Tactile sensor for magnitude and direction detection based on a liquid alloy droplet

Bei Wang[1,2], Wenci Xin[1], Zhigang Wu[1,2]

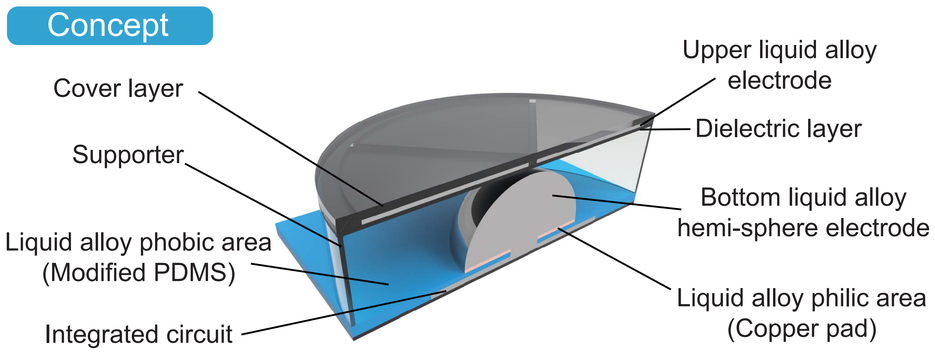
1 State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology, Wuhan 430074, China
2 Department of Engineering Sciences, Uppsala University, SE-75121, Sweden

① Introduction

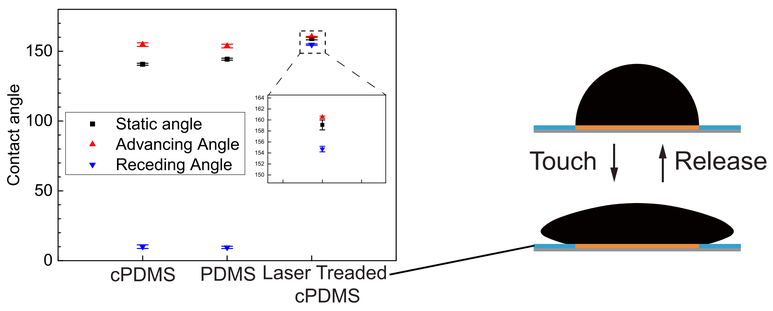
To measure the tactile signals, such as magnitude, strain and especially direction, various types of sensors have been developed. However, these devices are either very complex in structureonly or only can obtain single signal. This work presents a novel soft tactile sensor with capacitance between liquid alloy based hemisphere and planar electrodes. Due to the nature high surface tension and flowability of liquid alloy droplet, the dynamic re-distribution of charges on electrodes can achieve high sensitivity, wide range and abundant functions, e.g. magnitude or direction of external force.

② Results

Concept

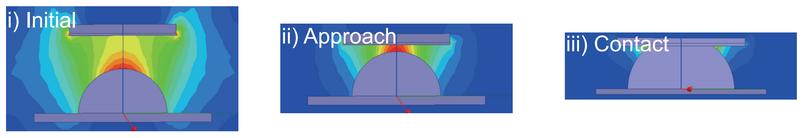


Surface Modification



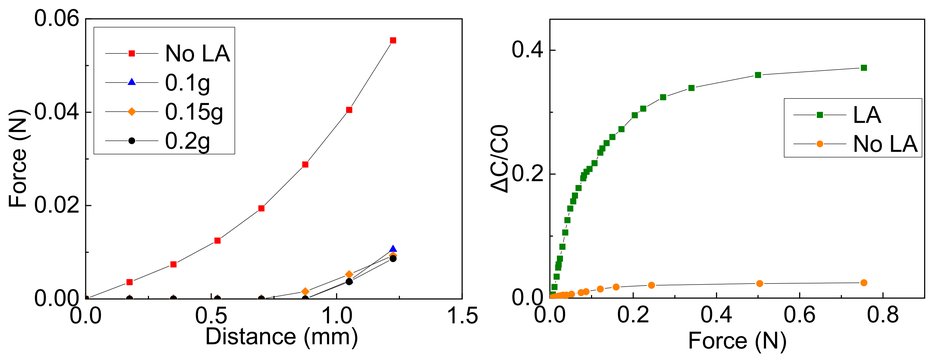
Laser treated surface modified the wettability of liquid alloy oxide to substrate, so the liquid alloy could not remain on the surrounding area after contact.

Charge Distribution



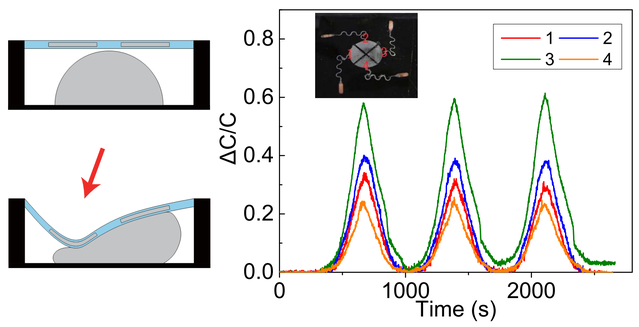
As the upper electrode apprached the droplet, the charge distribution changed from being focused to uniform, which could improve the sensitive of our proposed sensor.

Advantages



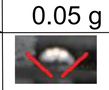
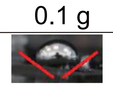
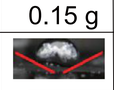
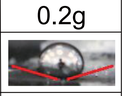
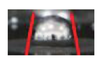
When comparing the rigid with liquid alloy electrode, the later could detect much smaller tactile force . Moreover, its capacitivity sensitivity to force was higher.

Capability



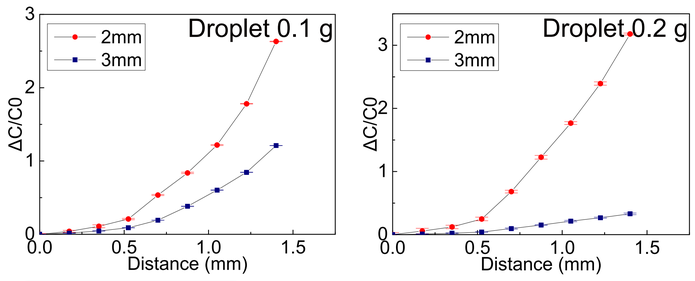
There were four upper electrodes circular evenly distributed. When the tactile force was loaded, their capacitance values became different, which provides us with information not only the magnitude of forcebut also of its direction .

Morphology

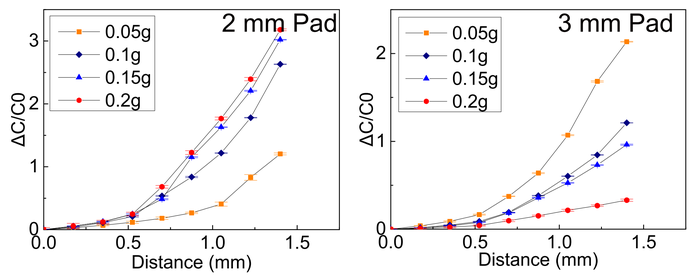
D \ M	0.05 g	0.1 g	0.15 g	0.2g
2 mm				
3 mm				

When the diameter of bottom pad and the mass of liquid alloy were different, the final equilibrium state were changed.

Mass Impact

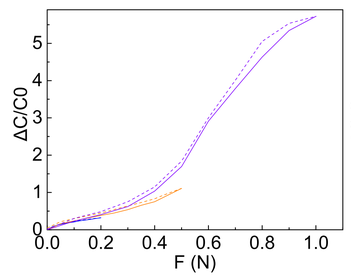


Pad Impact

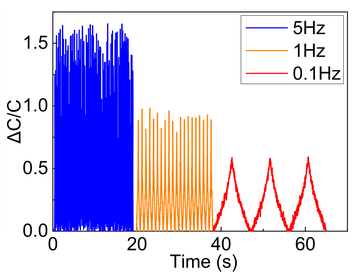


As the mass of droplet were increasing or the diameter of pad were decreasing, the capacitance became more sensitive.

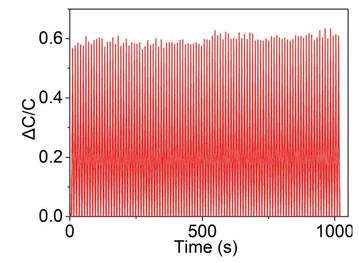
Hysteresis



Frequency

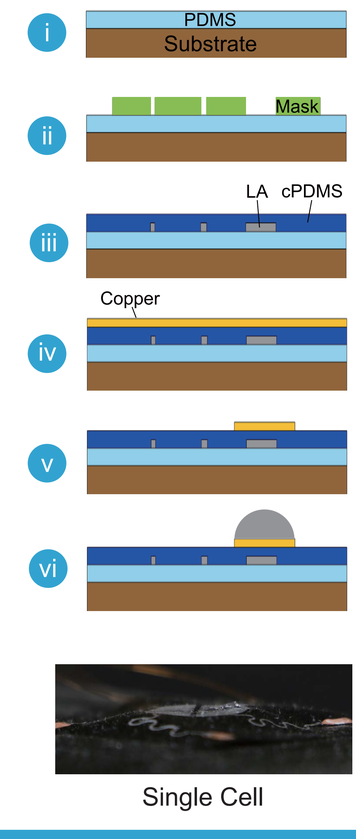


Repeatability



The hysteresis were less than 12%, and the frequency and repeatability was in a distinguishing and stable state.

Fabrication



PDMS substrate molding

Mask patterning by laser

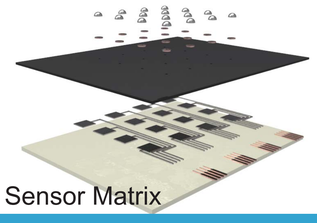
LA deposition and cPDMS encapsulation

Copper fixing

Copper patterning and cPDMS modification by UV laser

Assemble the LA droplet

Single Cell



Sensor Matrix

③ Conclusion

This work demonstrated a novel tactile sensor that can detect both magnitude and direction of force simultaneously. The sensitivity was much higher compare to traditional sensor, since it is more susceptible to deformation. Other factors have been studied in this work are charge distribution, mass of droplet, dimension of pad, and etc.

④ Reference

1. Wang B.,Wu K., Hjort K., Guo C. F., Wu Z. G.; Soft Robotics, DOI: 10.1089/soro.2018.0008
2. Zhang S., Wang B., Jiang J. J., Wu K., Guo C. F., Wu Z. G. ACS Appl. Mater. Interface, DOI: 10.1021/acsami.8b20595
3. Won D. J., Baek S., b , Huh M., Kim H. Lee S., Kim J., Sensors and Actuators A, 259 (2017) 105-111