The Frequency Characteristic Of MEMS Beam Resonator

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Abstract - **In this paper the model of the MEMS (microelectromechanical systems) beam resonator.**

Keywords - **MEMS, Resonator, Frequency Characteristic.**

A model of the MEMS beam resonator [1] (shown in Fig. 1) is proposed considering that ferroelectric electrostrictive constants is defined by the isotropic tensor of rank 4. The beam resonator (see 1 in Fig.1) is made from the ferroelectric material. The beam is attached to the substrate, made from polysilicon (2 in Fig. 1), with thing layers of the metal electrodes (3 and 5 in Fig.1). The DC voltage U_p is applied to electrodes through the resistor R_0, which value is about mega ohm. That voltage U_p (which value is about 10-20 V) creates in the beam resonator polarizing electric field with intensity equal to $E_2^0 \cong (0,3 \div 0,4)$ МВ/м. Moving resonators part length L_0 is equal to 30-40 µm. DC voltage U_p induces in ferroelectric bar static deflections w^0 (fig. 3) and static shear strains ε_{32}^0. These strains and voltage U_p generate additional piezoelectric constant $e_{24} = e_{232}$ in piezoelectric stress matrix of the ferroelectric that polarized with constant electric field $E_2^0 = -U_p / L_0$. This electric field also charges bar material with the electric charge which linear density is $q^0 = D_2^0 bh / L_0$, where b is the bar width.

Time-harmonic driving voltage with amplitude value $U_0^{in} \le 10\,\text{mV}$ is applied through the central electrode which

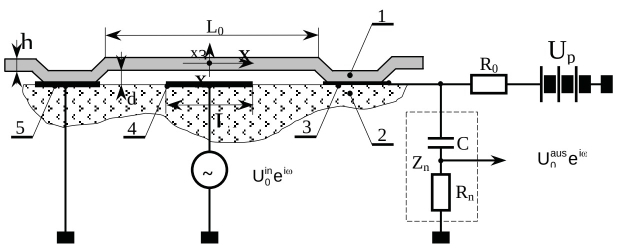

Fig. 1 MEMS beam resonator

width is marked 4 in Fig. 1 as L_e. As distance d between the beam and the central electrode value is not exceed 100 nanometers, than there are appears essential Coulomb forces ad axial to Ox_3. The harmonic oscillation of the cross bending with the amplitude of sidewise displacements $w^*(x_2)$ is induced in the bar by Coulomb forces. Incipient dynamic deformations $\varepsilon_{32}^*(x_2)e^{i\omega t}$ create dynamic polarization charge which value is proportional to the product $e_{232}\varepsilon_{32}^*$. This charge electric field induces current in conductors. If the load resistance R_n (Fig.1) value is small ($R_n << R_0$) than AC current in load impedance Z_n and in R_n is AC voltage with the amplitude value U_0^{aus}:

$$U_0^{aus} = -\frac{i\omega Z_n C_0}{1 - i\omega Z_n C_0} \cdot \frac{e_1^*(e_1 - e_2)e_{323}U_p^2}{16\chi_1\chi_2^* YhL_0^2} \int_0^{L_0} w^*(x_2)dx_2,$$

where C_0 - static electric capacity of the beam moving part and electrodes 3 and 5 (fig. 1); e_1^* and χ_1^* - are electrostrictive constant and dielectric constant; e_1, e_2 and χ_1 - are electrostrictive constant ($e_1, e_2 \le 10^{-5}$ Ф/м) and dielectric constant in the crosswise direction; Y - Young modulus of nonpolarized ferroelectric.

On some value of the frequency ω_1 of the AC voltage U_0^{in} creates in the beam mechanical resonance, what means that deflection amplitudes $w^*(x_2)$ and dynamic deformation $\varepsilon_{32}^*(x_2)$ values sharply increases. So, amplitudes of the output signal U_0^{aus} (Fig. 2) increase on the resonance frequency too. The beam resonance frequencies ω_1 can be controlled in wide region of its values by means of the declivity angle between the moving resonators part and the fixed base.

CONCLUSION

The researched MEMS beam resonator model can be used for the one chip electric signal filter. Integration of the several resonators on one chip are used in the design of the filter with grand off-frequency rejection. Several resonators switching allows improving frequency characteristics of the channel and change its width and shape.

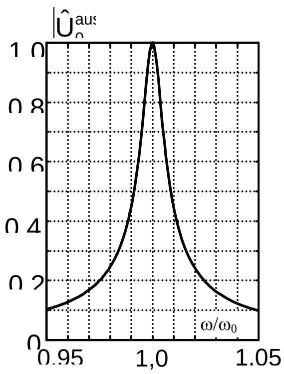

Fig. 2 MEMS output signal frequency characteristic

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