Energy Harvesting from Fluids Using Ionic Polymer Metal Composites

M. Porfiri

Department of Mechanical and Aerospace Engineering,
Polytechnic Institute of New York University, Brooklyn, NY 11201

Abstract:

In this talk, we discuss energy harvesting from steady, oscillatory, and unsteady water flows using Ionic Polymer Metal Composites (IPMCs). After a brief description of this new class of active materials and their ability to transduce strain energy into electrical form, we propose a modeling scheme based on the Poisson-Nernst-Planck framework to describe their complex chemoelectrical response to an imposed mechanical deformation. We utilize the method of matched asymptotic expansions to compute a closed-form solution for the electric potential and counterion concentration in the IPMC. The model predicts that IPMC sensing is independent of the time rate of deformation and linearly correlated to the mechanical curvature, with a coefficient of proportionality that is a function of the ionomer thickness and the thermal voltage. We present a few case studies spanning this broad range of flow environments, spanning base excitation, impulsive loading from an impinging vortex ring with an IPMC, and impact on the free surface of a quiescent fluid. Analytical insight on the mechanics of the coupled fluid-structure problem is used to interpret experimental results and provide design guidelines for sensors and energy harvesters based on active compliant materials in fluids.

Bio:

Maurizio Porfiri was born in Rome, Italy in 1976. 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. From 2005 to 2006 he held a Post-doctoral position with the Electrical and Computer Engineering Department at Virginia Tech. He has been a member of the Faculty of the Mechanical and Aerospace Engineering Department of the Polytechnic Institute of New York University since 2006, where he is currently an Associate Professor. 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 135 journal publications and the recipient of the National Science Foundation CAREER award (Dynamical Systems program) in 2008. 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 an invitation to the Frontiers of Engineering Symposium organized by National Academy of Engineering in 2011, the Outstanding Young Alumnus award by the college of Engineering of Virginia Tech in 2012, the ASME Gary Anderson Early Achievement Award by in 2013, and the ASME DSCD Young Investigator Award in 2013.