

Structure-Electrostatics Interaction in MEMS

Test name: FVM-MEMSHUB

Code: MEMOSA-FVM

Features tested: (i) Effect of structure deformation on temporal deflection of the beam (ii) Effect of approximate electrostatic force computation on temporal deflection of the beam

Description: A fixed-fixed beam is subjected to electrostatic force. FVM simulations are performed with varying conditions of structure deformation and electrostatic force computation. RMS errors in the maximum beam deflection between the FVM results and the Memshub tool results are computed to understand the differences between them.

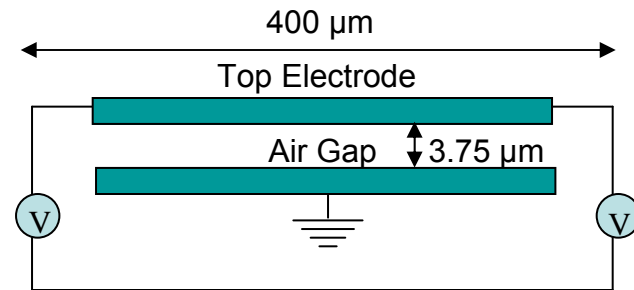
Result Summary: At low voltages, Memshub tool results for the maximum beam deflection match with FVM results. However, at higher applied voltages, differences start to appear. The non-linear structure deformation, which is not taken care of in the Memshub tool, is responsible for these differences.

Assessment: Passed.

Test Description

Overview: A fixed-fixed beam is subjected to electrostatic actuation. The objective is to compare the results obtained with the FVM solver with those obtained with the Memshub tool.

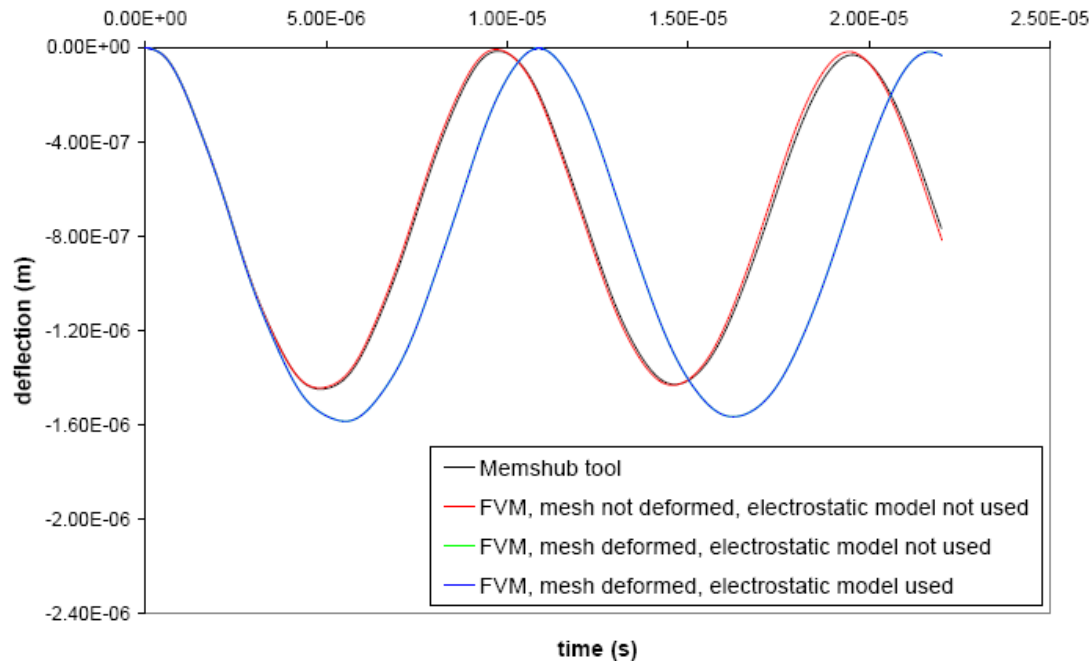
Parameter	Value
Young's Modulus	200 GPa
Poisson's ratio	0.31
Density	7854 Kg/m ³



Description: Computations are performed in MEMOSA-FVM. The beam is assumed to have zero deflection and zero velocity as the initial conditions. At time $t = 0$, beam is subjected to electrostatic actuation. The top face is a traction-free surface. The left and right faces are constrained to have zero displacement. A uniform quad mesh, of size 1000×20 is used for the computation. The timestep used is $\Delta t = 8.8043 \times 10^{-9}$ s. The FVM simulations are first performed at 160V applied voltage for three cases: (1) structure is not deformed and simplified expression of electrostatic force used, (2) structure is deformed and simplified expression of electrostatic force used, and (3) full FVM model is solved, i.e. structure is deformed and electrostatic model is solved to compute the electrostatic force. RMS errors in the maximum beam deflection between the FVM results and the Memshub tool results are computed to quantify the differences between them.

Results

Temporal Variation of Maximum Beam Deflection 160 V Applied Voltage



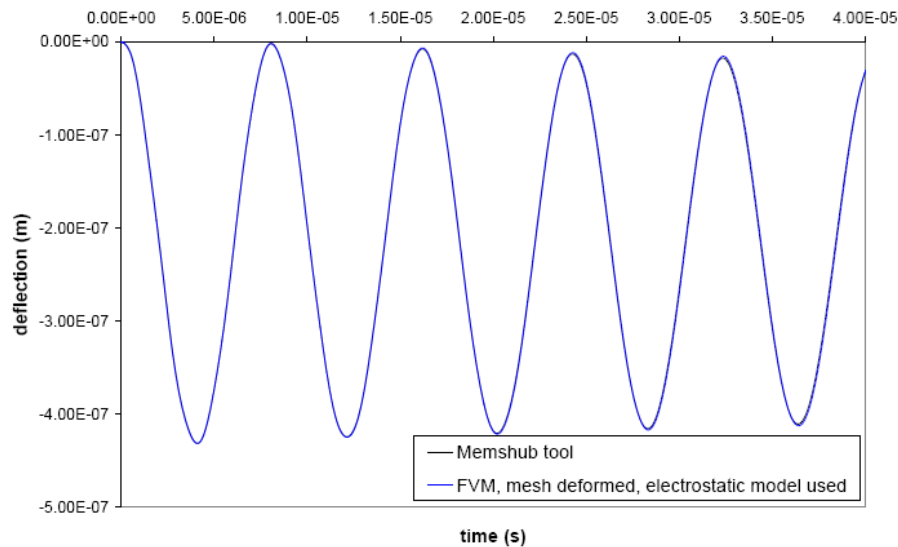
Case #	RMS error in beam deflection (m)
1	1.835e-8
2	4.149e-7
3	4.151e-7

- Approximate electrostatic force computation gives accurate results for beam deflection.
- Structure deformation primarily responsible for the difference between the results obtained with Memshub tool and full FVM model.

Effect of Applied Voltages

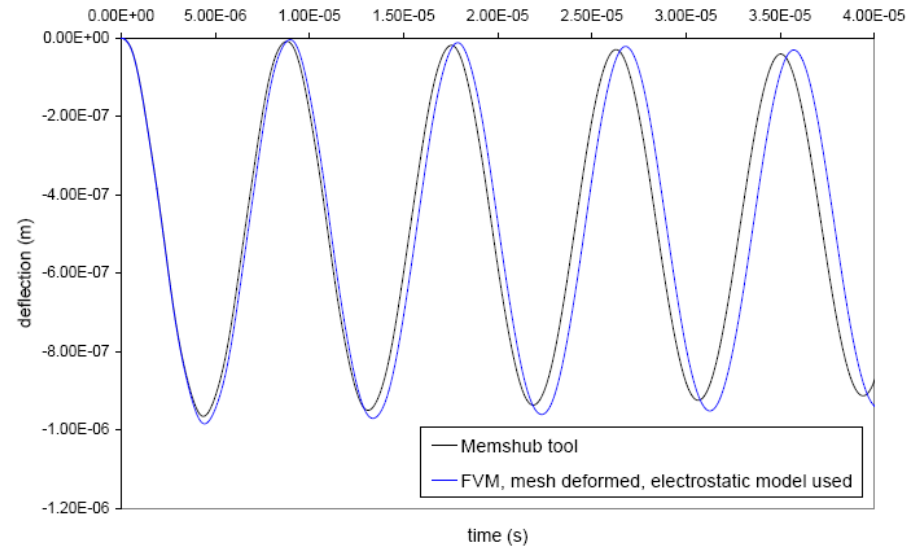
Temporal Variation of Maximum Beam Deflection

100 V



RMS Error = 1.75×10^{-9} m

140 V



RMS Error = 5.99×10^{-8} m

- Non-linear effects of structure deformation become important only at large applied voltages

Assessment

- Structure deformation is primarily responsible for difference between the results obtained with Memshub tool and FVM solver.
- The test is considered passed.