SELF ORDERED NANOPOROUS ALUMINUM OXIDE MEMBRANE FOR NANOFILTRATION USING SURFACE ACOUSTIC WAVES FOR MICROHYDRUALIC DEVICES IN BIOMEDICINE

Yatinkumar Patel[1*], Arvydas Palevicius[1], Giedrius Janusas[1]

[1] Department of Mechanical Engineering, Kaunas University of Technology, Lithuania
y.patel@ktu.lt

Aluminum is ubiquitous metal. There are plenty of methods developed in last few decades for the development of nanoporous aluminum oxide membrane using different electrolytes such as Oxalic acid ($C_2H_2O_4$), phosphoric acid (H_3PO_4), chromic acid (H_2CrO_4) or sulphuric acid (H_2SO_4). Moreover, there are possibilities to control their geometry of the pores such as diameter of hole and interpore distance by controlling the voltage applied during the electrochemical process and duration of the anodization process. Also, it is possible to fabricate aluminum oxide membrane by applying two step anodization methods mild anodization (MA) and hard anodization (HA) [1]. By improving the geometrical dimensions and functionality of the nano membrane could be increase in the applicability in micro hydraulic devices at nano level such as particle separation, filtration of nano powders, phase separation and so on [2]. There are huge number of researches is going on in the field of the microsystem for development and applicability of the aluminum oxide membrane in microhydraulic devices.

The major mechanical challenge in the filtration process is to pass the biocells from the nano holes fabricated in aluminum oxide membrane without mechanical damge [3]. Surface acoustic waves (SAW) is widely used and most approprite method because of such a small scale, wide range of frequency and excellent stability. The surface acoustic wave effect possible to produce using the actuating agent such as piezoelectric materials. By actuating the piezoelectric cylinder at different range of frequency it is possinle to generate SAW effect on the suraface of nanomemnrane. Using standing and travelling waves principle concentration of the particles for the seperation and filtration can be done in rapidy [2,4].

The objective of the work is to fabricate the nanoporous aluminum oxide membrane with predefined geometry of hole size and interpore distance for nanofiltration and actuating the nano membrane at different range of frequency by using the piezoelectric cylinder to produce the SAW effect which is usefull as a filtering agent for microhyraulics in the field of biomedicine.

Firstly, By applying two step anodization mehod (MA & HA) self orderd nanoporous aluminum oxide membrane was fabricated using custom made anodization experimental setup. After fabrication the confirmation of the diamer and interpore distance was identified by scanning electron microscopy (SEM) and surface morphology. Diameter of fabricated nano memnrane is 30 mm, diameter of the nano pores 70 ±20 nm and interpore distance 110± 10 at constant voltage 60 V and oxalic acid as electrolyte during anodization.

After fabrication of the nano membrane actuation was performed using the piezoelectric cylinder. Nano membrane was fixed on the piezoelectric cylinder. Piezoelectric cylinder was actuated at the frequency range of 1-100 kHz. The nondestructive testing methods was used to analyze the different mode of vibration acting on the surface of aluminum oxide nano membrane. PSV-500-3D Scanning Vibrometer (Polytech) and holographic PRISM optical system (USA by HYTECH) was used to analyses the distribution of the vibration on the nanoporous aluminum oxide membrane by mounting nano membrane on the piezoelectric ring. Those methods confirm the different mode of the vibrations and patterns of the surface acoustic waves which is useful for the particle filtration and separation in microhydraulic devices in biomedicine.

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[1] Zhou, Z., & Nonnenmann, S. S. (2019, August 1). Progress in nanoporous templates: Beyond anodic aluminum oxide and towards functional complex materials. Materials, Vol. 12. https://doi.org/10.3390/ma12162535

[2] Janusas, G., Guobiene, A., Palevicius, A., & Ramalis, L. (2017). Nanoporous aluminum oxide membranes for biomedical micro hydraulic devices. Vibroengineering Procedia, 15, 110–114. https://doi.org/10.21595/vp.2017.19448

[3] Sara Salehyar and Qiang Zhu. (2016) Deformation and internal stress in a red blood cell as it is driven through a slit by an incoming flow. Soft Matter, 12, 3156-3164.

[4] Zhang, A., Liu, W., Jiang, Z., & Fei, J. (2009). Rapid concentration of particle and bioparticle suspension based on surface acoustic wave. Applied Acoustics, 70(8), 1137–1142. https://doi.org/10.1016/j.apacoust.2009.02.007