Electromechanical Characterization Of Non-Uniformly Charged Ionic Polymer-Metal Composite Devices

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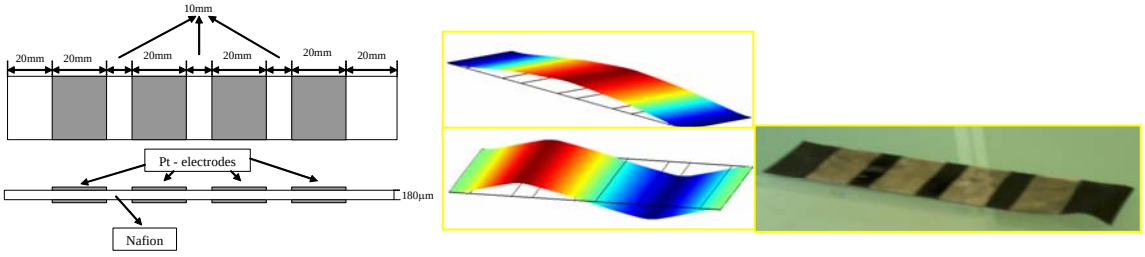
Research about electromechanical characterization of non-uniformly charged IPMC devices is quasi-absent. This has limited the use of IPMCs to only those devices where the IPMC is completely covered with electrode surfaces (uniformly charged).

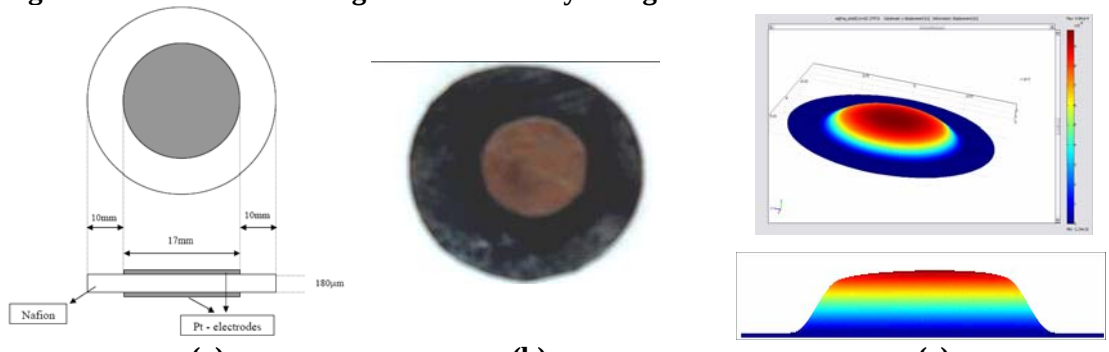
The IPMC models proposed do not allow a simple numerical analysis of IPMC devices. Some authors use a microscopic model approach [1]. Other models are so complex [2] that special FEM programs had to be developed. The bimorph beam model proposed in [3] uses a piezoelectric equivalence technique. This allows FEM analysis of IPMC devices, including the non-uniform charged ones. However, their approach shows a difficult physical interpretation.

Based on our previous work [4], we develop a theoretical study for electromechanical characterization of non-uniformly charged IPMC devices. A continuum model taking also into account the gravitational forces, important for large IPMC devices, was developed for force density and material displacement characterization. Based on this approach, FEM analysis of IPMC devices using Comsol Multiphysics is introduced in a very simple way (Figs. 1(b) and 2(c)). Two IPMC devices (Figs. 1(a,c) and 2(a,b)) with the electrodes covering only part of their membrane were studied.



(a) **(b)** **(c)**

Figure 1: First device using a non-uniformly charged IPMC.



(a) **(b)** **(c)**

Figure 2: Second device using a non-uniformly charged IPMC.

[1] Nemat-Nasser S and Li J, “Electromechanical response of ionic polymer–metal composites”, J. Appl. Phys. Vol. 87, pp. 3321–3331, 2000
[2] Y. Toi and S. Kang, Finite Element Modelling of Electrochemical-Mechanical Response of Ionic Conducting Polymer-Metal Composite Plates, SEISAN KENKYU 55, 449 2003
[3] Sangki Lee, Hoon Cheol Park and Kwang Jin Kim, “Equivalent modeling for ionic polymer-metal composite actuators based on beam theories”, Smart Materials and Structures Vol. 14, pp. 1363, 2005
[4] P.J. Costa Branco and J.A. Dente, "Derivation of a continuum model and its electric equivalent-circuit representation for ionic polymer-metal composite (IPMC) electromechanics", *Smart Materials and Structures*", Vol. 15, pp. 378-392, 2006.