Accepted Manuscript

Towards Fully Polymeric Electroactive Micro Actuators with Conductive Polymer Electrodes

Jenny Shklovsky, Amir Reuveny, Yelena Sverdlov, Slava Krylov, Yosi Shacham-Diamand

PII: S0167-9317(18)30337-X
DOI: doi:10.1016/j.mee.2018.07.012
Reference: MEE 10836

To appear in: *Microelectronic Engineering*

Received date: 28 March 2018
Revised date: 27 June 2018
Accepted date: 21 July 2018

Towards Fully Polymeric Electroactive Micro Actuators with Conductive Polymer Electrodes

Jenny Shklovsky [a], Amir Reuveny [a,1], Yelena Sverdlov [a], Slava Krylov [b], Yosi Shacham-Diamand [a]

[a] *School of Electrical Engineering, Faculty of Engineering, Tel Aviv 69978 University, Tel Aviv, Israel*

[b] *School of Mechanical Engineering, Faculty of Engineering, Tel Aviv 69978 University, Tel Aviv, Israel*

Abstract

The performance of micro devices actuated using electroactive polymers is often limited by the high stiffness of metallic electrodes, which prevents the the polymeric components extension. In this work we report on an approach allowing to reduce the use of metals to minimum by incorporating of softer conductive polymer electrodes. A multilayered actuator incorporating polyimide (PI) substrate and a thin electroactive polymer (EAP) layer of P(VDF-TrFE-CFE) squeezed between polyaniline (PANI) electrodes was fabricated and characterized. The PANI layer was electrodeposited on the electroactive structures using cyclic voltammetry . Our results show that while the use of conjugate conductive polymer electrodes is feasible, the influence of the thin metallic seed layers required for electro-deposition is significant. The proposed electro-deposition based polymeric process is highlighted by its simplicity and relatively low cost, compared to common Physical Vapor Deposition processes, and can be extended to other polymers.

Keywords: Polymeric MEMS, microprocessing, electropolymerization, conductive polymer, polyaniline, flexible actuator

1. Introduction

Conductive polymers (CP) are flexible and relatively inexpensive materials, offering low elastic modulus and high resilience [1]. They are considered as promising for implementation in soft robots and micro scale actuators. The 2000 Nobel Prize in chemistry was awarded for the discovery and development of conductive polymers [2], confirming the high interest in those materials. Polyaniline (PANI) is one of the most studied organic conducting polymers due to its electrical and optical properties, easy preparation by both electro-polymerization and chemical oxidation of aniline, good chemical, electrical and environmental stability [3].

Polymeric materials are actively used in flexible MEMS (Microelectromechanical Systems) sensors and actuators as substrates, structural or functional thin films [4]. Fabrication cost of polymeric materials is significantly lower compared to those being used for conventional MEMS materials such as silicon, ceramics, glasses or metals. Using polymers with a lower Young's modulus made possible the development of micro-actuators with reduced stiffness and larger deformations under lower driving forces, compared to silicon based devices [5, 6, 7, 8, 9].

However, metal electrodes which are necessary for the application of an electric field on the actuators, represent a mechanical constrain preventing the extension of the polymeric component. This

Email address: `Yevgeni8@post.tau.ac.il` (Jenny Shklovsky [a])

[1]Current affiliation: Jacobs Technion-Cornell Institute at Cornell Tech