# The University of Arizona

## *Chemical and Environmental Engineering Department – Seminar*

## ®"Polymers that Remember: Using protons and electrons to impart plasticity to semiconductors"

**Alberto Salleo, PhD**
**Professor and Chair**
**Department of Materials Science**
**Stanford University**

**Monday, November 16, 2020 – 3:00-3:50 PM**
**Zoom:** https://arizona.zoom.us/j/99357350715

***Stick around for more Q&A after the seminar***

## ABSTRACT

Organic semiconductors have been traditionally developed for making low-cost and flexible transistors, solar cells and light-emitting diodes. In the last few years, emerging applications in health care and bioelectronics have been proposed. A particularly interesting class of materials in this application area takes advantage of mixed ionic and electronic conduction in certain semiconducting polymers. Indeed, the ability to transduce ionic fluxes into electrical currents is useful when interacting with living matter or bodily fluids. My talk will focus on using these materials in polymer-based artificial synapses.

The brain can perform massively parallel information processing while consuming only ~1- 100 fJ per synaptic event. I will describe a novel electrochemical neuromorphic device that switches at record-low energy (<0.1 fJ projected, <10 pJ measured) and voltage (< 1mV, measured), displays >500 distinct, non-volatile conductance states within a ~1 V operating range. Furthermore, it achieves record classification accuracy when implemented in neural network simulations. Our organic neuromorphic device works by combining ionic (protonic) and electronic conduction and is essentially similar to a concentration battery. The main advantage of this device is that the barrier for state retention is decoupled from the barrier for changing states, allowing for the extremely low switching voltages while maintaining non-volatility. Our synapses display outstanding speed (<20 ns) and endurance achieving over $10^9$ switching events with very little degradation all the way to high temperature (up to 120°C). These properties, which are unheard of in the realm of organic semiconcuctors, are very promising in terms of the ability to integrate with Si electronics to demonstrate online learning and inference. When connected to an appropriate access device our device exhibits excellent linearity, which is an important consideration for neural networks that learn with blind updates. Finally, the inherent compatibility of these polymers with living matter can be exploited to use a chemical signal, such as dopamine secreted from cells to generate electronic updates to the device, as a first step towards integrated brain-machine interfaces.

## BIOSKETCH

Alberto Salleo is currently Full Professor of Materials Science and Department Chair at Stanford University. Alberto Salleo holds a *Laurea* degree in Chemistry from *La Sapienza* and graduated as a Fulbright Fellow with a PhD in Materials Science from UC Berkeley in 2001. From 2001 to 2005 Salleo was first post-doctoral research fellow and successively member of research staff at Xerox Palo Alto Research Center. In 2005 Salleo joined the Materials Science and Engineering Department at Stanford as an Assistant Professor in 2006. Salleo is a Principal Editor of MRS Communications since 2011.While at Stanford, Salleo won the NSF Career Award, the 3M Untenured Faculty Award, the SPIE Early Career Award, the Tau Beta Pi Excellence in Undergraduate Teaching Award, and the Gores Award for Excellence in Teaching, Stanford's highest teaching award. He has been a *Thomson Reuters Highly Cited Researcher* since 2015, recognizing that he ranks in the top 1% cited researchers in his field.

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