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Force and displacement characteristics of an artificial sarcomere unit

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Natural muscle is a sophisticated biological actuator composed of a vast array of serial and parallel functional units – the sarcomeres. Currently no human made actuator has so highly serialized and parallelized structure. Soft polymer actuators can achieve relatively high strains and large displacements and are suitable for miniaturization. However a problem for many types of polymer actuators is that unlike natural muscle they do not contract, but bend under actuation. We have proposed a linear actuator design based on bending and buckling [1, 2], which can be easily serialized and parallelized (Fig. 1). In order to predict the scaling of such large structure we investigate the displacement and the force characteristics of a simplified version of the basic building block – the artificial sarcomere shown in Fig. 2. It consists of a pair of multi-segment IPMC (ionic polymer metal composite) strips, which buckle under actuation.

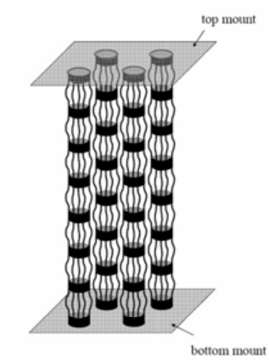

Fig. 1. Concept of a highly serialized and parallelized artificial muscle

Due to the geometry of buckling - the contraction along the actuator is related non-linearly to the applied voltage (Fig. 3) and is roughly 0.4 mm/V on the tested unit. Maximum observed blocked force (Fig. 4) at 3V was around 18 mN from the low range values, which is roughly 6 mN/V.

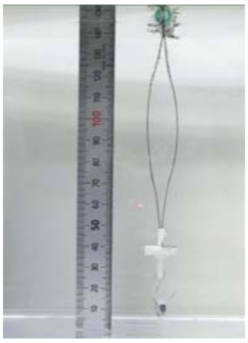

Fig. 2. Artificial sarcomere unit, made of two multi-segment IPMC strips

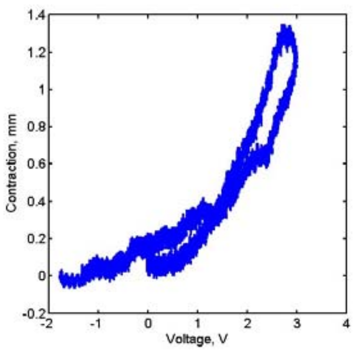

Fig. 3. Contraction of the artificial sarcomere under slowly varying voltage.

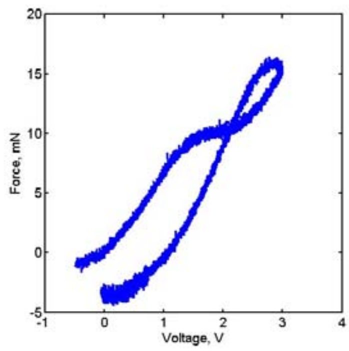

Fig. 4. Blocked force of the artificial sarcomere under slowly varying voltage.

[1] 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.
[2] B. L. Stoimenov, J. M. Rossiter, T. Mukai, "**Manufacturing of ionic polymer metal composites (IPMCs) that can actuate into complex curves**," Electroactive Polymer Actuators and Devices (EAPAD) 2007. Edited by Y. Bar-Cohen, *Proceedings of the SPIE*, Volume 6524, pp. 65240T, 2007.

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