FMRI RET 2014-Experimental Evaluation of Electrical Response of Passivating Alloys in Different Electrolytes

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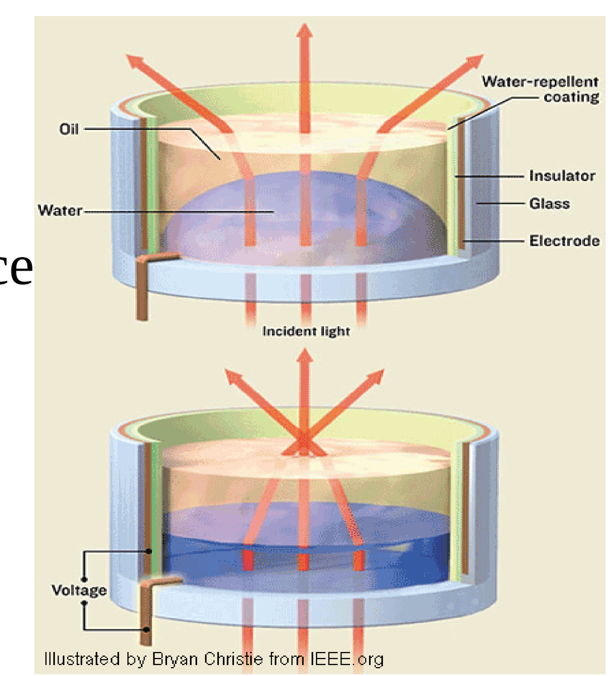
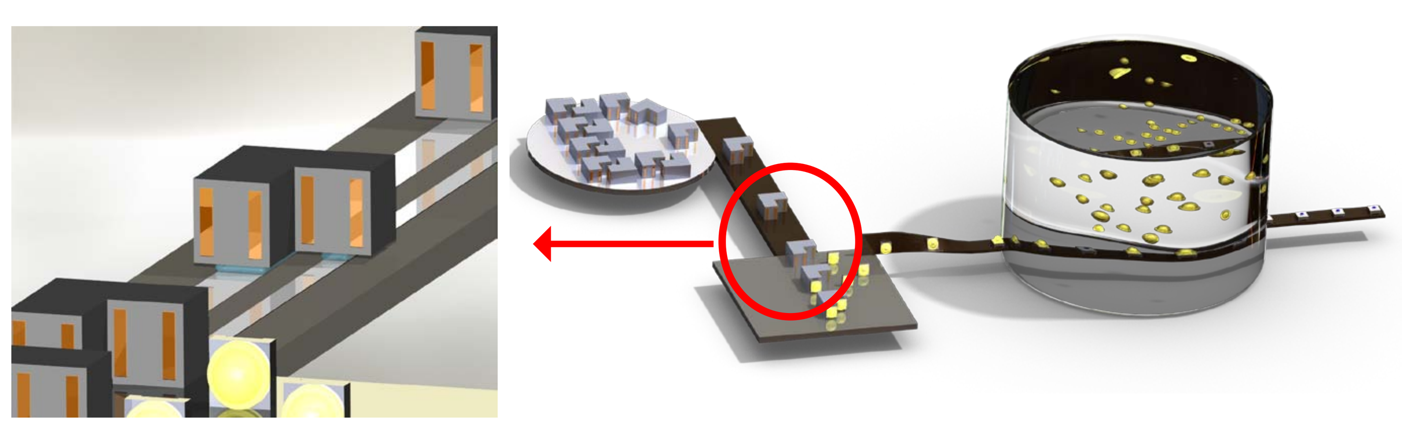
Abstract

Continuous electrowetting (CEW) is an evolution in conventional electrowetting (EW) in which two electrodes are used instead of multiple electrodes. CEW allows a more rapid transportation of micro-droplet as well as a more simplified control scheme. In CEW, metal electrodes are combined with electrolyte solutions to create a series of diodes by etching/passivating the metal in different location of the droplet. For long term reliability, CEW requires the use of metal electrodes and electrolyte solutions that can not only withstand chemical etching but also provide diode behavior in repeated electric cycling.

Background

Current applications of EW include display technology and micro lenses (right). Research in EW is now focused on enhancing the performance of electro-chemical diodes for long-term use in fluid transportation (below). Through the use of different metal-electrodes, electrolytes, and dielectric materials, there have been significant breakthroughs in the field.





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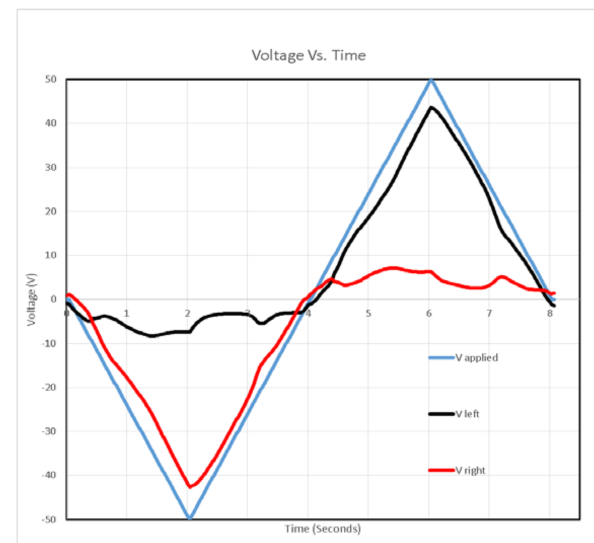
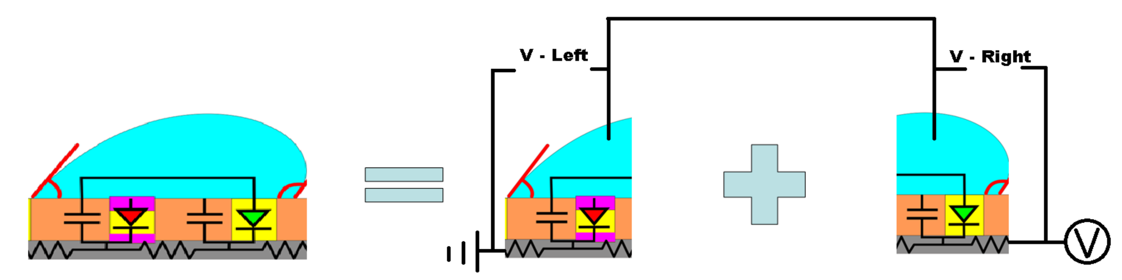
Objectives

To determine which combination of electrode metal and electrolyte solution sustain less degradation after 2000 cycles.

Approach

Circular tubes are attached to the top of a wafer with desired electrode. The tubes are filled with electrolyte solution and are connected by a wire. A voltage ramp is supplied and the total applied voltage on one side of the droplet/diode voltage and current is measured. The actuation coefficient is calculated to compare the performance of each electrode/electrolyte combination.





$$V_{right} = V_{app.} - V_{left}$$

Actuation Coefficient

For a grounded droplet, the force can be approximated by

$$\vec{F} = \frac{\epsilon \pi r}{4d} V_{max}(V_{max} - 2V_{drop})$$

For an ideal diode, $V_{drop} = 0$. So the ideal force will be

$$\vec{F} = \pm \frac{\epsilon \pi r}{4d} V_{max}^2$$

Taking the ratio of F_{actual}/F_{ideal}, the activation coefficient is defined as

$$\eta_{actuation} = \left| \frac{\frac{\epsilon \pi r}{4d} V_{max}(V_{max} - 2V_{drop})}{\frac{\epsilon \pi r}{4d} V_{max}^2} \right| = \left| 1 - 2\frac{V_{drop}}{V_{max}} \right|$$

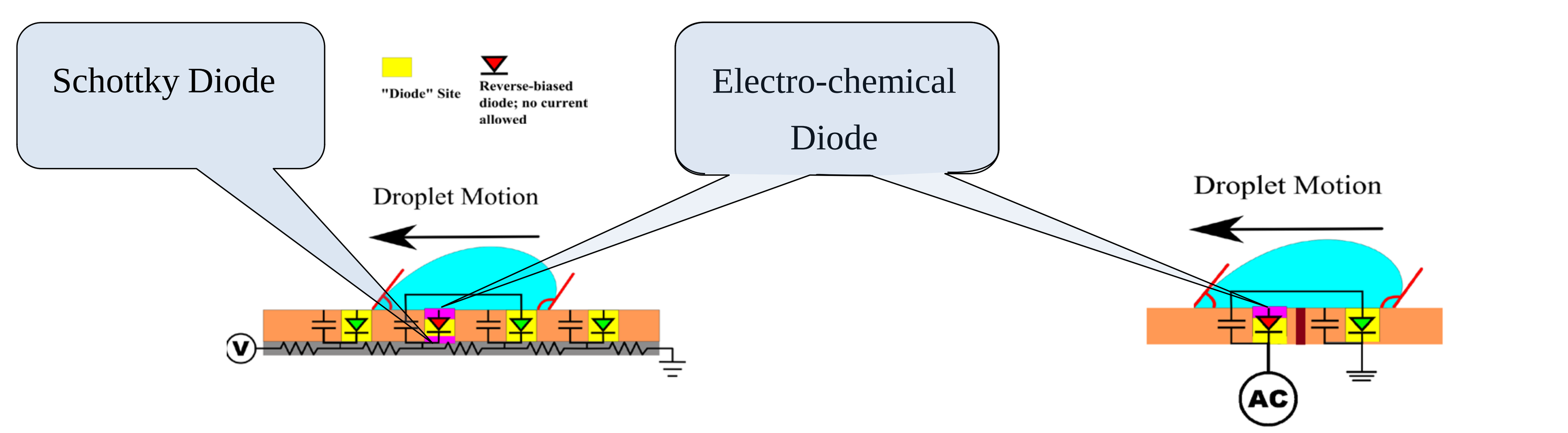
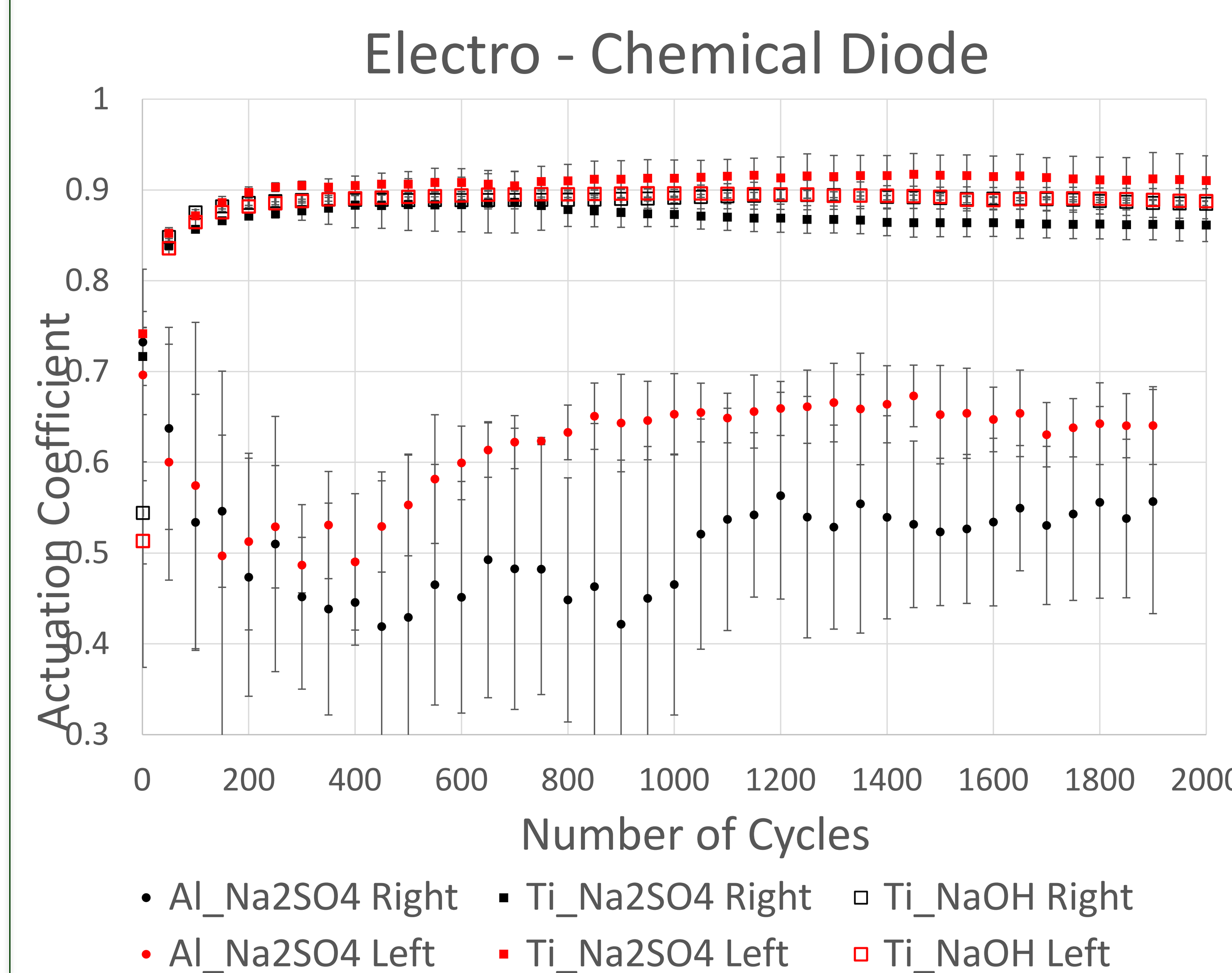
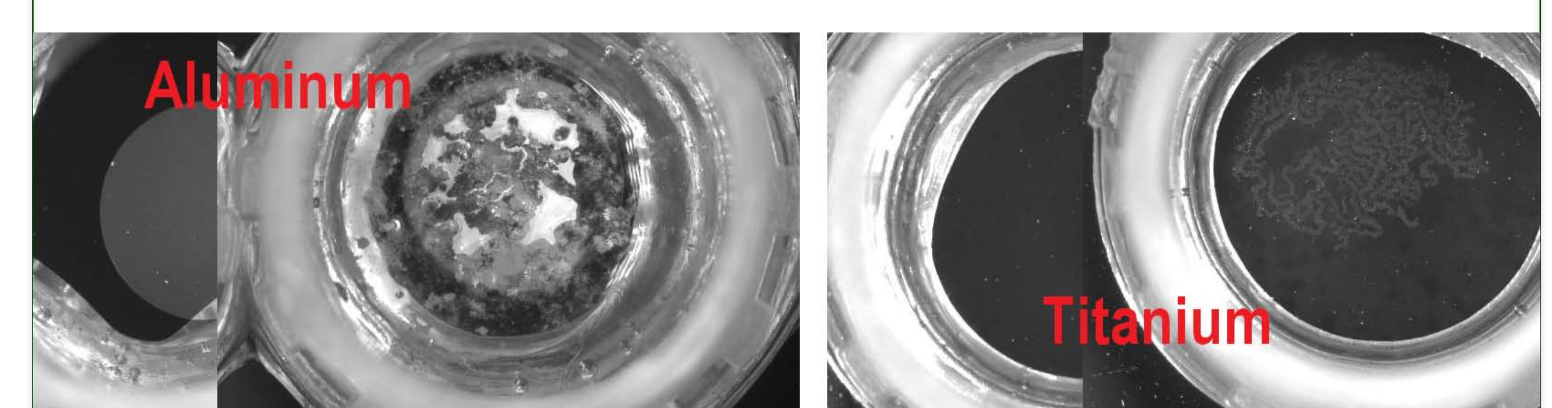


Figure above shows the motion of a droplet due to two types of diodes: A metal/semiconductor Schottky diode and electro-chemical diode. Both diodes are critical to the application of CEW.

Conclusions

- Titanium in Na_2SO_4 and NaOH solutions performed better than aluminum as shown on graph.
- There is less etching of titanium over 2000 cycles as shown on picture below.





Etching after 2000 cycles

Referenced Resources

1. IEEE Organization "Through a Lens Sharply" B. Hendriks & S. Kuiper http://spectrum.ieee.org/biomedical/imaging/through-a-lens-sharply web 28 July 2014.

*For more information about the program visit: http://fmri-ret.eng.usf.edu/. The Research Experience for Teachers (RET) at the Functional Materials Research Institute at USF is funded by the National Science Foundation under award number 1301054.