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

Support Information for "Design and Characterization of Single Channel Two-Liquid Capacitor and its Application to Hyperelastic Strain Sensing" by *Shanliangzi Liu, Xiaoda Sun, Owen J. Hildreth, and Konrad Rykaczewski**

*Contact: konradr@asu.edu

1. Two liquid capacitor simulation

A 2D axisymmetric simulation of the electric field around the different geometries of the two liquid capacitor with and without tube was performed using the Electrostatic module in COMSOL Multiphysics 5.0 modelling software. The end-to-end facing 1 mm, 1.6 mm, and 2 mm liquid metal rods with length of ~1 cm were surrounded by a 0.2 to 1 mm thick PCV (ε~3.2) or PDMS (ε~2.8) tubing a 2 cm tall and 1.5 cm radius 'cylinder' of region with adjustable dielectric constant (i.e. water, glycerol, silicone oil, or air). As in our experiments, the regions surrounding this model were set to air. The overall domain size was increased until it no longer affected the simulated capacitance values. Free triangular mesh with "finer" size was used to discretize the simulation domain. This mesh size was sufficient small to provide a mesh independent solution. For boundary conditions, the outer surface of the upper liquid metal cylinder was set to "terminal", while the lower one was set to "ground". To test different geometrical arrangements (e.g. effect of presence of tubing), the dielectric constant of the different regions was adjusted. Figure S1 shows example geometry, mesh, and entire potential field distribution resulting from the simulation.

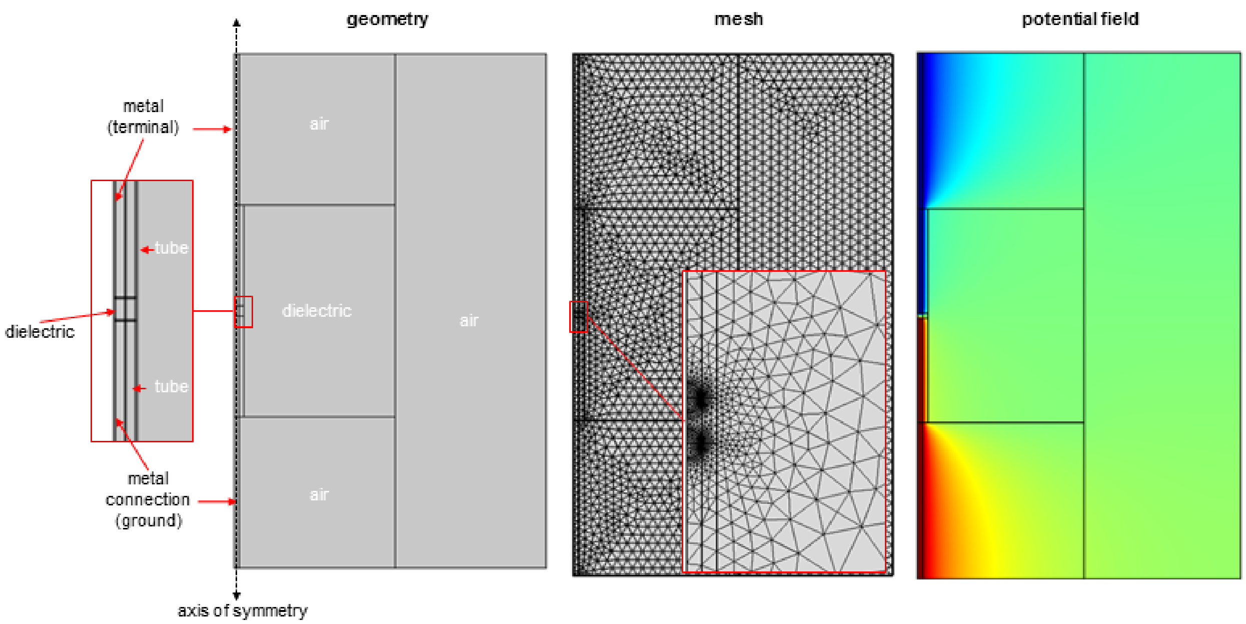

Fig.S1 Example geometry, mesh, and potential field distribution resulting from the simulation.

2. Experimental setup

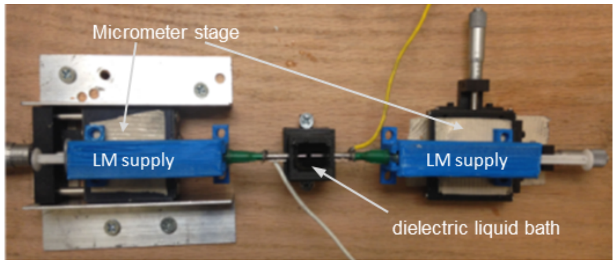

Fig.S2. Picture of the experimental two-tube and dielectric "bath" setup.

tubes with 2 mm ID separated by air with different relative humidity which was adjusted using a humidity chamber.

3. Additional simulation results

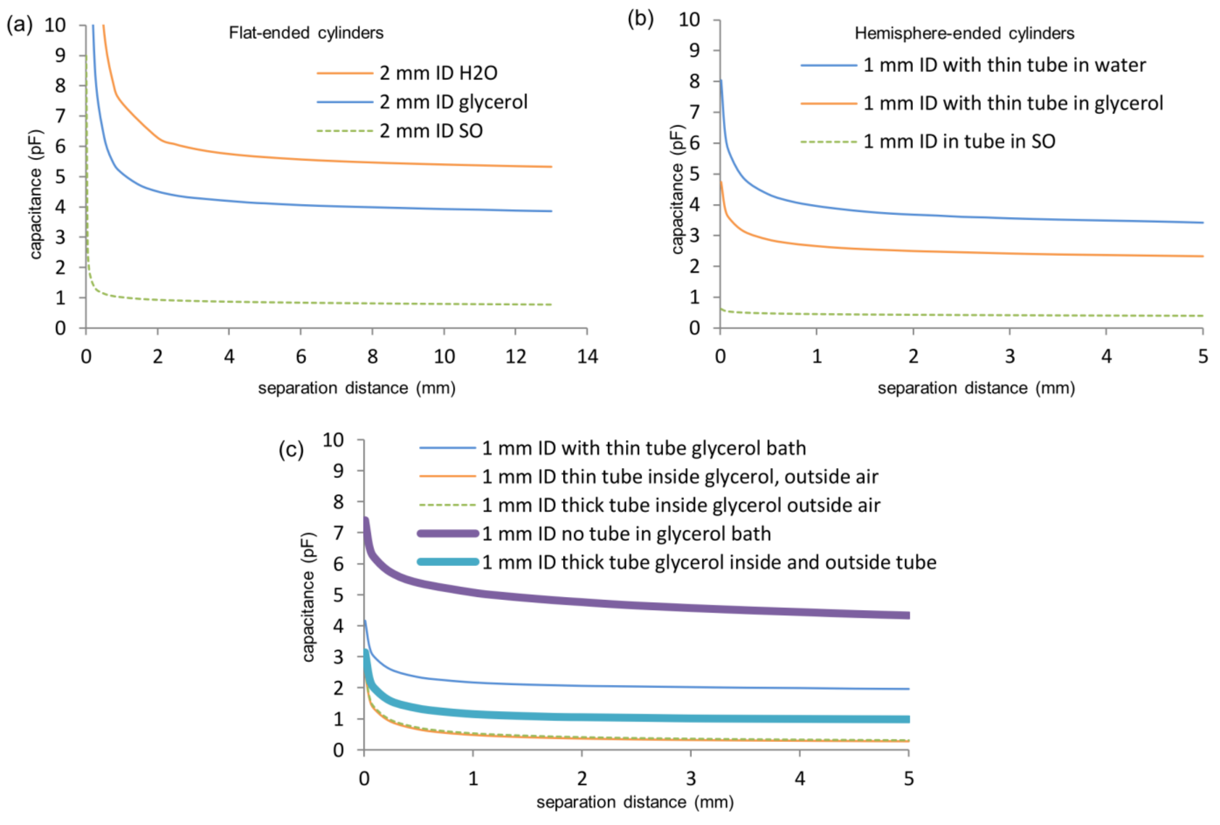

Fig. S3 Additional simulation results: (a) for two-cylindrical flat ended 2mm ID electrodes in tube and (b) 1 mm hemisphere ended electrodes within a tube separated by different dielectric baths, and (c) various geometrical/material arrangements of the electrode system in (b).

4. Additional capacitance measurements

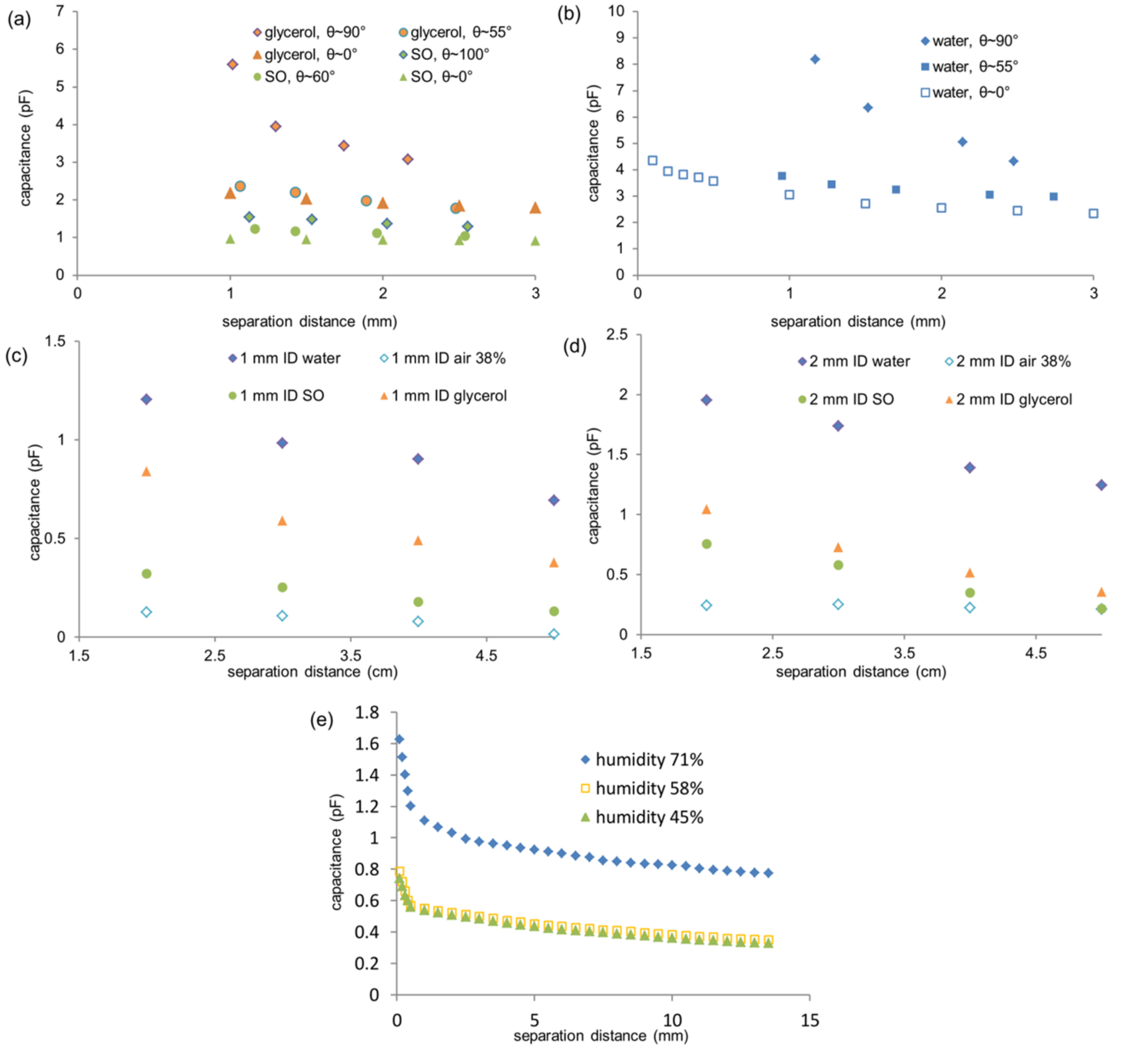

Fig. S4 Capacitance measurements for two-liquid capacitors with meniscus-ended electrodes with θ~60° and θ~90° for (a) glycerol and silicone and (b) water as function of separation distances (base-to-base); (c-d) capacitance for flat-ended liquid metal electrodes separated by large distances (2 to 5 cm) within different dielectric liquid baths and 38% relative humidity air for (c) 1 mm ID and (d) 2 mm ID tubes, and (e) capacitance of flat-ended liquid metal filled