# Thin-film electrode patterning for encapsulated and air-stable droplet interface bilayers

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Our research focuses on formation of synthetic lipid bilayers arrays to study and employ biomolecular functionality for sensing, actuation, and energy-conversion. In these systems, a synthetic lipid bilayer forms at the interface of two, lipid coated aqueous droplets submerged in oil. Known as droplet interface bilayers (DIBs), these assemblies provide an environment for studying many aspects of membrane transport including single channel protein gating. Typically DIBs are formed in an open oil reservoir contained within a solid substrate. However, recent progress in our group has shown DIBs can be: 1) organized rapidly into large networks within a closed microfluidic environment[1], and, separately, 2) assembled on top of an oil-coated surface, allowing DIBs to interact with the surrounding ambient environment.[2] For both environments, we envision significant value can be gained from integrating thin-film electrodes onto the solid substrate in place of manually positioning bulky, wire-type electrodes. Also, patterned electrodes can help understand collective utility of large arrays of DIBs by appropriately summing the signals that develop at each lipid bilayer interface.

Therefore, our current objective is to design and fabricate thin-film surface electrodes to enable electrical measurement of DIBs. Surface electrode patterns are constructed using photolithography on glass wafers. A chrome adhesive layer is deposited onto the unmasked regions using thin film deposition, followed by a conductive layer of gold or silver, which is evaporated and patterned by lift-off to define the electrodes for bilayer measurements. Figure 1 shows four sets of thin-film gold electrodes fabricated in this manner, and Figure 2 shows a DIB formed on top of gold electrodes. In addition, we are exploring direct printing methods with silver nanowire ink using a process developed by Hu, et al.[3] After fabrication of candidate designs, electrical measurements will be used to characterize bilayer formation along with collective images to examine droplet wetting on the patterned surfaces. Together, these recordings will be used to fine-tune the planar geometry and thickness of the electrode to enable consistent contact with the aqueous droplet interior for measuring ion transport with minimal droplet wetting.

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[1] Mary-Anne Nguyen and Stephen A. Sarles, in *ASME 2014 Smart Materials, Adaptive Structures and Intelligent Systems* (Newport, RI, 2014), Vol. 2.

[2] Jonathan B. Boreyko, Georgios Polizos, Panos G. Datskos, Stephen A. Sarles, and C. Patrick Collier, Proceedings of the National Academy of Sciences 111 (21), 7588 (2014).

[3] R. Z. Li, A. Hu, T. Zhang, and K. D. Oakes, ACS Appl. Mater. Interfaces 6 (23), 21721 (2014).

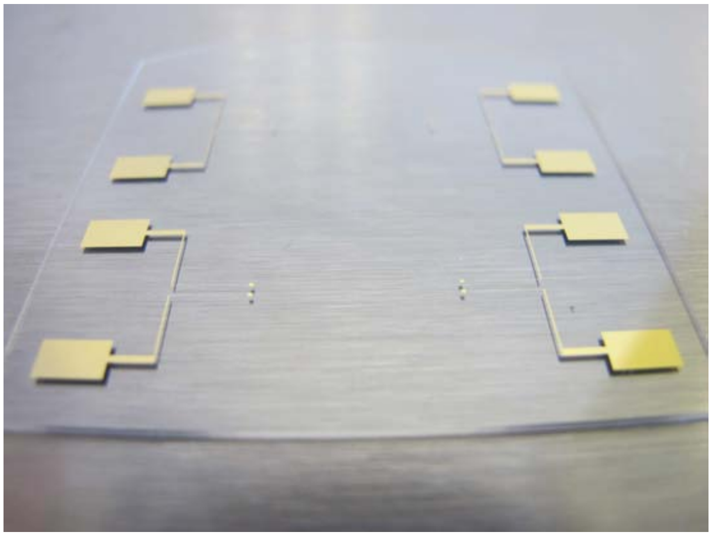

*Figure 1: Thin-film gold surface electrodes:* Four sets of gold electrodes patterned on glass.

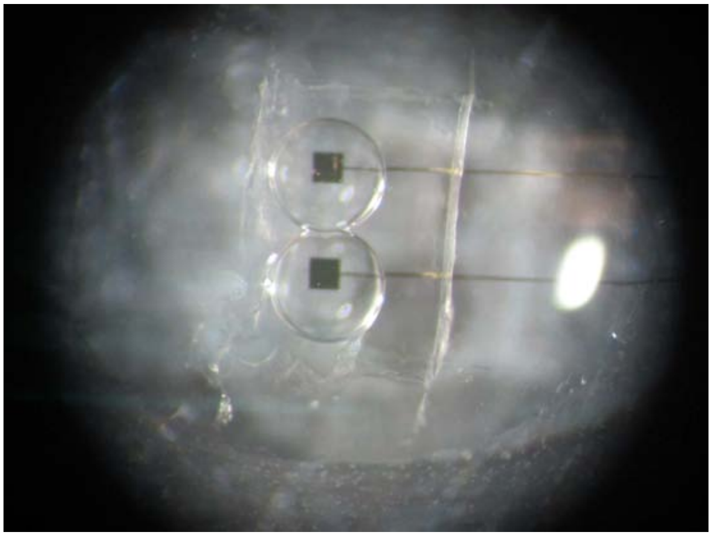

*Figure 2: DIB on top gold electrode pads:* A DIB is formed in hexadecane oil within a polymeric substrate bonded to a glass slide with the gold surface electrodes.