Effect of Pre-strain on the Antagonistically Driven Dielectric Polymer Actuator

J. C. Koo¹, a, Kwang-Mok Jung¹, b, Min-Young Jung¹, c, Hyoukryeol Choi¹, d, J. D. Nam², e, and Y. K. Lee², f

¹ School of Mechanical Engineering, ² School of Applied Chemistry, Sungkyunkwan University, Suwon, Korea.

{jckoo, jungkm}@me.skku.ac.kr, {hrchoi @me.skku.ac.kr: Corresponding Author,
{picaskk, jdnam, yklee}@skku.edu

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Abstract. Many publications have demonstrated advantages of smart polymer actuators over the traditional electromagnetic transducers. One of the most significant contributions of the polymers might be their soft actuation mechanism. Hence unlike the traditional actuators, there is morphological freedom for actuator construction that benefits production of either small scale complex mechanisms or human-like applications. Although many different actuation paradigms of polymer actuators presented in previous publications, no significant contributions are made for the actual industrial applications. A noble idea for acquiring controllable actuation is antagonistic drive mechanism of dielectric elastomer. The mechanism provides fairly accurate controllable motion and relatively large actuation forces. A strong dependency to pre-strain of the polymer is however one of the major constraints of the actuator driving mechanism. A detailed characterization of pre-strain effects should be done for the successful construction of the actuators. Hence an experimental and theoretical consideration about mutual effects of pre-strain and actuator performance is to be presented in the present work.

Introduction

Recently, electroactive polymers (EAPs) are widely investigated by researchers in various fields from medical to robotic applications mainly because they provide higher energy efficiency, light weight, and flexible architecture compare to the traditional electromagnetic actuators. EAPs are normally classified by ionic properties and those including ionic polymer metal composite (IPMC), conducting polymer (CP), polymer gels, dielectric elastomer, and piezoelectric polymer are adopted for new kinds of transducer constructions. However most of them have many technical problems so it is yet far from actual implementation for industry applications.

Although ionic polymers such as IPMC (Ionic Polymer Metal Composite) have been popular for the actuator development, non-ionic polymers like dielectric elastomers are to be often employed for the actuators because of its operating conditions so-called “dry operation”. The dry operation environment benefits commercialization of the actuators. And those non-ionic polymer actuators guarantee not only simple fabrication process but also longer life time. There are a few dielectric elastomers such as polyurethane and silicone are currently available for either laboratory or industry level applications.

The principle physics for the operation of the material as an actuator is that the polymer intrinsically deforms either in expanding or in contracting when electrical voltage is applied at its surfaces. Although numerous authors recently have presented many different polymer actuation concepts, few of the literatures demonstrate controllable actuator system that can be implemented with simple control laws. In the present work, an antagonistically configured dielectric elastomer actuator is presented. Given the material and the geometrical constraints which should be well