Web: http://faculty.poly.edu/~mporfiri/

Title: Modeling ionic polymer metal composites: where we are and where we should be

Abstract: Ionic polymer metal composites (IPMCs) are a promising class of soft active materials. Their high compliance, low actuation voltage, and ability to operate in wet environments have motivated two decades of intensive research on IPMC actuators. While we have witnessed several breakthroughs in the technology of IPMCs, from additive manufacturing of IPMCs to IPMC-based robots, our understanding of the physical underpinnings of their actuation remains elusive. There is a paucity of continuum physically-based models to investigate IPMC actuation and sensing. Presently, the literature relies on either black-box lumped models, whose parameters are experimentally identified from data, or phenomenological distributed models, constructed upon classical beam theory. In this sense, we know little about multiaxial deformations elicited by counterions' diffusion and electromigration through the ionomer. In this talk, we present a novel physics-based modeling framework that describes the chemoelectromechanical behavior of IPMCs and, especially, resolves the complex interface phenomena taking place in the vicinity of the electrodes. The chemoelectromechanical constitutive behavior is obtained from a Helmholtz free energy density, which accounts for mechanical stretching, ion mixing, and electric polarization. Focusing on experimental observations, we demonstrate the application of the framework to study both actuation and sensing through a combination of perturbation methods and finite element analysis.

Bio: Maurizio Porfiri is a Professor in the Department of Mechanical and Aerospace Engineering at New York University Tandon School of Engineering. He received M.Sc. and Ph.D. degrees in Engineering Mechanics from Virginia Tech, in 2000 and 2006; a ‘Laurea” in Electrical Engineering (with honours) and a Ph.D. in Theoretical and Applied Mechanics from the University of Rome “La Sapienza” and the University of Toulon (dual degree program), in 2001 and 2005, respectively. He is engaged in conducting and supervising research on dynamical systems theory, multiphysics modeling, and underwater robotics. Maurizio Porfiri is the author of more than 275 journal publications and the recipient of the National Science Foundation CAREER award. He has been included in the “Brilliant 10” list of Popular Science in 2010 and his research featured in all the major media outlets, including CNN, NPR, Scientific American, and Discovery Channel. Other significant recognitions include invitations to the Frontiers of Engineering Symposium and the Japan-America Frontiers of Engineering Symposium organized by National Academy of Engineering; the Outstanding Young Alumnus award by the college of Engineering of Virginia Tech; the ASME Gary Anderson Early Achievement Award; the ASME DSCD Young Investigator Award; and the ASME C.D. Mote, Jr. Early Career Award.