Electronic Supplementary Material (ESI) for Lab on a Chip.

Supporting Information

Oxidized Liquid Metal Based Microfluidic Platform for Tunable Electronic Devices Applications

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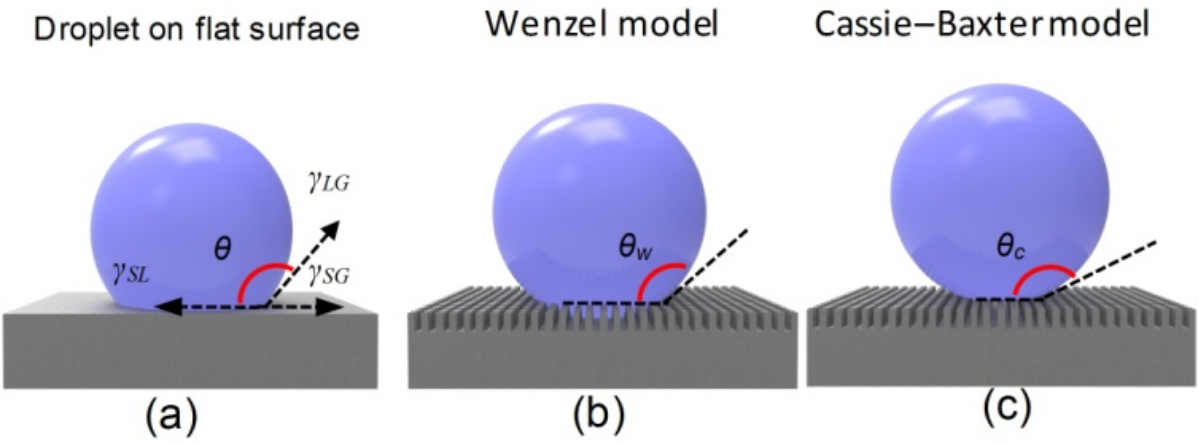

Fig. S1 (a) Contact angle of a liquid droplet wetted to a rigid solid surface; **(b)** Wenzel model; **(c)** Cassie–Baxter model.

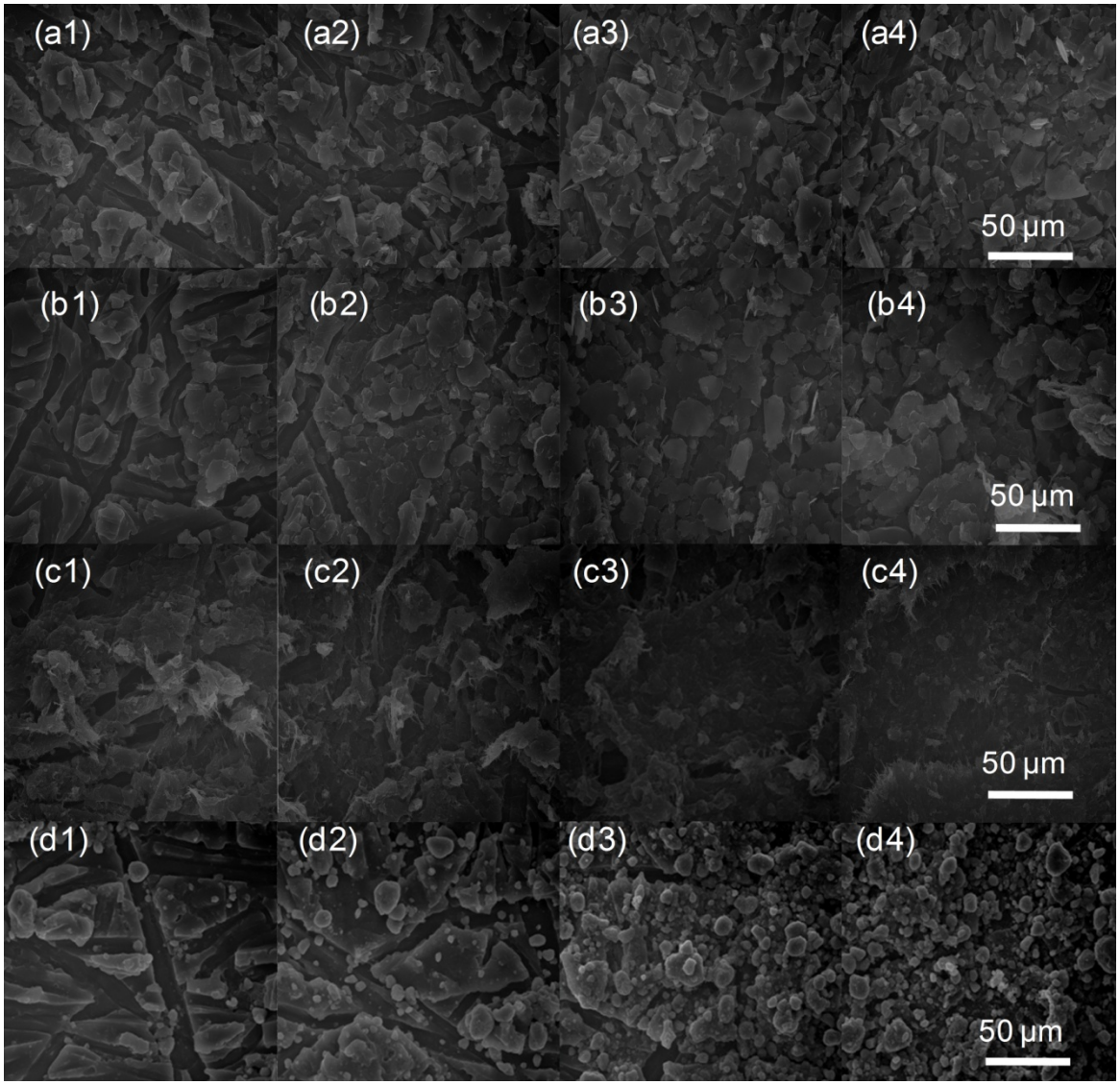

Fig. S2 SEM images of the paper-textured PDMS surface after immerging 2, 4, 6 and 8 mg/ml particle solution of **(a)** graphite, **(b)** graphene, **(c)** CNT and **(d)** TiO_2.

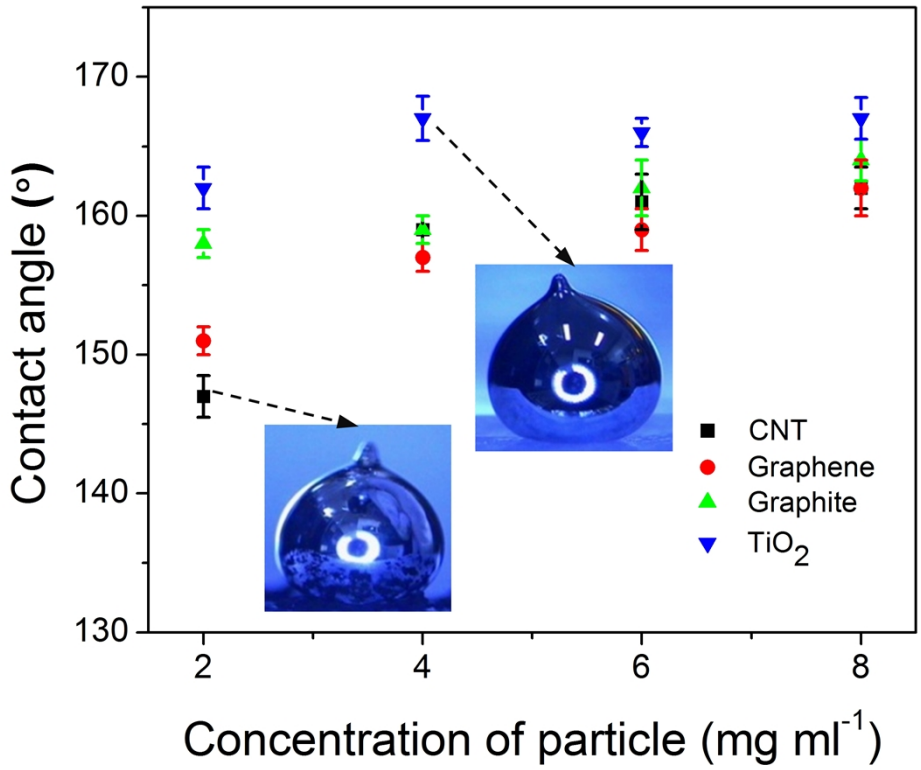

Fig. S3 Static contact angle of ~8 µl oxidized Galinstan droplet on the paper-textured PDMS surface after immerging different concentration particle solutions of CNT, graphene, graphite, and TiO_2.

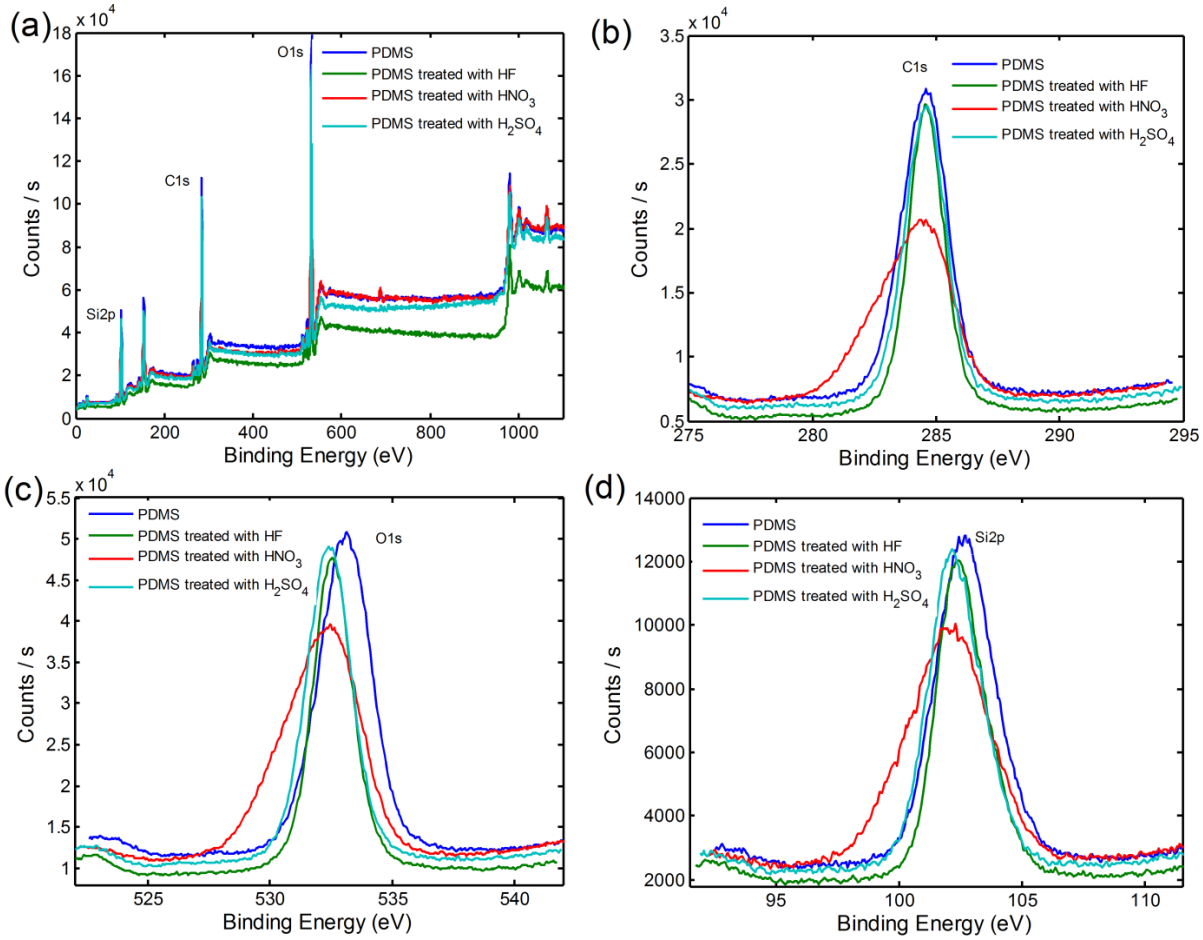

Fig. S4 XPS spectra of chemically untreated PDMS and chemically treated PDMS using HF, HNO_3 and H_2SO_4, respectively.

The effect of HF, HNO_3 and H_2SO_4 treatment on PDMS is studied with the help of XPS analysis. Here, Figure S4a-4d show the XPS spectra of chemically untreated PDMS and chemically treated PDMS using HF, HNO_3 and H_2SO_4, respectively. Considering the basic peaks of PDMS materials (O1s, C1s and Si2p peaks), O1s peak in case of chemically treated PDMS varies with the type of acid treatment, as shown in Table S2. Additionally, Si2p peak shift isobserved between chemically treated PDMS and untreated PDMS. These peak shifts indicates slight chemical variation on the surface of chemically treated PDMS.F1s peak of HF treated PDMS is observed which is located at 687.42 eV. Discovery of F1s peak implies

that chemical composition of PDMS is changed. On the contrary, N1s and S2p peak are not founded in PDMS treated with HNO_3 and H_2SO_4 respectively, which indicates PDMS treated with HNO_3 as well as H_2SO_4 is still consisted of the element of C, O, Si. Therefore, the non-wetting property of oxidized Galinstan on PDMS treated with H_2SO_4 is due to the micro/nano structure surface with high lyophobicity rather than chemical composition.

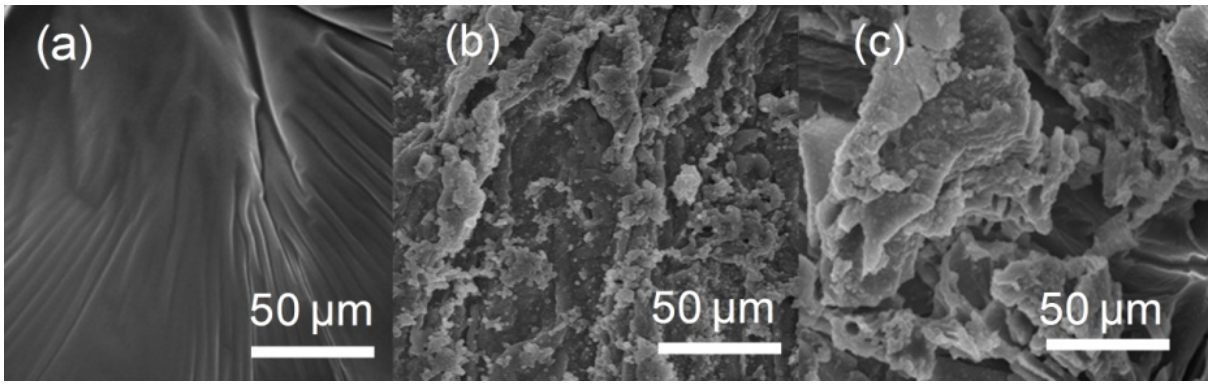

Fig. S5 SEM images of PDMS after immerging in 89 wt% H_2SO_4 solution for **(a)** 10 sec, **(b)** 1.5min, and **(c)** 5 min.

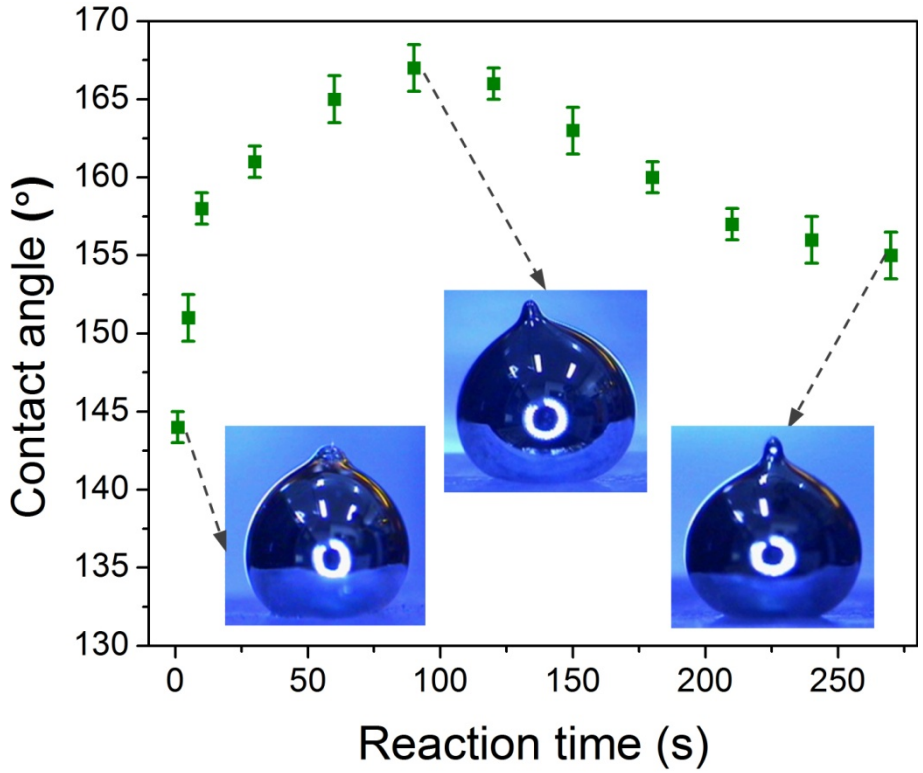

Fig. S6 Static contact angle of ~ 8µl oxidized Galinstan droplet on PDMS substrate immersed in 89 wt% H_2SO_4 solution for different lengths of time.

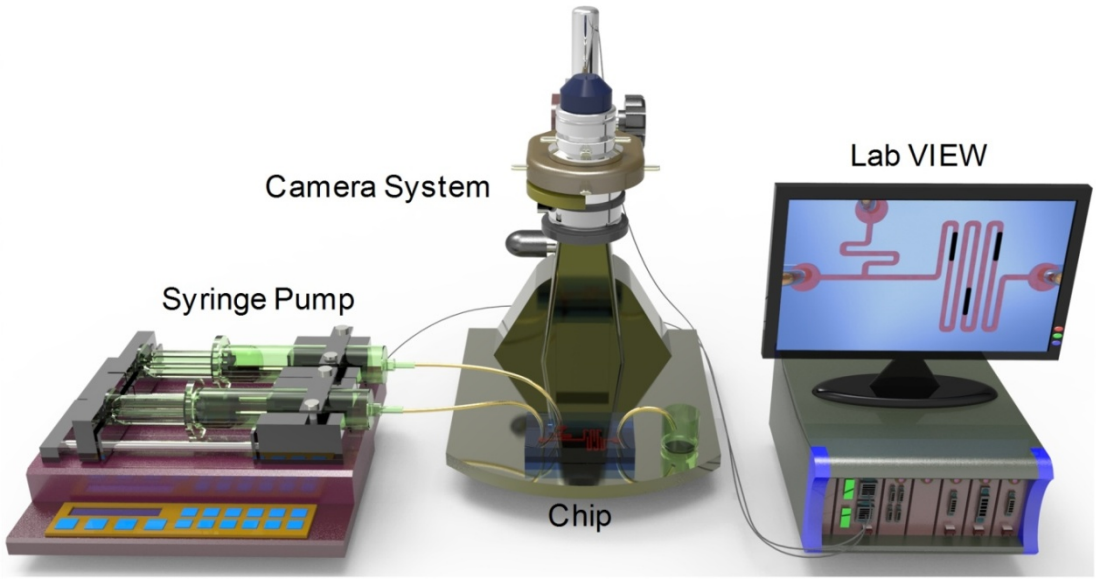

Fig. S7 Experimental setup used for controlling Galinstan droplet comprised of CCD camera system and Lab-VIEW controlled syringe pump system.

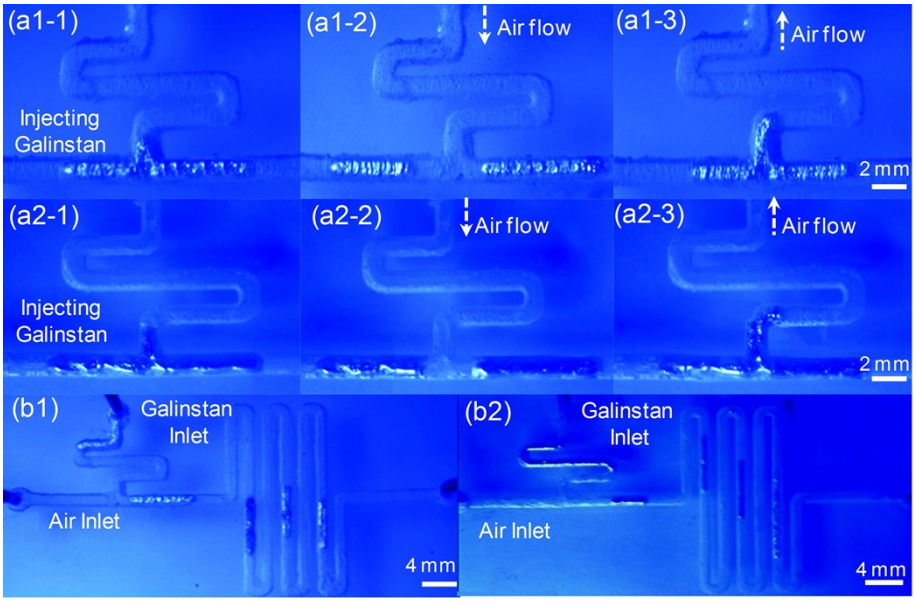

Fig. S8 Separating and merging oxidized Galinstan droplet in complex microfluidic channel fabricated using **(a1)** physical technique and **(a2)** chemical technique; Multi-Galinstan droplets generated in complex microfluidic channel fabricated using **(b1)** physical technique and (b2) chemical technique.

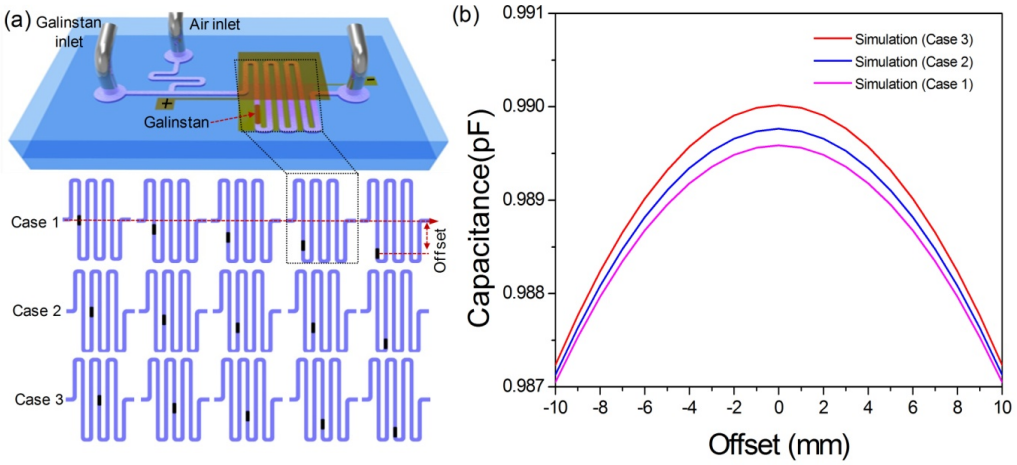

Figure S9. The relationship between adjustable capacitor capacitance and Galinstan droplet position: **(a)** The sketch of Galinstan droplet moving in the channel of adjustable capacitor with three cases; **(b)** Capacitance of P-adjustable capacitor as a function of oxidized Galinstan droplet offset microfluidic channel.

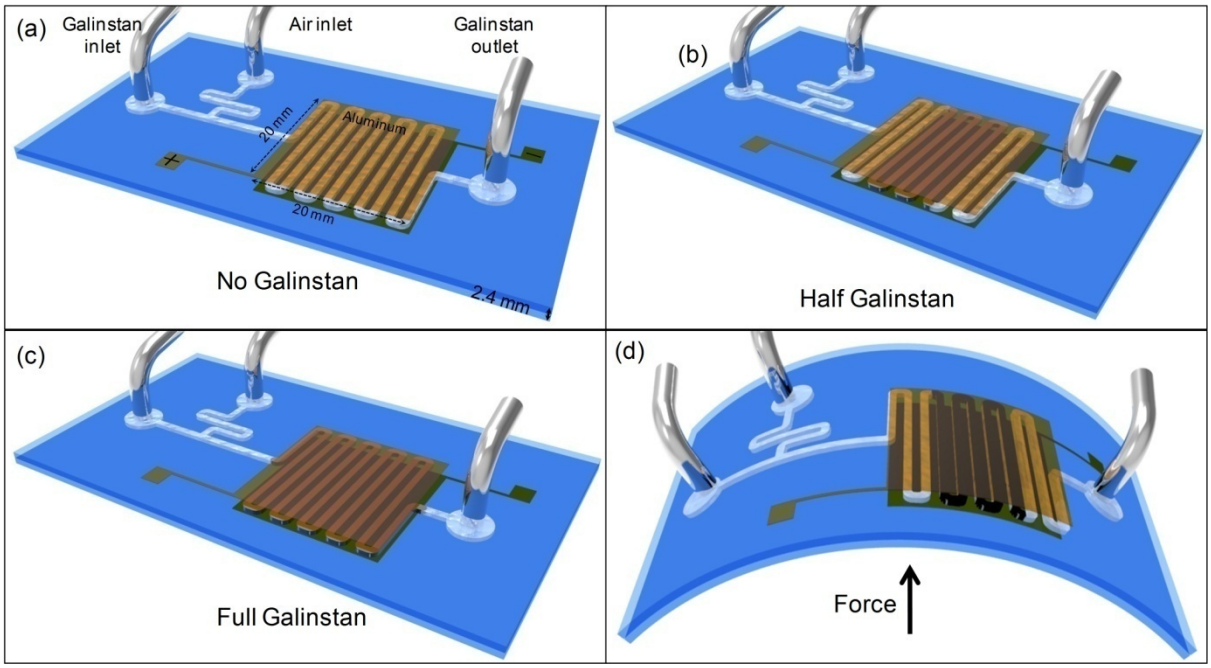

Fig. S10 C-adjustable capacitor (channel cross-sectional area: 1000μm width×800μmheight): **(a)** No Galinstan (the microfluidic channel part under the capacitor plate is empty); **(b)** Half Galinstan (Half of the microfluidic channel under the capacitor plate is filled with Galinstan); **(c)** Full Galinstan (the microfluidic channel part under the capacitor plate is completely filled with Galinstan); **(d)** Adjustable capacitor with the flexibility.

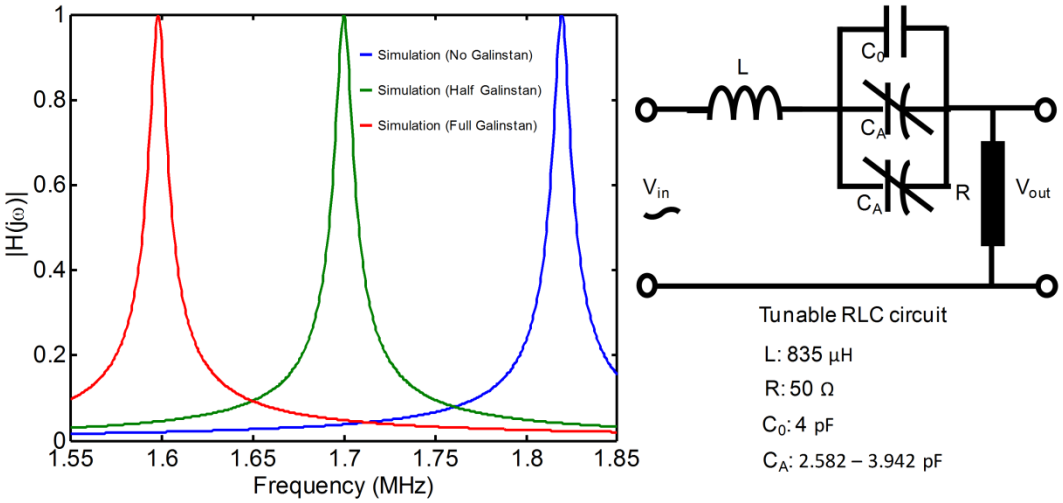

Fig. S11 Frequency response of tunable RLC filter applied to band of home-portabletelephones (1.8 –2.0 MHz) (C_0: the capacitance of the fixed capacitor; Full Galinstan: the microfluidic channel part under the capacitor plate is fully filled with Galinstan; Half Galinstan: Half part of the microfluidic channel under the capacitor plate is filled with Galinstan; No Galinstan: the microfluidic channel part under the capacitor plate is empty.).

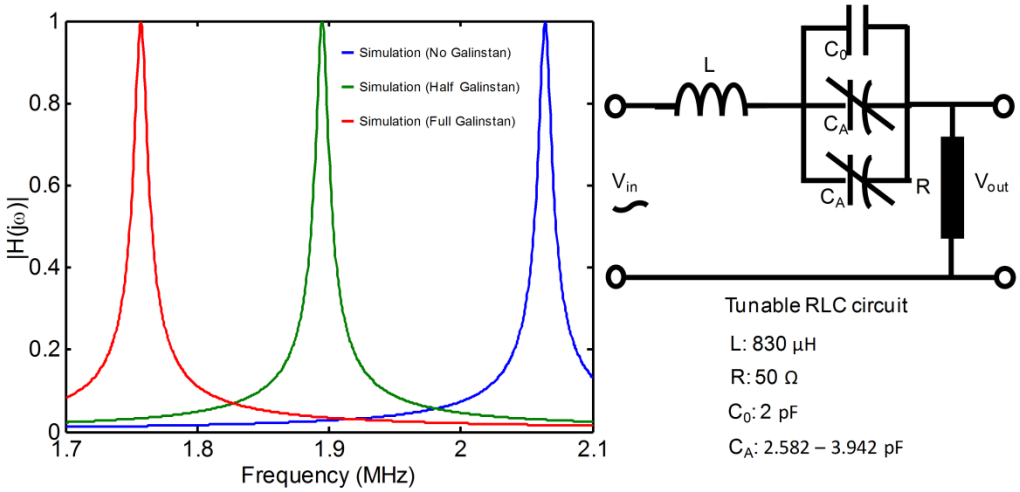

Fig. S12 Frequency response of tunable RLC filter applied to band of amateur radio (1.8 –2 MHz) (C_0: the capacitance of the fixed capacitor; Full Galinstan: the microfluidic channel part under the capacitor plate is fully filled with Galinstan; Half Galinstan: Half part of the microfluidic channel under the capacitor plate is filled with Galinstan; No Galinstan: the microfluidic channel part under the capacitor plate is empty.).

Table S1. Materials used for modifying paper-textured PDMS surface during Physical technique.

	Model	Size	Shape
Graphite		< 45 μm	Irregular
Graphene powder: multilayer flakes	MO-1	Flake thickness: 28 nm	Sheet
CNT	CM-100	Diameter: 10–15 nm, length: ~20 μm	Spindly
TiO_2	VK-TA18S	Diameter: ~20 nm	Spherical

Table S2. O1s, C1s and Si2p peak binding energy of untreated PDMS and chemically treated PDMS using HF, HNO_3 and H_2SO_4, respectively

Sample	Peak binding energy (ev)		
	O1s	C1s	Si2p
PDMS	532.48	284.6	102.24
PDMS + HF	532.47	284.6	102.2
PDMS + HNO_3	532.5	284.6	102.34
PDMS + H_2SO_4	532.45	284.6	102.29

Supporting Video SV1. The video shows the behavior of oxidized Galinstan under impact on the modified PDMS surface after release from a height of 10 mm.

Supporting Video SV2. The video shows the oxidized Galinstan droplet linear movement in the microfluidic channel (fabricated using the physical technique) with various air flow rates controlled by the syringe pump.

Supporting Video SV3. The video shows the oxidized Galinstan droplet linear movement in the microfluidic channel (fabricated by chemical technique) with various air flow rates controlled by the syringe pump.

Supporting Video SV4. The video shows the oxidized Galinstan droplet reciprocating movement in the microfluidic channel (fabricated using the physical technique) with 2ml/min air flow rate controlled by the syringe pump.

Supporting Video SV5. The video shows the oxidized Galinstan droplet reciprocating movement in the microfluidic channel (fabricated using the chemical technique) with 2ml/min air flow rate controlled by the syringe pump.