Multiphysics Simulation of a Self-heating Paraffin Membrane Microactuator

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Introduction: Among the various microactuators introduced in the last years of particular interest are those based on phase change materials and especially paraffin wax, which can volumetrically expand up to 15%, providing high force actuation. This study presents the numerical simulation of such a concept [1] (Fig.1) by coupling multiple physics and phase change.

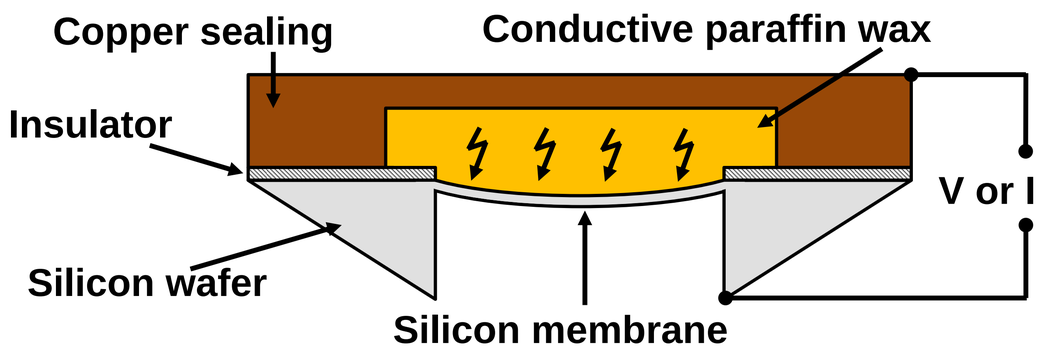

Figure 1. Paraffin self-heating phase change microactuator concept, simplified from [1]

Computational Methods: In order to solve the transient actuation problem, the electric currents, the heat transfer and the fluid-structure interfaces are used in combination with user-defined functions for the material properties change during phase transition (Fig.2). The geometry used is 2D symmetric (Fig.3).

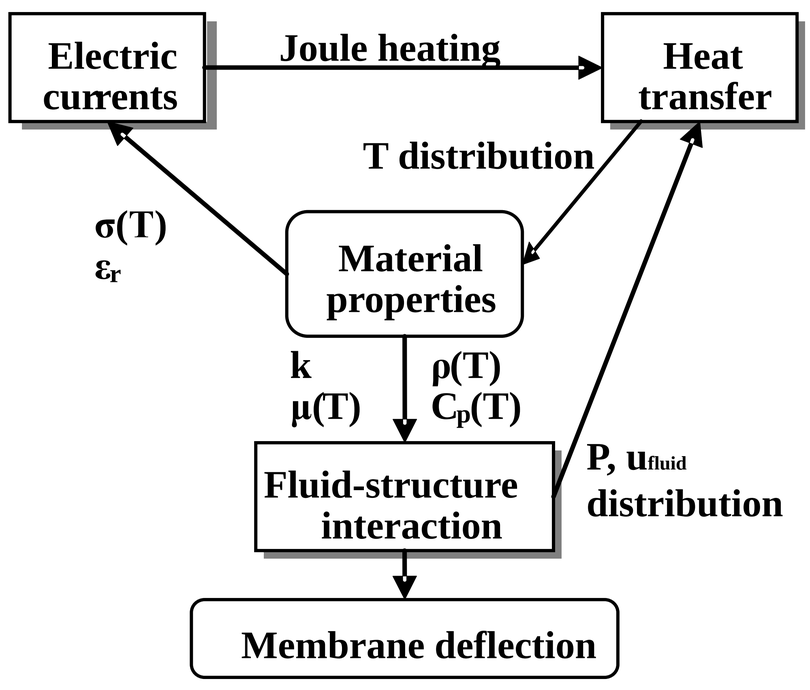

Figure 2. Simplified coupling diagram and operational loop

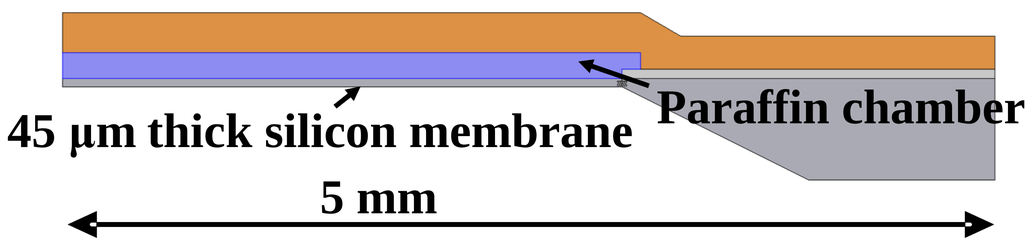

Figure 3. 2D symmetric geometry of the actuator

Results: Fig. 4 shows the phase transition and the actuator's membrane deflection for different time moments. Fig. 5 (a) presents the full mirrored geometry while (b) the comparison of simulation results with the experimental ones, showing a good accordance.

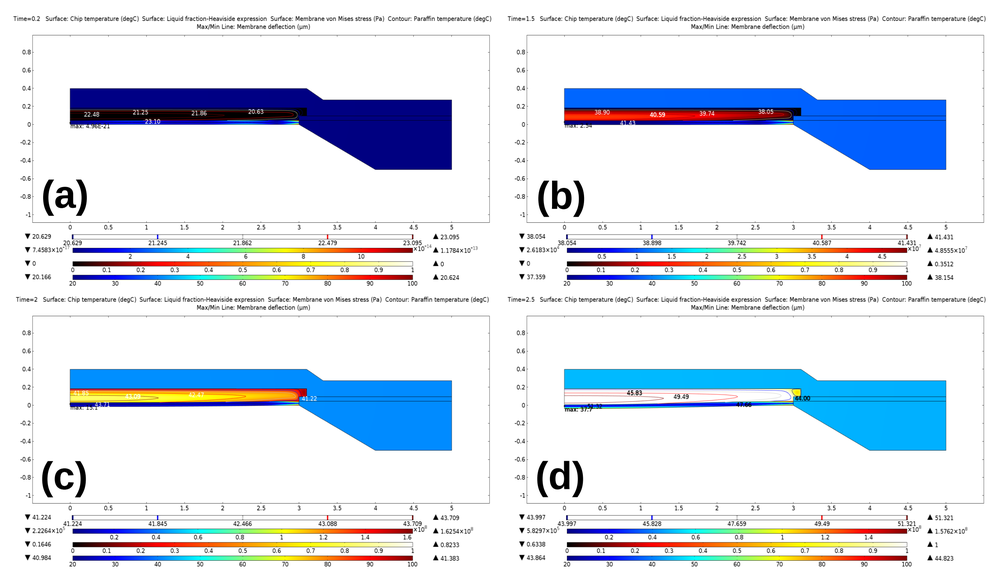

Figure 4. Phase change and membrane deflection for (a) t=0.2 s, (b) t=1.5 s, (c) t=2 s and (d) t=2.5 s

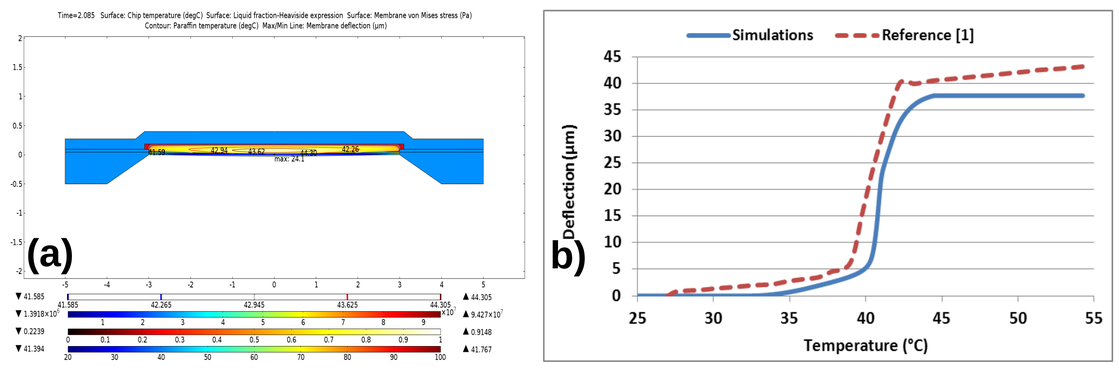

Figure 5. (a) Full actuator geometry and (b) comparison of experimental and simulation results

Conclusions: The calculated deflection of the actuator's membrane closely follows the real one, despite the approximations made due to lack of sufficient modeling data from [1]. The coupling of multiple different physics was successful and thus this kind of complex simulations can be used as a prediction and optimization tool for real experiments.

References:

1. F. Goldschmidtboing et al., "A novel self-heating paraffin membrane micro-actuator", Micro Electro Mechanical Systems 2008, MEMS 2008. IEEE 21st International Conference on, 531-534 (2008)

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