8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

UNCERTAINTY OF DESIGN PARAMETERS AND THEIR INFLUENCE ON DYNAMIC PROPERTIES OF MEMS MICRORESONATORS

***Adam Martowicz[1], Irina Codreanu[2] and Tadeusz Uhl[3]**

[1] AGH University of Science and Technology
al. Mickiewicza 30,
30-059 Krakow, Poland
adam.martowicz@agh.edu.pl

[2] AGH University of Science and Technology
al. Mickiewicza 30,
30-059 Krakow, Poland
irina.codreanu@agh.edu.pl

[3] AGH University of Science and Technology
al. Mickiewicza 30,
30-059 Krakow, Poland
tuhl@agh.edu.pl

Key Words: *MEMS, Uncertainty analysis, Structural Dynamics.*

ABSTRACT

Microelectromechanical systems (MEMS) [1] are systems which utilize mechanical and electronic parts of microns' scale integrated in one device. Application of both mechanical moving parts and electronic circuit in one considerably small unit enables a variety of applications in different areas of human activity: biology, chemistry, optics, measurement techniques etc. MEMS are made of semiconducting material and manufactured mainly by processes based on lithography. Microsystems feature necessity of taking into account multi-physics approach since in micro scale the phenomena of air flow (fluid dynamics), electrostatic field as well as heat transfer play an important role. Presented work deals with uncertainty propagation in structural dynamics carried out for microresonator considered as one of most commonly used MEMS structure. Fig. 1a shows FE model of simulated microresonator.

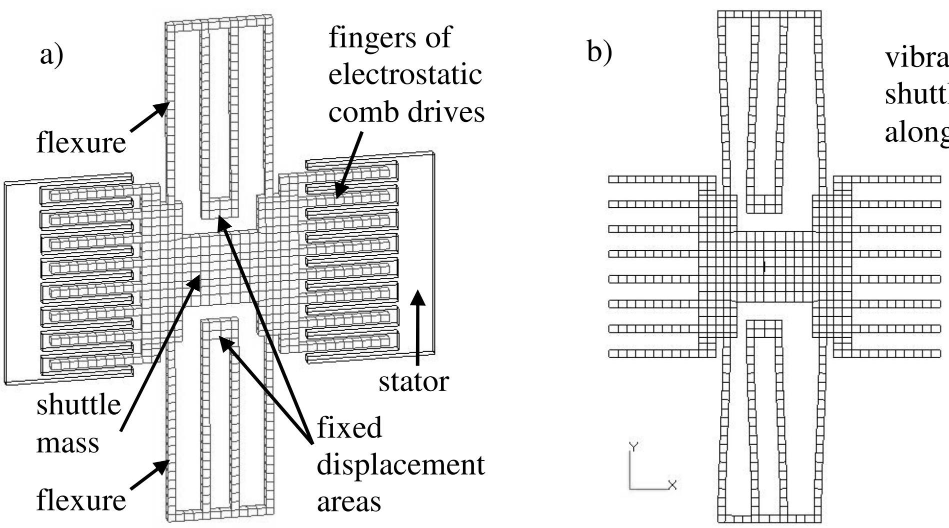

Fig. 1 FE model of microresonator and analyzed mode shape

Analyzed microresonator consists of shuttle mass, area-efficient folded flexures and electrostatic comb drives that make the structure vibrate. Coupled-domain problem of electrostatics and fluid dynamics is considered in elaborated FE model in a simplified way. The phenomena connected both to air flow and to electrostatic field are modelled by lumped dampers and springs. Direct voltage is applied to comb drives. Dynamic FE analyses have been performed to study the influence of assumed uncertain parameters on the range of vibration frequency of interesting mode shape, presented in Fig. 1b. The following steps have been carried out within the application of uncertainty analysis: parameterization of FE model regarding given uncertainties, sensitivity analysis (Fig. 2a) and study of uncertainty propagation for chosen resonance (Fig. 2b). The results have been yielded by the use of probabilistic and possibilistic computational techniques: Monte Carlo [2] applied with Latin hypercube sampling [3], the vertex method [4] and Genetic Algorithms [5]. Fig. 2 shows the results of uncertainty analysis.

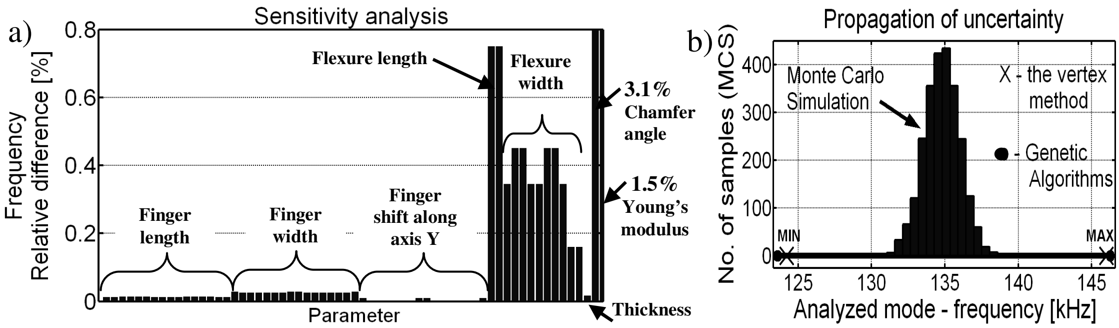

Fig. 2 Results of uncertainty analysis

Considered uncertainties express geometrical imperfections and variations of Young's modulus of polisilicon. Sensitivity analysis has been performed to search for the most influential design parameters that should be of engineer's concern as first while improving the dynamic characteristics of the structure. Gained knowledge can be utilized to make considerations what properties of manufacturing process and design parameters should be characterized in a more strict way and respectively which of them can be treated as negligible to keep the frequency of vibration between required bounds.

REFERENCES

[1] R.M. Lin and W.J. Wang, "Structural dynamics of microsystems – current state of research and future directions", *Mechanical Systems and Signal Processing*, Vol. **20**, pp. 1015-1043, (2006).

[2] G.I. Schueller, "A state-of-the-art report on computational stochastic mechanics" *Probabilistic Engineering Mechanics*, Vol. **12**(4), pp. 197–321, (Oct 1997).

[3] J.C. Helton and F.J. Davis, "Latin hypercube sampling and the propagation of uncertainty in analyses of complex systems" *Reliability Engineering and System Safety*, Vol. **81**(1), pp. 23-69.

[4] D. Moens and D. Vandepitte, "A survey of non-probabilistic uncertainty treatment in finite element analysis" *Comput. Methods Appl. Mech. Engrg.*, Vol. **194, pp.** 1527-1555, (2005).

[5] Z. Michalewicz, *Genetic algorithms + data structures = evolution programs*, Springer-Verlag, Berlin, Heidelberg, 1996.