Plastic electrochemical devices: from wearable sweat sensors to artificial synapses

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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 case 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 presentation will focus on two families of devices made with such materials: electrochemical transistors and artificial synapses.

1- Wearable sensors using electrochemical transistors: The continuous monitoring of human health can greatly benefit from devices that can be worn comfortably or seamlessly integrated in household objects, constituting "health-centered" domotics. I will describe electrochemical transistors that detect ionic species either directly present in body fluids or resulting from a selective enzymatic reaction (e.g. ammonia from creatinine) at physiological levels. Additionally, I will show that non-charged molecules can be detected by making use of custom-processed polymer membranes that act as "synthetic enzymes". Using these membranes in conjunction with electrochemical transistors we demonstrate that we are able to measure physiological levels of cortisol in real human sweat.

2- 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, and has been cycled for over 10^6 switching events. 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.

Biography:

Alberto Salleo is currently an Associate Professor of Materials Science at Stanford University. Alberto Salleo 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 and was promoted to Associate Professor in 2013. 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 honor. He has been a *Thomson Reuters Highly Cited Researcher* in Materials Science since 2015.