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Short communication

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Parameters of a nanopiezoengine for astrophysics research

Abstract

The static and dynamic parameters of a nanopiezoengine for astrophysics research are determined. The function of the nanopiezoengine is obtained. The parameters of the transverse nanopiezoengine are written.

Keywords: nanopiezoengine, parameter, function, characteristic, astrophysics research

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Introduction

For astrophysics research a nanopiezoengine is applied.[1–12] The energy transformation is clearly for a nanopiezoengine.[11–34]. A nanopiezoengine is promising for nanotechnology, microscopy, interferometers, adaptive optics and astrophysics research.[20–42]

Determination of parameters

The static and dynamic parameters of a nanopiezoengine for astrophysics research are written from piezoelasticity and its differential equation.

Piezoelasticity is determined[6–42]

$$S_i = v_{mi}\Psi_m + s_{ij}^{\Psi} T_j$$

Here Ψ_m the control parameter is E_m the strength electric field or D_m the electric induction, v_{mi} the piezoconstant is d_{mi} the piezomodule or g_{mi} the piezocoefficient, s_{ij}^{Ψ} the elastic compliance, S_i is the relative displacement, T_j the strength mechanical field.

Its differential equation[6–39]

$$\frac{d^2\Xi(x,s)}{dx^2} - \gamma^2\Xi(x,s) = 0$$

Here $\Xi(x,s), s, x, \gamma$ are the Laplace transform of nanodisplacement, the parameter, the coordinate and the propagation coefficient.

The matrix of the nanodisplacements[6–39]

$$\begin{pmatrix}\Xi_1(s)\\ \Xi_2(s)\end{pmatrix} = \begin{pmatrix}W_{11}(s) & W_{12}(s) & W_{13}(s)\\ W_{21}(s) & W_{22}(s) & W_{23}(s)\end{pmatrix}\begin{pmatrix}\Psi_m(s)\\ F_1(s)\\ F_2(s)\end{pmatrix}$$

Then the transverse static nanodisplacements

$$\xi_1 = d_{31}(h/\delta)UM_2/(M_1+M_2)$$
$$\xi_2 = d_{31}(h/\delta)UM_1/(M_1+M_2)$$

To the transverse PZT engine d_{31} = 0.2 nm/V, h/δ = 10, U = 50 V, M_1 = 0.25 kg, M_2 = 1 kg its parameters are written ξ_1 = 80 nm, ξ_2 = 20 nm with 10% error.

If the boundary conditions $\Xi(0,s) = \Xi_1(s) = 0$ for $x = 0$ $\Xi(h,s) = \Xi_2(s)$ for $x = h$ then the solution at fixed first end of the transverse nanopiezoengine

$$\Xi(x,s) = \frac{\Xi_2(s)\,\mathrm{sh}(x\gamma)}{\mathrm{sh}(h\gamma)}$$

and

$$\frac{\Xi_2(s)\gamma}{\mathrm{th}(h\gamma)} + \frac{\Xi_2(s)s_{11}^E M_2 s^2}{S_0} + \frac{\Xi_2(s)s_{11}^E C_1}{S_0} = d_{31}E_3(s)$$

Therefore, the function at the voltage control and $R = 0$ is determined

$$W(s) = \frac{\Xi_2(s)}{U(s)} = \frac{d_{31}(h/\delta)}{M_2 p^2/C_{11}^E + h\gamma\,\mathrm{cth}(h\gamma) + C_e/C_{11}^E}$$

where $\Xi_2(s)$, C_{11}^E, C_e are the transform the nanodisplacement its second end, the stiffness transverse piezo engine and its load.

At elastic-inertial load for $M_2 \gg m$, m the mass of the engine, its function is written

$$W(s) = \frac{\Xi(s)}{U(s)} = \frac{k_{31}^U}{T_t^2 s^2 + 2T_t\xi_t s + 1}$$

$$k_{31}^U = d_{31}(h/\delta)/\left(1 + C_e/C_{11}^E\right), T_t = \sqrt{M_2/\left(C_e + C_{11}^E\right)}$$

To the PZT engine C_e = 0.33×10⁷ N/m, C_{11}^E = 3×10⁷ N/m, M_2 = 1 kg its parameter is obtained T_t = 0.17×10⁻³ s with 10% error.

$$\Delta h = \frac{d_{31}(h/\delta)U}{1 + C_e/C_{11}^E} = k_{31}^U U$$

To the PZT engine d_{31} = 0.2 nm/V, h/δ = 10, U = 50 V, C_e/C_{11}^E = 0.11, k_{31}^U = 1.8 nm/V its parameter is determined Δh = 90 nm at 10% error.

For the transverse nanopiezoengine mechanical characteristic with maximums values of its parameters are obtained

$$\Delta h = \Delta h_{\max}\left(1 - F/F_{\max}\right)$$

$$\Delta h_{\max} = d_{31}(h/\delta)U$$

$$F_{\max} = d_{31} S_0 E_3 / s_{11}^E$$

To the PZT engine h/δ = 10, U = 50 V, E_3 = 1×10^5 V/m, S_0 = 1×10^{-5} m^2, d_{31} = 0.2 nm/V, s_{11}^E = 10×10^{-12} m^2/N its parameters are received $\Delta h_{\max}$ = 100 nm, $F_{\max}$ = 20 N with 10% error.

Discussion

The transverse nanopiezoengine is used for astrophysics research, interferometers, adaptive optics. The parameters of the nanopiezoengine are obtained for astrophysics research.

Conclusion

The parameters of the nanopiezoengine are received. The function of the nanopiezoengine is obtained for astrophysics research. The parameters of characteristic the transverse nanopiezoengine are determined.

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None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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