Opto-Electronic Advances

Supplementary information

July 2023, Vol. 6, No. 7

DOI: 10.29026/oea.2023.220172

Laser direct writing of Ga_2O_3/liquid metal-based flexible humidity sensors

Songya Cui[1,2†], Yuyao Lu[1†], Depeng Kong[1], Huayu Luo[1], Liang Peng[2], Geng Yang[1], Huayong Yang[1] and Kaichen Xu[1*]

[1]State Key Laboratory of Fluid Power and Mechatronic Systems, School of Mechanical Engineering, Zhejiang University, Hangzhou 310030, China; [2]School of Information and Electrical Engineering, Hangzhou City University, Hangzhou 310015, China.

[†]These authors contributed equally to this work.

*Correspondence: KC Xu, E-mail: xukc@zju.edu.cn

Supplementary information for this paper is available at https://doi.org/10.29026/oea.2023.220172

Fig. S1 | Images of water contact angles on (**a**) pristine and (**b**) laser sintered GWLM films.

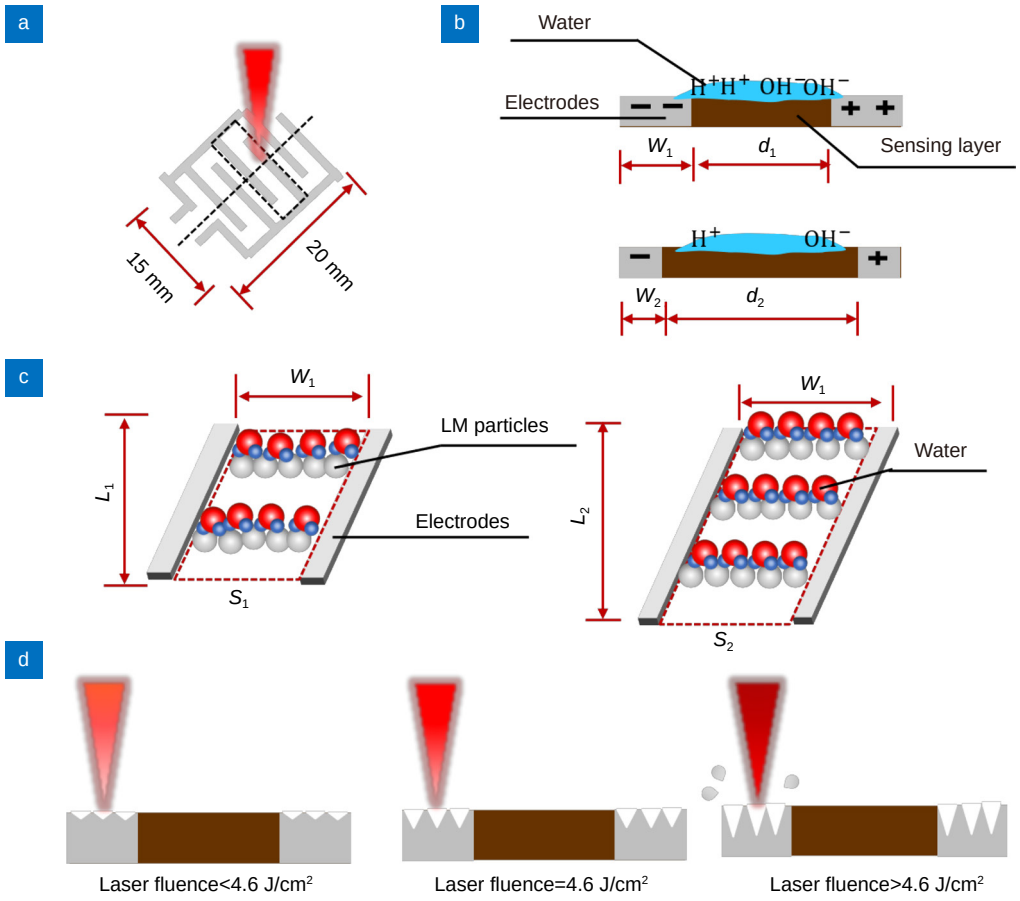

Fig. S2 | Schematics to illustrate the fabrication parameters' effect on the performances of humidity sensors. (**a**) Schematic of the Ga_2O_3/LM-based humidity sensor. (**b**–**c**) Schematics of the electrode widths and lengths' effect on the performances of these sensors. (**d**) Schematics of the laser fluence's effect on the performances of humidity sensors.

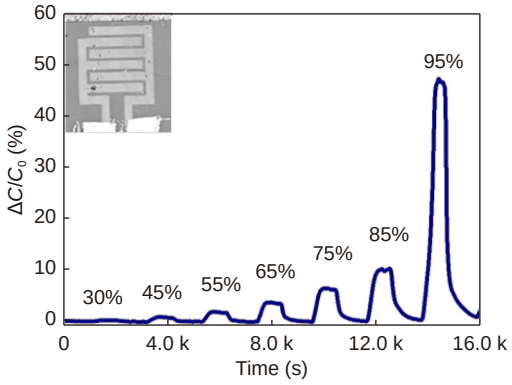

Fig. S3 | Capacitance change of the Ga_2O_3/LM-based humidity sensor fabricated by a CO_2 laser at different RHs. The inset shows the image of this sensor.

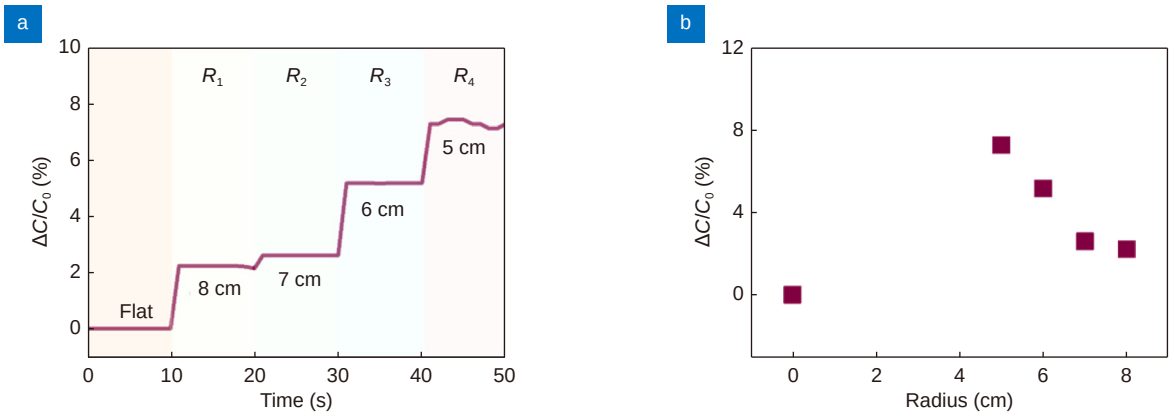

Fig. S4 | (**a**–**b**) Real-time measurement of a Ga_2O_3/LM-based humidity sensor under various bending radii.

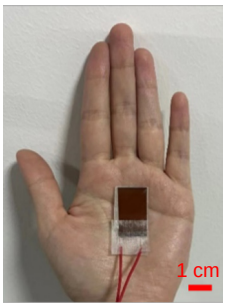

Fig. S5 | A photo of Ga_2O_3/LM-based humidity sensor attached on a hand for human physiological monitoring.

Table S1 | Comparison of humidity sensing performances of capacitive-type sensors fabricated with different functional materials and methods.

Sensing material	Fabrication method	Humidity range (%RH)	Cycle test	Response time (s)	Recovery time (s)	Measurement frequency (Hz)	Applications	Reference
Carboxymethyl cellulose	Inkjet printing	12–97	5	15.5	3.3	1 k	Human breathing and noncontact fingertip movement	1
CeO_2/g-C_3N_4	Screen printing	0–97	6	12	N.A.	100	Respiration and body physiological monitoring	2
Armalcolite/ polydimethylsiloxane	Spin coating	33–95	7	8.53	11.25	100	Respiration	3
Keratin/1% carbon fibers	Drop casting	16–92	N.A.	21	56	100	Respiration	4
Graphene oxide	Laser direct writing	10–90	N.A.	15.8	N.A.	50	Respiratory monitoring and plant transpiration	5
Yarn	Mechanical spinning	6–97	2	3.5	4	10 k	Respiration	6
Ionic polymer metal composite	Impregnation-reduction plating process	22–100	N.A.	<0.5	N.A.	50	N.A.	7
P(VDF-TrFE) nanocone arrays	Hot-pressing method and the anodized aluminum oxide template transfer method	50–90	10,000	3.693	3.43	1 M	Respiration and body physiological monitoring	8
Ga2O3/LM-based sensor	UV laser sintering	30–95	50	1.2	1.6	100 k	Respiration and body physiological monitoring	Current work

References

S1. Shen YK, Hou SJ, Hao DD, Zhang X, Lu Y et al. Food-based highly sensitive capacitive humidity sensors by inkjet printing for human body monitoring. *ACS Appl Electron Mater* **3**, 4081–4090 (2021).

S2. Gong LK, Wang XW, Zhang DZ, Ma XD, Yu SJ. Flexible wearable humidity sensor based on cerium oxide/graphitic carbon nitride nanocomposite self-powered by motion-driven alternator and its application for human physiological detection. *J Mater Chem A* **9**, 5619–5629 (2021).

S3. Tripathy A, Sharma P, Pramanik S, Silva FS, Osman NABA. Armalcolite nanocomposite: a new paradigm for flexible capacitive humidity sensor. *IEEE Sens J* **21**, 14685–14692 (2021).

S4. Hammouche H, Achour H, Makhlouf S, Chaouchi A, Laghrouche M. A comparative study of capacitive humidity sensor based on keratin film, keratin/graphene oxide, and keratin/carbon fibers. *Sens Actuator A:Phys* **329**, 112805 (2021).

S5. Lan LY, Le XH, Dong HY, Xie J, Ying YB et al. One-step and large-scale fabrication of flexible and wearable humidity sensor based on laser-induced graphene for real-time tracking of plant transpiration at bio-interface. *Biosens Bioelectron* **165**, 112360 (2020).

S6. Ma LY, Wu RH, Patil A, Zhu SH, Meng ZH et al. Full‐textile wireless flexible humidity sensor for human physiological monitoring. *Adv Funct Mater* **29**, 1904549 (2019).

S7. Wang YJ, Tang GQ, Zhao C, Wang KL, Wang JL et al. Experimental investigation on the physical parameters of ionic polymer metal composites sensors for humidity perception. *Sens Actuators B:Chem* **345**, 130421 (2021).

S8. Niu HS, Yue WJ, Li Y, Yin FF, Gao S et al. Ultrafast-response/recovery capacitive humidity sensor based on arc-shaped hollow structure with nanocone arrays for human physiological signals monitoring. *Sens Actuators B:Chem* **334**, 129637 (2021).