Synthetic Neural Interface

Jason Farkas / Electrical Engineering Major / Ventura Community College / farkasjason@hotmail.com

Introduction and Purpose

Abstract :

Ever since Hans Berger's discovery of electrical activity inside the human brain, scientists have dreamed of restoring the functionality of damaged sensory organs. Restoring a specific functionality, vision, is of particular interest to our group. The goal of this project is to create a 2-D array of electrically gated ion selective pumps for neural stimulation to restore vision in patients with retinal degenerative diseases.

Summer Research Goals:

Test and fabricate a conjugate polymer for an ion pump. Ensure the polymer meets the 4 criteria: electrically conductive, permeable to potassium ions, membrane is stability in an aqueous environment, and a reversible reduction / oxidation cycle.

Test and fabricate an ion pump from the conjugate polymer. Using cyclic voltammetry ensure ion transport stops when off, engages when turned on, and only passes potassium ions(if loaded with a selective intermeidate region).

Neural Interface Diagram

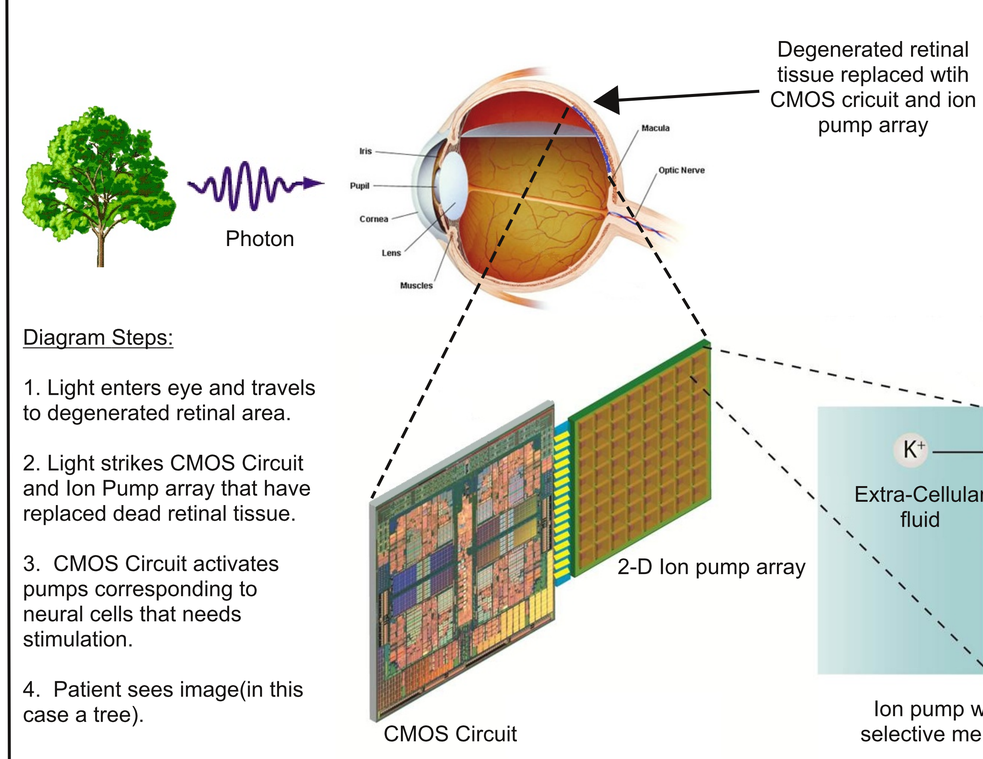


Diagram Steps:

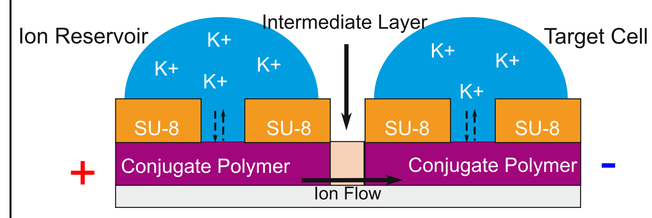
1. Light enters eye and travels to degenerated retinal area.

2. Light strikes CMOS Circuit and Ion Pump array that have replaced dead retinal tissue.

3. CMOS Circuit activates pumps corresponding to neural cells that needs stimulation.

4. Patient sees image(in this case a tree).

Pump Details

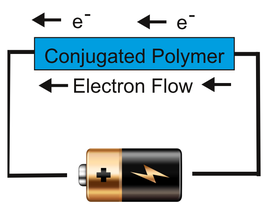


Conjugated Polymer enables a electric field to be created around intermediate region. This drives cations from one reservoir to another. Since ions must pass through polymer, it is crucial polymer is permeable to ions.

Experiments and Results

Polymer Testing:

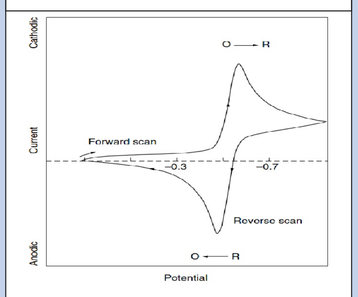
Electrically Conductive



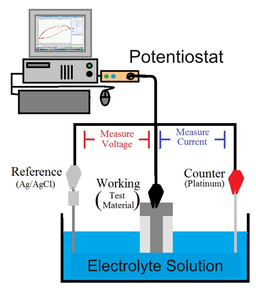
Tested with Multimeter

*Also used to measure resistance

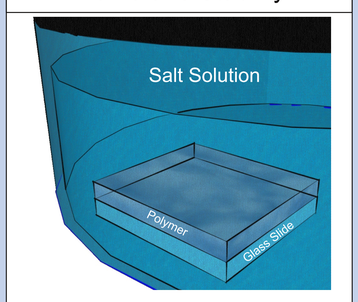
Reversible Red/Ox



Tested with Cyclic Voltammetry



Membrane Stability



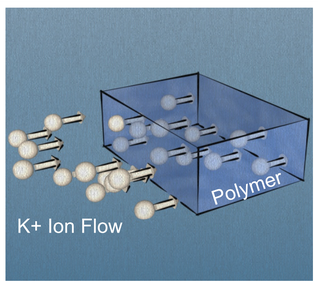
Tested with Sample Submersion

Leave submerged 24hrs

Shake/Stir Solution

Blast with Dionized water

K+ Permability



Polymers Tested

Polyurethane
Polyurethane w/ TCNQ-HE
PEDOT:PSS
PEDOT:PSS w/ Silquest 187A
Polyaniline (PANI)
PEDOT / PANI Copolymer
PANI Plated PEDOT

Results

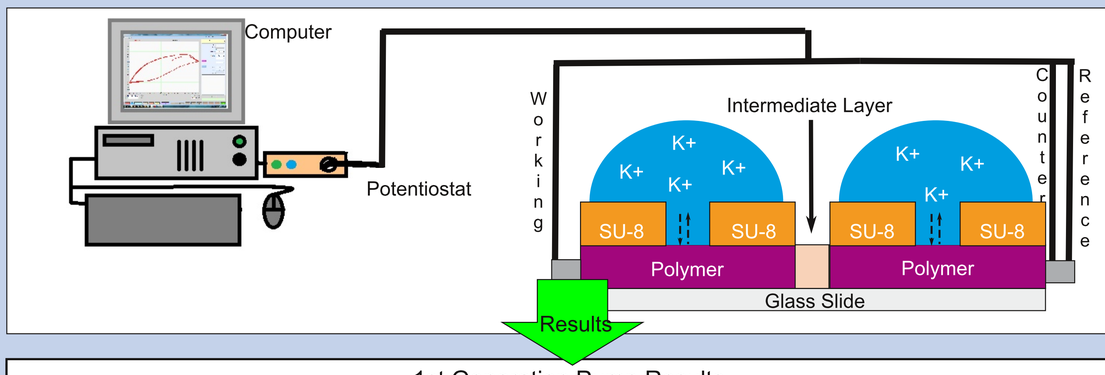
	Conductive	Membrane Stability	Reversible Red/Ox
Polyurethane	✗	✓	✗
Polyurethane w/ TCNQ-HE	✓	✗	✗
PEDOT:PSS	✓	✗	✗
PEDOT:PSS w/ Silquest	✓	✓	✓
Polyaniline	✓	✗	✗
PEDOT/PANI Copolymer	✓	✗	✗
PANI Plated On PEDOT	✓	✓	✗

PEDOT:PSS with Silquest 187A, which is an epoxy functional silane, posses all three traits that we are looking for. The 4th trait, Potassium Ion permability is tested at the same time as pump operations.

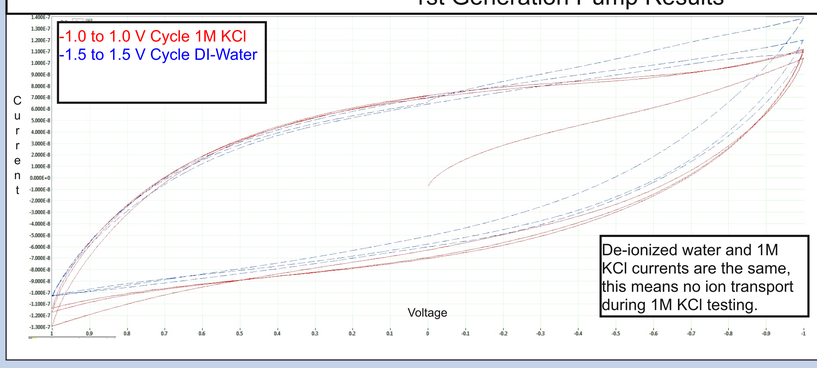
Three different blends of PEDOT:PSS were tested, Clevios P, Clevios PH-1000, and Clevios PH-1000 with DMSO.

2000 RPM with Clevios PH-1000 baked at 100 C for 10 mins offers most uniform coating.

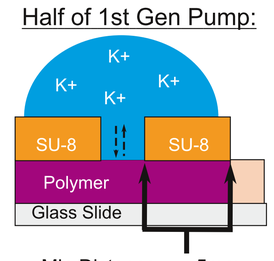
Pump Testing:



1st Generation Pump Results



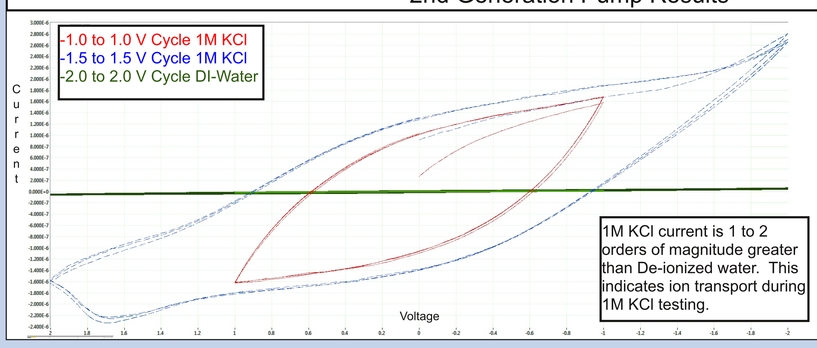
Half of 1st Gen Pump:



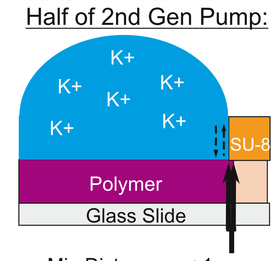
Min Distance = ~ 5mm

Weak influence from intermediate electric field due to large distance.

2nd Generation Pump Results



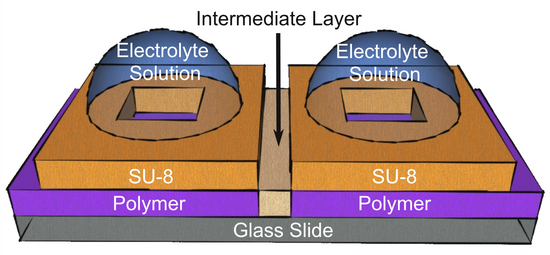
Half of 2nd Gen Pump:



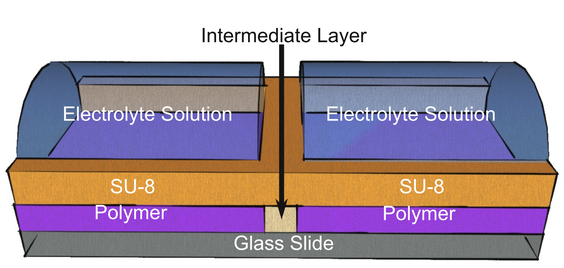
Min Distance = < 1 mm

Strong influence from intermediate electric field due to short distance.

3-D View of 1st Generation Pump



3-D View of 2nd Generation Pump



Conclusion

Conclusion:

PEDOT:PSS with Silquest 187A, a functional epoxy silane, is the polymer that best suits are purpose. The ion pump itself requires further improvements before quantitative data can be collected for proof of ion movement though the 2nd generation pump design has proven the concept of ion transportation. Further study of voltage vs rate of ion flow and ion selectivity can now be examined, however we need a way to manufacture uniform devices for quantitative analysis.

Acknowledgements

JOAKIM ISAKSSON1, PETER KJA¨ LL, DAVID NILSSON, NATHANIEL D. ROBINSON, MAGNUS BERGGREN1 AND AGNETA RICHTER-DAHLFORS, "Electronic control of Ca2+ signalling in neuronal cells using an organic electronic ion pump" , *Nature(VOL 6 SEPTEMBER 2007)*, 673-679

G.M. El-Enany, M.A. Ghanem, M.A. Abd El-Ghaffar, "Electrochemical Deposition and Characterization of Poly(3,4-ethylene dioxythiophene), Poly(aniline) and their Copolymer onto Glassy Carbon Electrodes for Potential Use in Ascorbic Acid Oxidation", *Portugaliae Electrochimica Acta 2010*, 28(5), 336-348

Dr. Luke Theogarajan, Samuel Beach, and Chris Nakamoto

INSET, NSF, NIH