Modeling and Analysis of Three-Dimensional Design of the Mixer Considering Production Technology

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Abstract - **In the paper the resuls of the research of output parameters of microfluidic T-mixer considering production technology is presented. The model is developed using the Comsol system and research conducted. The results allow to state that although the flow is laminar in the connection of two input streams there is only a slight perturbation flow that depends on the input speed of the liquid and its viscosity.**

Keywords - **microfluidic T-mixer, model, Comsol, manufacturing technology.**

I. INTRODUCTION

Today in various industries a variety of MEMS [1, 2] are being actively developed and used, mostly liquid MEMS [3], which is being actively investigated by many scientists around the world. Such MEMS technology designed for a variety of chemical and physical processes with small volumes of liquid reagents. Typical sizes of microfluidic systems range from a few micrometers to a few millimeters, and the typical fluids - from a few microliters to milliliters per minute dozens [4 - 9]. Their main advantages are (1) the use of a microscopic amount of liquids that can handle microfluidic device, (2) small size and (3) cost of their production. The research, design and development of such systems are vital issues.

II. FEATURES OF MICROFLUIDIC MEMS ELEMENTS MANUFACTURING TECHNOLOGY

The following items are usually distinguished as the main elements of microfluidic systems: micro pump, valves (active and passive) and ancillary items such as mixers, diffusers, heat exchangers, channels, sensors, actuators, etc. [10].

Today there are several basic technologies of microfluidic MEMS in the world, namely [10, 11]: bulk and surface micromachining, LIGA and SIGA technologies and MUMPs process. The use of technologies depends on the use of the device. LIGA technology (from the German Lithographic, Galvanoformung und Abformung) is a promising process with high potential for mass production, which performed well during use in hydraulic MEM devices. Quite often in the process of manufacturing of the chip micro laboratory systems the etching (isotropic and anisotropic) of glass plates and silicon wafers are used.

III. THE DESIGN OF MICROFLUIDIC MIXER

Fig. 1 depicts the design of microfluidic mixer system. T-mixer made in the volume of silicon using etching. The feature of this etching is that at the end we do not have 90 degrees angle relative to the plane of the surface, but 54.74 degrees.

The presented design and dimensions allow to conclude that this integral device has small values of depth. To analyze and study design of T-mixer the Comsol system was used [12], using which a solid model was built, finite element mesh covering was conducted, the physics of the process was selected and the boundary conditions was set. The example of mesh cover of T-mixer design shown in Fig.2, Fig.3 and Fig.4. Surface mesh of finite elements associated with significant cost of computer resources due to the size difference in different directions. However, feature and advantage of the finite element method is to reduce the number of elements gradually increasing their size, where it is possible from the viewpoint of providing a given accuracy of calculations.

IV. SIMULATION RESULTS

The study of the microfluidic T-mixer system at the input channels the pressure (400KRa) were set, and 0 Ra at the output channel. Water was used as liquid. The results of the pressure distribution and velocity in the T-mixer structures shown in Fig. 5 and Fig. 6. From the received data it follows that although the laminar flow in the connection of two input streams have a slight perturbation flow that depends on the input speed of the liquid and its viscosity. In particular, increasing the speed of the liquid and reduce its viscosity leads to strengthening of disturbance.

V. CONCLUSIONS

To determine the output parameters of T-mixer considering technological features of its production the Comsol system was used. This allows to automate the process of solving the problem, namely the construction of a model of its solution and presentation of results.

A solid model of T-mixer considering technological features of its production to determine the pressure distribution and velocity in the simulation was designed. Solid-state model was covered with a mesh, the physics of the process was select and the boundary conditions were set.

The results of the pressure distribution and velocity of fluid in the microfluidic T-mixer were received.

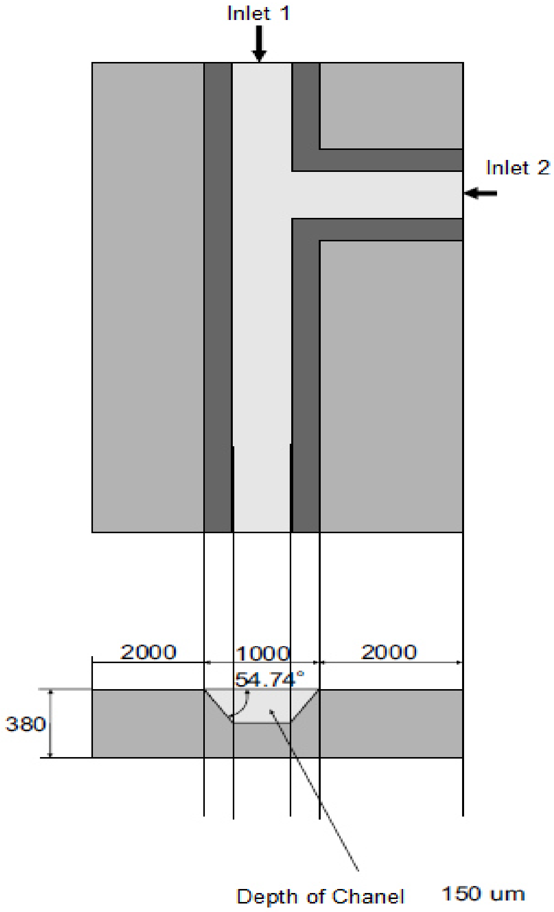

Fig.1 The design of the channel allowing for the etching of silicon

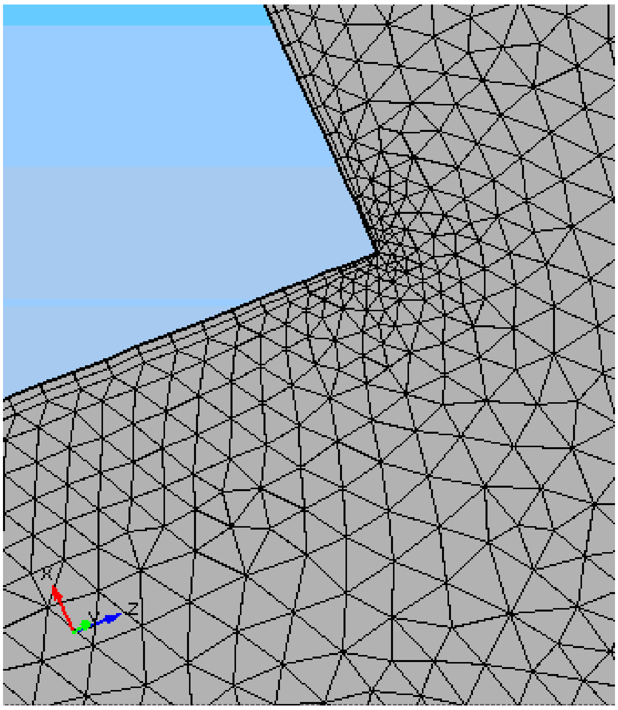

FIg.2. Example fragment covering grid finite element modeling of the T-mixer micro fluid system

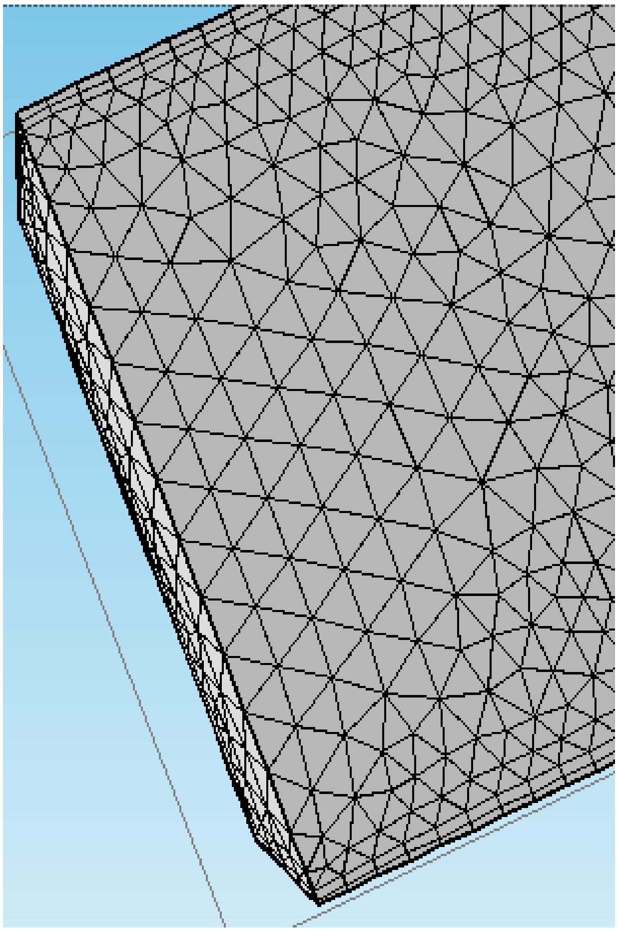

Fig.3. Example fragment covering grid finite element modeling of the T-mixer microfluidic system in the incoming feed liquid

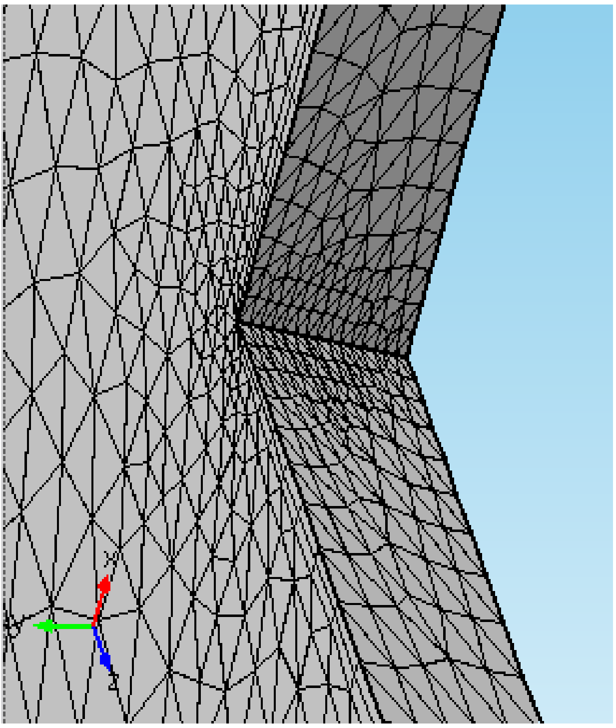

Fig.4. Example fragment covering grid finite element modeling of the T-mixer micro fluid system in combining two input streams

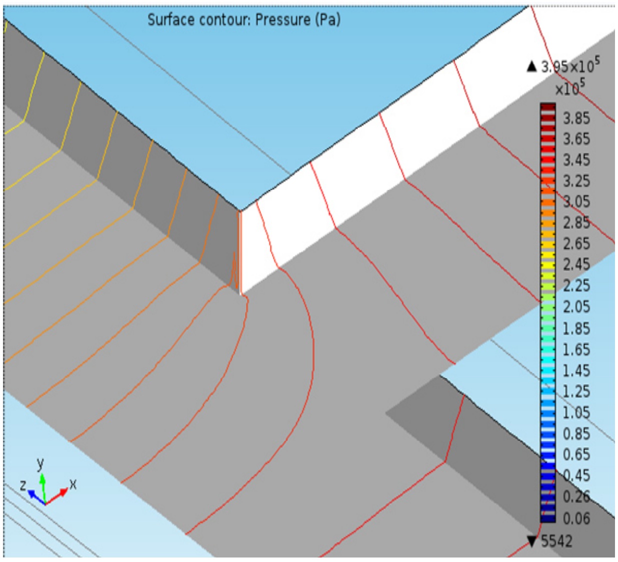

Fig. 5. Schedule changes in pressure in T-mixer

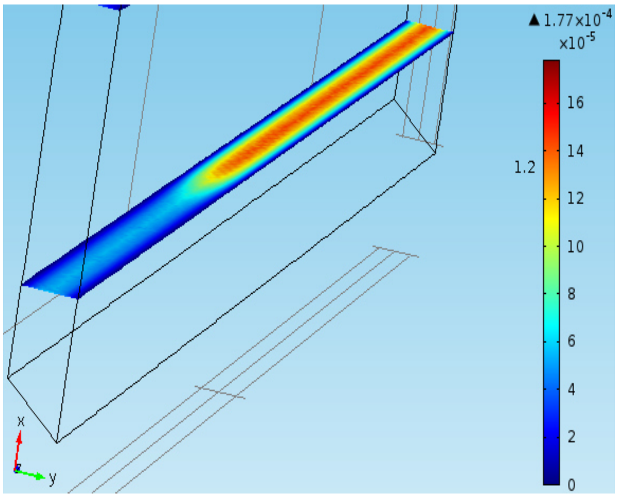

Fig.6. Chart speed change in the direction of the main channel of T-mixer

REFERENCES

[1] Napieralski A., Napieralska M., Szermer M., Maj C. The evolution of MEMS and modeling methodologies, COMPEL: *The International Journal for computation and Mathematics in Electrical and Electronic Engineering*, 2012, vol.31, pp.1458 – 1469.

[2] V. Teslyuk, M. Pereyma, P. Denysyuk, I. Chimich, “Computer-aided system for MEMS design “ProMIP”,” in *Int. Conf. Perspective Technologies and Methods in MEMS Design*, Lviv–Polyana, Ukraine, 2006, pp. 49-52.

[3] Augustyniak I., Knapkiewicz P. and Dziuban J. 2012. Modeling and tests of silicon-glass structure of dose high-energy radiation MEMS sensor. *PRZEGLĄD ELEKTROTECHNICZNY*, no.11b. P.272- 274.

[4] S. Yuhong, R. W. Barber and D. R. Emerson Inverted velocity profiles in rarefied cylindrical Couette gas flow and the impact of the accommodation coefficient, *Physics of Fluids*, Vol. 17(4), 047102, 2005.

[5] Fernandez, Javier G.; Mills, Christopher A.; Rodríguez, Romen; Gomila, Gabriel; Samitier, Josep All-polymer microfluidic particle size sorter for biomedical applications Physica Status Solidi (A), *Applied Research*, vol. 203, Issue 6, pp.1476-1480,- 2006.

[6] Cheung, K. Gawad, S. Renaud, P. , Microfluidic impedance spectroscopy flow cytometer: particle size calibration - M*icro Electro Mechanical Systems, 2004. 17th IEEE International Conference*. (MEMS), pp. - 343- 346.

[7] Nguyen, Nam-Trung Fundamentals and applications of microfluidics/Nam-Trung Nguyen, Steve Wereley.2nd ed. cm. Boston— *Artech House integrated microsystems series* p.- 497.

[8] Squires, Todd M., and Stephen R. Quake. "Microfluidics: Fluid physics at the nanoliter scale." *Reviews of modern physics* 77.3 (2005): 977.

[9] Denysyuk, P., "Usage of XML for Fluidic MEMS Database Design," Perspective Technologies and Methods in MEMS Design, 2007. *MEMSTECH 2007. International Conference* , vol., no., pp.148,148, 23-26 May 2007

[10] Dziuban, Jan A. Technologia i zastosowanie mikromechanicznych struktur krzemowych i krzemowo-szklanych w technice mikrosystemów / Jan A. Dziuban. Wrocław : *Oficyna Wydawnicza Politechniki Wrocławskiej*, 2002. 345 s. ISBN 83-7085-634-9.

[11] Теслюк В. М., Денисюк П.Ю. Автоматизація проектування мікроелектромеханічних систем на компонентному рівні: Монографія. – *Львів: Видавництво ”Львівської політехніки”,* 2011 – 192 с.

[12] Kattabooman N., Sarath S., Komarigiri R. VLSI Layout Based Design Optimization of a Piezoresistive MEMS Pressure Sensors Using COMSOL // *Proceedings of the 2012 COMSOL Conference in Bangalore.* – Pp. 5.

ACKNOWLEDGEMENT

This research was supported by the FP7-PEOPLE “Marie Curie Actions (IRSES)” Project, entitled "Developing Multidomain MEMS Models for Educational Purposes", acronym: EduMEMS, Number: 269295.