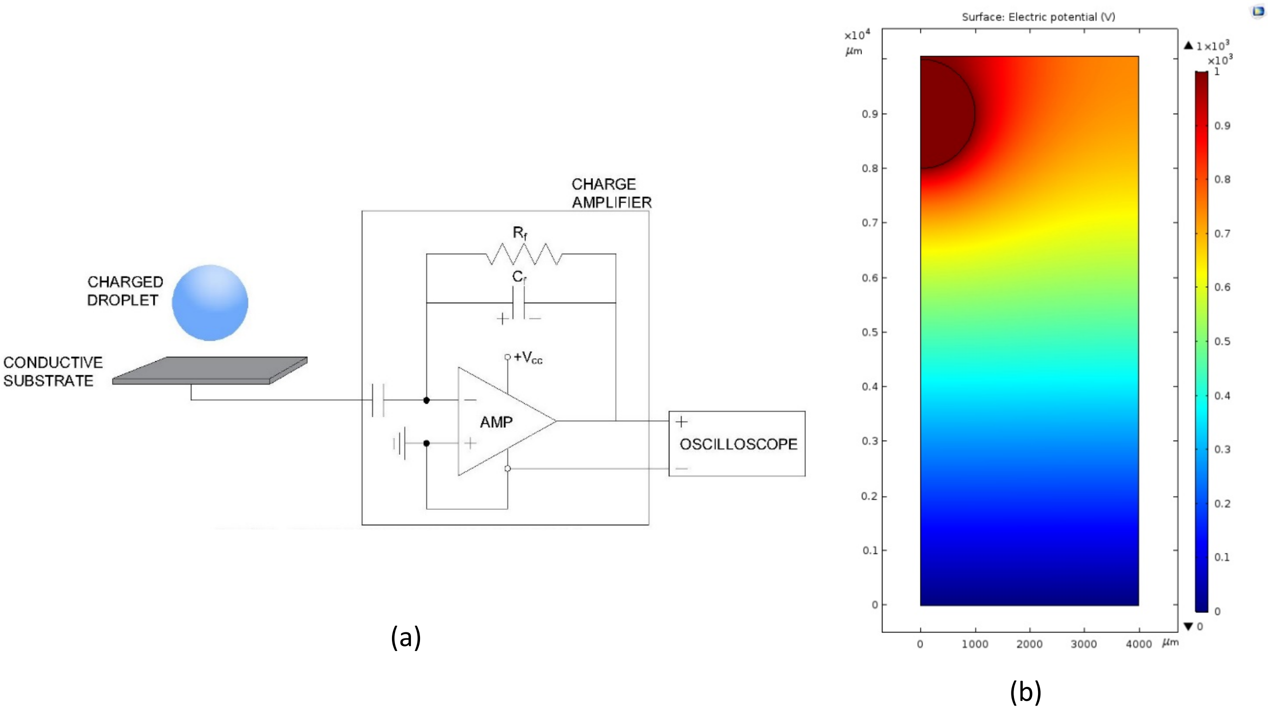
1. Experimental Method of Charge Measurement

We used a charge amplifier (HAMAMATSU H4083) to measure the amount of charge on the droplet. The setup is shown in Fig. S1(a). The gain of this charge amplifier is 0.5V/pC. Every time a charged droplet impacting the conductive substrate, there would be a pulse signal recorded by the oscilloscope. The amount of charge is proportional to the peak of the pulse recorded.

We also used COMSOL to numerically calculate the amount of charge. An example is shown in Fig. S1(b). The droplet is charged at 1kV with standoff distance of 8 mm from the shielding electrode. The amount of charge calculated from the simulation is $0.9 \times 10^{-11} C$, which is comparable to the $1.1 \times 10^{-11} C$ measured by the charge amplifier.



(a)

(b)

Fig S1. (a) Schematic of the charge measurement with a charge amplifier. (b) COMSOL simulation of the electric field. The simulation also provides information of the charge density and total amount of charge of the droplet.

At the early stage of droplet impact on a flat and smooth solid surface, the air pressure underneath the droplet increases rapidly as the thin layer of air is being squeezed out before the droplet wets the surface. This build-up of air pressure flattens or even dents the droplet, forming a nonequilibrium convex lens shaped air film that involves multiple length scales.[1]

The quantitative film profile measurement is carried out using dual color illumination of 460 nm and 650 nm pulsed light emitting diodes (LEDs), which unambiguously determine the absolute film thickness[2, 3]. The measured air film profile shown in Fig .S2 is similar to typical data reported in literature[2, 4-6]

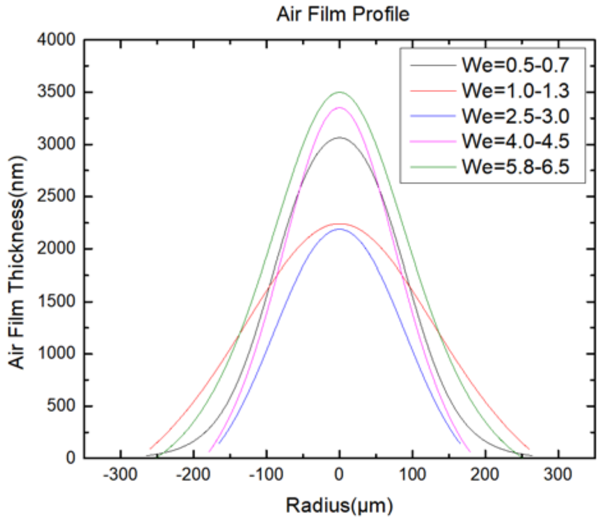


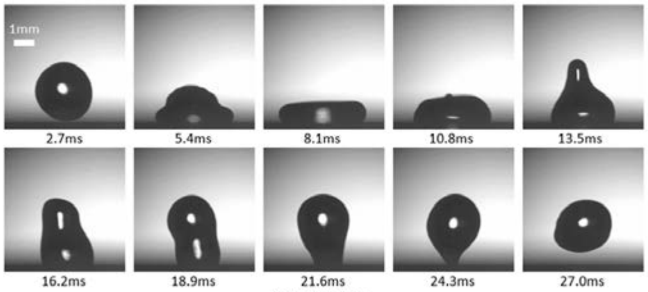
Fig S2. Air film profile measured via dual-wavelength measurement of water droplet (diameter: 2.8mm).

Droplet impact on superhydrophobic surfaces tends to bounce or splash. The droplet contact time on rigid superhydrophobic surface has been studied and was found it is independent of the impact velocity over a wide range of velocities[7]:

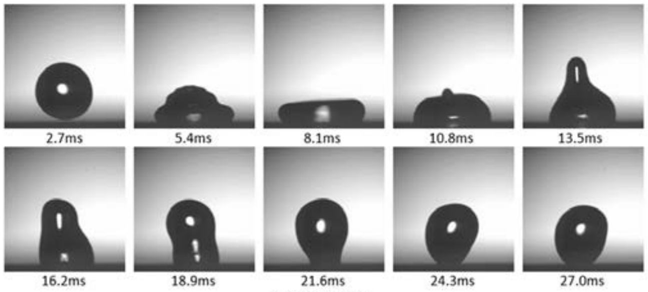
$$t_{c,th} = 2.6\sqrt{\frac{\rho D_0^3}{8\gamma}},$$

where ρ is the liquid density, D_0 is the droplet diameter, γ is surface tension.

We found that the contact time on superhydrophobic surface is influenced by the electric charge. The superhydrophobic surface was made by spin coating a 500 nm thick fluoropolymer (FluoroPel PFC M1604V) layer on the ITO glass slide. For the 2.8 mm droplet with 1 m/s impacting velocity, the contact time for neutral droplet is 22.1 ms, while for the droplet charged at 10% of the Rayleigh limit the contact time is 28.8 ms, corresponding to a 30% increase.



Neutral droplet



Charged droplet

Fig S3. Neutral and charged droplet impact on superhydrophobic substrate.

In some cases, the charged droplet could even avoid rebound altogether. Fig S3 shows the comparison between neutral and charged droplets (10% Rayleigh limit). The droplet diameter is 2.66 mm and impact velocity is 0.46 m/s for both cases. The charged droplet ceased to rebound.

Although the electric charge seems to extend contact time and suppress rebound, we are still unclear about the role played by the thin dielectric layer of super hydrophobic coating. We are currently investigating this question.

3. Raw data used to plot Fig.5

To verify Eq.(8), we conducted a series of experiments. The data were plotted in Fig.5 and listed in Table S1. For each liquid and droplet diameter, before we change the velocity (hence Ca_g), we adjusted the amount of charge to find the transient status between center conical contact and circular gas disk formation. We also varied the droplet size to verify that the critical charge level is not related to the droplet diameter. The data obtained show decent agreement with Eq.8:

$$\Gamma_c = \sqrt{\frac{3}{2}Ca_g},$$

Table S1. Experimental data of figure 5

	Diameter（mm）	Ca_g	Γ for disk-shape gas film			Γ_c for transient gas film	Γ for conical contact		
Water	2.8	2.82E-05	6.11E-04	1.83E-03	3.05E-03	6.11E-03	1.22E-02	1.83E-02	2.44E-02
	2.8	4.00E-05	6.32E-04	1.90E-03	3.16E-03	6.32E-03	1.26E-02	1.90E-02	2.53E-02
	2.8	6.50E-05	6.32E-04	1.90E-03	3.16E-03	6.32E-03	1.26E-02	1.90E-02	2.53E-02
	2.8	8.93E-05	6.53E-04	1.96E-03	3.27E-03	6.54E-03	1.31E-02	1.96E-02	2.61E-02
	2.8	1.42E-04	1.29E-03	3.86E-03	6.43E-03	1.29E-02	2.57E-02	3.86E-02	5.14E-02
	0.3	2.56E-04	1.09E-03	3.28E-03	5.46E-03	1.09E-02	2.19E-02	3.28E-02	4.37E-02
	0.3	2.80E-04	1.10E-03	3.31E-03	5.52E-03	1.10E-02	2.21E-02	3.31E-02	4.41E-02
	0.3	2.94E-04	1.47E-03	4.42E-03	7.37E-03	1.47E-02	2.95E-02	4.42E-02	5.89E-02
	0.3	3.09E-04	1.93E-03	5.79E-03	9.64E-03	1.93E-02	3.86E-02	5.79E-02	7.71E-02
	0.3	3.19E-04	2.95E-03	8.84E-03	1.47E-02	2.95E-02	5.89E-02	8.84E-02	1.18E-01
	0.3	3.50E-04	3.83E-03	1.15E-02	1.91E-02	3.83E-02	7.65E-02	1.15E-01	1.53E-01
Liquid eutectic alloy	4.2	6.09E-05	7.16E-04	2.15E-03	3.58E-03	7.16E-03	1.43E-02	2.15E-02	2.87E-02
	4.2	7.11E-05	1.07E-03	3.21E-03	5.36E-03	1.07E-02	2.14E-02	3.21E-02	4.29E-02
Ethanol	0.3	2.03E-04	3.49E-02	5.24E-02	6.99E-02	1.75E-02	3.49E-02	5.24E-02	6.99E-02
	0.3	2.66E-04	2.94E-02	4.40E-02	5.87E-02	1.47E-02	2.94E-02	4.40E-02	5.87E-02
	0.3	2.92E-04	3.35E-02	5.03E-02	6.71E-02	1.68E-02	3.35E-02	5.03E-02	6.71E-02

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