Sensing in a Multi-segment Buckled Beam Ionic Polymer-Metal Composite (IPMC) Artificial Muscle

J. M. Rossiter[a], *B. L. Stoimenov*[b] *and T. Mukai*[b]
[a] University of Bristol, Bristol, BS8 1TR, UK, Jonathan.Rossiter@bris.ac.uk ,
[b] The Institute of Physical and Chemical Research, Riken, Biomimetic Control Research Center, 2271-130, Anagahora, Shimoshidami, Moriyama-ku, Nagoya, 463-0003, Japan{stoimenov,tosh}@bmc.riken.jp.

In this paper we examine the sensing capabilities of multi-segment ionic polymer-metal composite (IPMC) artificial muscles, a characteristics of multi-segment IPMCs that has largely been overlooked[1,2]. Here we focus on the buckled beam and linear actuator configurations[3] and the comparison of these multi-segment structures with simple one-segment actuators in the same configuration. We show how a three segment IPMC strip is a more effective mechanism for measuring linear (axial) deflection than a single segment strip. We also show how the multi-segment IPMC strip can be used to estimate sideways deflection of the end point by measuring the individual response of each segment. A sensor/actuator of this form has the potential for use as an active tip for remote probing, where 2-DOF actuation and sensing of the end point is possible. Such a probe is shown in Figure 1, where the soft deformable probe tip is used to actively investigate abnormalities in some biological channel, such as an artery or intestine. Figure 2 shows an example of the sensing of axial compression in a multi-segment IPMC strip.

We further consider the case where a buckled IPMC strip is embedded in a deformable medium, such as sponge or rubber. Local or global deformations of the medium cause local or global deformations of the actuator strip. By suitable differentiation of the output from each segment, physical deformations such as global compression or sheer and localised pressure can be measured. Applications of these embedded structures include tactile sensing elements and small structural support elements that detect compression and sheer.

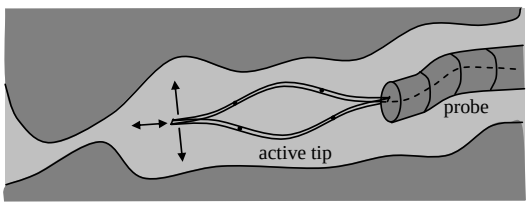

Figure 1. Application of a multi-segment actuator/sensor as a deformable active probe tip

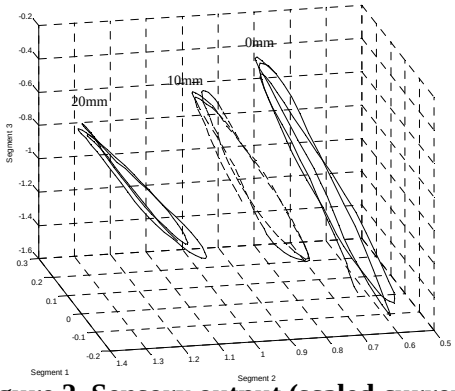

Figure 2. Sensory output (scaled current) of a 100mm×5.5mm, three-segment, buckled IPMC strip in response to a 12.5mm, 2.4Hz sine displacement input, for pre-load displacements of 0mm, 10mm, and 20mm

[1] C. Bonomo, L. Fortuna, P. Giannone, S. Graziani, S. Strazzeri, "**A model for ionic polymer metal composites as sensors**," *Smart Materials and Structures*, 15, pp.749-758, 2006
[2] K. J. Kim, W. Yim, J. W. Paquette, D. Kim, "**Ionic Polymer-Metal Composites for Underwater Operation**," *Journal of Intelligent Material Systems and Structures*, Vol. 18, No. 2, 123-131 (2007)
[3] J. M. Rossiter, B. L. Stoimenov, T. Mukai, "**A Linear Actuator from a Single Ionic Polymer-Metal Composite (IPMC) Strip**," Electroactive Polymer Actuators and Devices

(EAPAD) 2007. Edited by Y. Bar-Cohen, *Proceedings of the SPIE*, Volume 6524, pp.65241B, 2007