Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Effect of liquid droplet's surface tension on impact dynamics over hierarchical nanostructure surface

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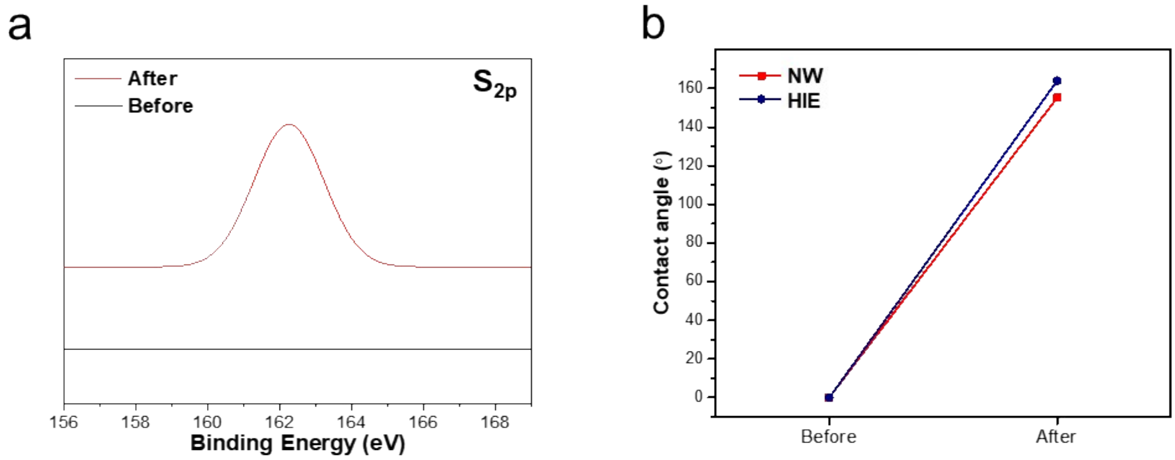

Fig. S1 (a) S_{2p} XPS spectra from ZnO NWs grown surface, (b) Contact angles of water measured on ZnO NWs and ZnO/Si HIE surfaces before and after coating the surfaces with octadecanethiol. XPS sulfur, S_{2p} peak is formed after coating the surface with octadecanethiol. Water contact angles increased from superhydrophilic to superhydrophobic state after SAM molecule coating on both surfaces.

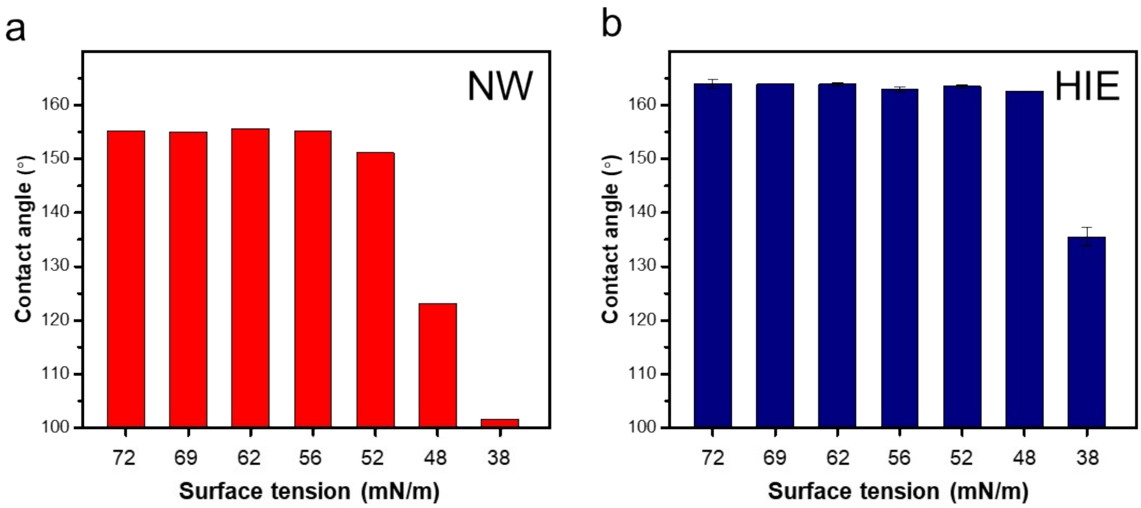

Fig. S2 The static contact angles of liquids having varied surface tensions from 72 to 38 mN/m on (a) NWs structured and (b) HIE structured surfaces.

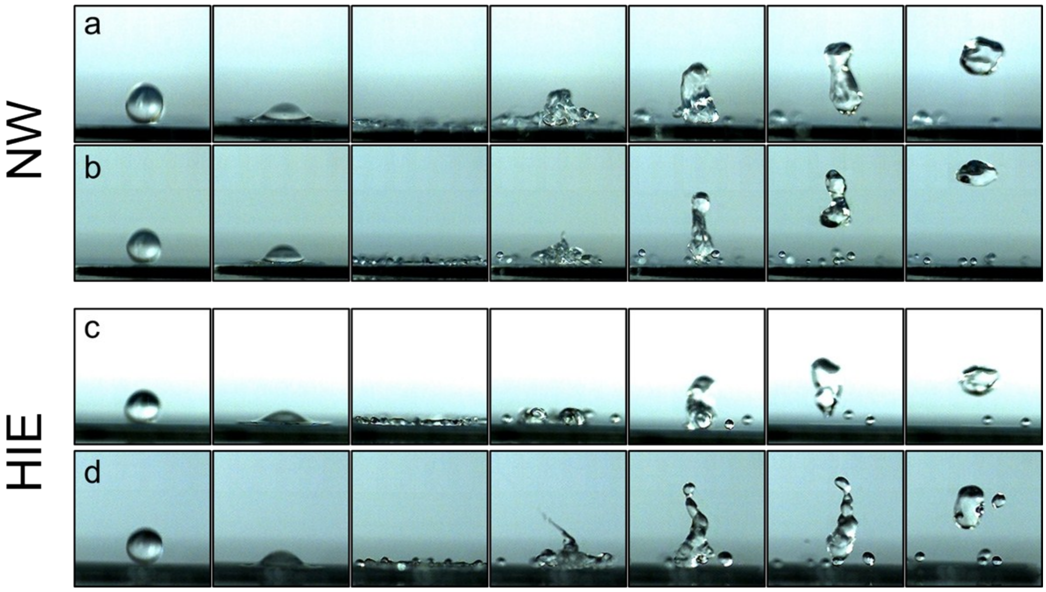

Fig. S3 Snapshots of the impact dynamics on NWs surface with (a) 0 %, pure water droplet and (b) 1 % ethanol in water mixture liquid droplet. Impact dynamics on HIE surface also captured with (c) 0 %, pure water droplet and (d) 1 % ethanol in water mixture liquid droplet. The dropping height is fixed at 30 cm, and the frame rate is 5000 fps.

Supporting Note. 1

When the liquid droplet collides with the surface, the anti-wetting pressure is generated by the capillary force caused by the air pocket existing under the liquid droplet. Therefore, the anti-wetting pressure is affected by the area of the air pocket present on the surface. The anti-wetting pressure (P_a) is known to be obtained as follows.[1,2]

$$P_a = -\gamma_{LV}\cos\theta\frac{L}{A}$$

where γ_{LV} is the surface tension of liquid, θ is the contact angle, L is the perimeter of air pocket, and A is the cross-sectional area of the air pocket.

Modeling was performed to apply the above pressures to the HIE structure. In order to systematically analyze the air pocket in a HIE structure, a unit cell shown in Fig. 6b was set first. In the unit cell, the cross-sectional area of the air pocket is $A = P^2 - \pi(r+l)^2 + \alpha$, and the perimeter is $L = 2\pi(r+l)$, where P is the interspacing of micropost (50 μm), r is the radius of the cross-section of micropost (10 μm), l is the length of ZnO nanowires (5 μm), and α is the cross-sectional area of the air pocket additionally held by the nanowire at the top of the micropost. ZnO NWs have a distance of 600 nm and radius of 75 nm, so α is calculated as follow;

$$\alpha = \frac{(600\times10^{-9})^2 - (75\times10^{-9})^2}{(600\times10^{-9})^2}\times\pi(10\times10^{-6})^2 = 3.09\times10^{-10}$$

Finally, the anti-wetting pressure in the HIE structure is derived by substituting the parameters as follows:

$$P_a = -2\gamma_{LV}\cos\theta\frac{\pi(r+l)}{P^2 - \pi(r+l)^2 + \alpha}$$

The anti-wetting pressure (P_a) for each concentration of ethanol using the above equation is shown in the below table.

Concentration (wt %) of ethanol	Surface tension (N/m)	Contact angle (°)	Anti-wetting pressure (Pa)
0	72.75	155.2	2960.9
1	69.06	155	2806.2
3	62.65	155.6	2558.0
5	56.41	155.3	2297.7
7	52.75	151.2	2072.5
10	48.14	123.2	1181.8
20	38.56	100.6	318.0

Supporting Note. 2

The wetting pressure (P_w) can be obtained from the following equation.

$$P_w = \frac{1}{2}\rho v^2$$

where ρ is the density of liquid, v is the impact velocity of liquid. In Fig. 4, the dropping height was the 5 cm when the water droplets collision, so the impact velocity is constant at 0.99. The density of the liquid depends on the ethanol concentration and the density and wetting pressure in each case are calculated in the below table.

Concentration (wt %)	Impact velocity (m/s)	Density (kg/m^3)	Wetting pressure (Pa)
0	0.99	998.2	404.3
1	0.99	996.4	403.5
3	0.99	992.8	402.1
5	0.99	989.4	400.7
7	0.99	986.3	399.4
10	0.99	981.9	397.7
20	0.99	968.6	392.3

Supporting Note. 3

The effective water hammer pressure (P_{ewh}) is obtained from the following equation.

$$P_{ewh} = k\rho cv$$

Effective water hammer pressure has a constant term k which is known to be varied depending on the anti-wetting pressure. In previous study, k value was calculated according to anti-wetting pressure.[3]

$$k = 2.54 \times 10^{-7} P_a + 7.53 \times 10^{-4}$$

In this study, the k values are calculated by the above equation and the resultant k values on HIE surfaces (Fig.4) are shown in the following table. Furthermore, the sound speed (c) in liquid changes depending on the ethanol concentration.[4–6] Sound speed is also found according to the ethanol concentration through the existing literature value. The effective water hammer pressure obtained using the above equation is shown in the below

Concentration (wt %)	Anti-wetting pressure (Pa)	k	Sound speed in liquid (m/s)	Effective water hammer pressure (Pa)
0	2960.9	1.50×10^{-3}	1475	1977.7
1	2806.2	1.47×10^{-3}	1490	1925.1
3	2558.0	1.40×10^{-3}	1500	1878.0
5	2297.7	1.34×10^{-3}	1520	1809.1
7	2072.5	1.28×10^{-3}	1535	1743.2
10	1181.8	1.05×10^{-3}	1550	1442.6
20	347.6	8.41×10^{-4}	1620	1177.5

table.

References

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