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Mechanical modeling of electrostatically actuated RF MEMS ohmic switch with two side electrodes – analysis of various loading conditions

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ABSTRACT

In this paper a 2D mechanical model is developed to analyze the behavior of the RF MEMS switches under various loading conditions and to predict the impact of the variation of selected parameters on the stiffness of the microbridge.

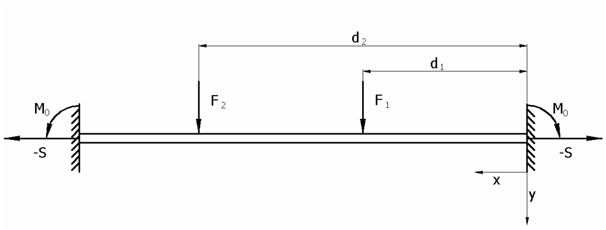

Figure 1. The schematic representation of the RF MEMS switch with two side electrodes.

The switch (Figure 1) is modeled as a fixed-fixed beam with two vertical mobile loads and two stretching axial forces. The vertical loads F_1 and F_2 correspond to the electrostatic actuation forces and are applied in the geometrical center of the electrodes. The axial forces S represent the residual stress which is unavoidable in microfabrication process and has significant influence on the mechanical properties of the structure [1, 2, 3]. In case of our analytical model the axial stretching component due to the deflection of the beam is neglected as the typical maximum deflection of the beam does not exceed its thickness [1].The main difference between this structure and the common ones frequently analyzed in the literature is the presence of two side electrodes (that is two loads) instead of one central [1, 2, 3, 4, 5].

According to [6] the deflection of the beam in figure 1 is given by the equation:
$z_{total} = z(d_1) + z(d_2)$, where

$$z(d_n) = -\frac{F_n \sinh pd_n}{Sp\sinh pl}\sinh px + \frac{F_n d_n}{Sl}x + \frac{F_n}{S}\left(\frac{2EIu}{l\tanh u}\right)\left(\frac{\sinh pd_n}{S\sinh pl} - \frac{d_n}{Sl}\right)\left[1 - \frac{\cosh p\left(\frac{l}{2} - x\right)}{\cosh\frac{pl}{2}}\right]$$

The stiffness is then calculated using formula as follows:

$$k = \frac{F_1 + F_2}{z_{total}}$$

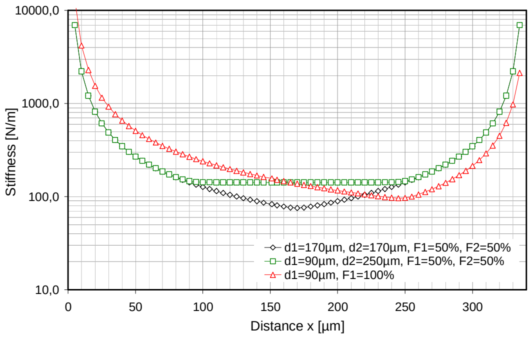

Figure 2. The distribution of the stiffness for three loading conditions which are one central load, two symmetrical loads applied in the distance of 90 µm from the anchor, one load applied 90 µm from the anchor.

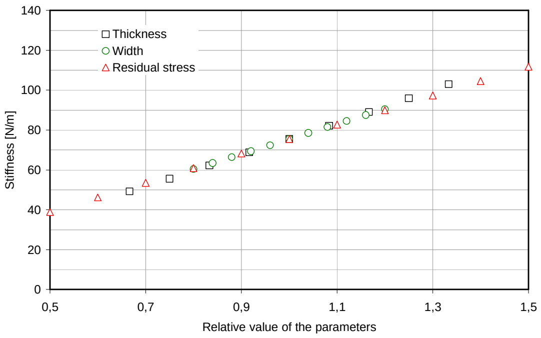

Figure 3. The influence of the thickness, width and residual stress variation on the stiffness of the beam in the central part.

After the analysis of the different loading conditions (Figure 2) it turned out that the stiffness in the central part of the microbridge is very sensitive to the points where the loads are applied. For instance in our case it is 75 N/m when the load is applied in the central part and 142N/m when it is applied symmetrically in the distance of 90 µm from the anchors. When there is only one load applied in the distance of 90µm from the anchor the stiffness in the central part is 142 N/m. In case the residual stress was neglected in the model the stiffness is estimated to 1 N/m. The influence of the thickness, width and residual stress on the stiffness (Figure 3) turns out to be linear in the range of 0.5 to 1.5 of the nominal values and none of the analyzed factors has a stronger effect on it.

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