

Multiphysics Simulation of a Self-heating Paraffin Membrane Microactuator

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Abstract

Active materials used in microactuators usually rely on a geometrical change created by phase change in order to generate the required force and movement. Such materials include piezoelectric materials, solid-to-solid phase change shape memory alloys and solid-to-liquid phase change materials like e.g. polyethylene and paraffin wax. Several actuator implementations have taken advantage of the paraffin's large volumetric expansion rates (up to 10-15%) during heating and phase change [1],[2],[3],[4].

This paper presents a numerical validation in COMSOL Multiphysics® of the actuator concept introduced in [4] (Figure 1). The principle of its operation lies in the Joule heating effect, through an applied current, of a mixture of paraffin wax and conducting carbon particles. As the mixture's temperature increases, it expands -eventually changing phase into liquid state- and deflects a silicon membrane, thus providing the necessary force and movement. The simulation of this multiphysics procedure takes into account Joule heating, heat transfer, thermal dilatation and solid to liquid phase change of the paraffin and fluid-structure interaction with the membrane. The calculated membrane deflection is finally compared and discussed along with the experimental results from [4].

Reference

- [1] Edwin Carlen and Carlos Mastrangelo , “Electrothermally activated paraffin microactuators,” J. Microelectromech. Syst.11(3), 165–174, 2002
- [2] Himanshu Sant et al, "An in situ heater for a phase-change-material-based actuation system", J. Micromech. Microeng. 20, 085039, 2010
- [3] Lena Klintberg et al, "A large stroke, high force paraffin phase transition actuator", Sensors and Actuators A: Physical, Volume 96, Issues 2–3, 28, 189-195, February 2002
- [4] Frank Goldschmidtboïng et al, "A novel self-heating paraffin membrane micro-actuator", Micro Electro Mechanical Systems 2008, MEMS 2008. IEEE 21st International Conference on, 531-534, 13-17 Jan. 2008

Figures used in the abstract

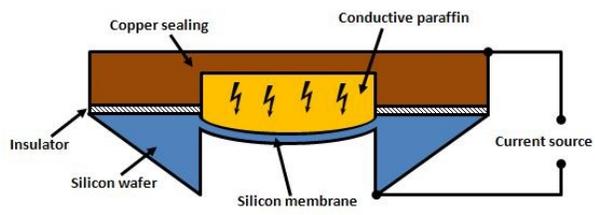


Figure 1: Paraffin self-heating phase change microactuator, adapted and simplified from [4]