Micro-Microscope Microcrystal Sensor Design for Chemical Detection in Zagros Area Tunnel Drilling

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abstract

In this paper, an example of a rectangular microtreatment of a head is shown under torsional conditions, in which length, width, thickness, height and distance between the piezoelectric layer under the influence of the frequency of frequency amplification and frequency sensitivity are investigated and discussed. Is. In this study, for the first time, the microtower vibrational motion analysis in the role of the sensor of gases in the excavation of tunnels is investigated and the effect of absorption of these gases on the microtight vibrational behavior is studied. To analyze this vibrating microcircuit, considering that it can be a fluid and air environment, the fluid environment is continuous and much larger than the microtreatment dimension, and the fluid is a Newtonian type with constant viscosity and an incompressible flow. Given the prevailing assumptions about this type of fluid, the equation of motion of a microtower is torsionally vibrational in a viscous fluid assuming Euler-Bernoulli. Before obtaining the quality coefficient of a torn vibrating microtreatment in a viscous fluid, first, the quality coefficient of a vibrational system under the mean burst is obtained according to the resonance frequency equation (by solving the equation of motion), and to obtain the coefficient of quality, first, The kinetic energy, potential energy, total energy and energy dissipation per cycle in the stable state system should be calculated, as well as the frequency spectrum obtained by the torsional deformation in terms of natural frequency.

Key words:

Micro-electromechanical systems, micro-sensors, vibration, torsion, piezoelectric, coefficient, frequency sensitivity.

Introduction

Chemical sensors are often used to identify chemicals, especially for the detection of organic gases. The basis of these sensors is that the chemical reactions between adsorbed gases and sensor surfaces change the resistance at lower sensor levels. Carbon nanotubes [20], [21], and polymer-based chemical sensors, metallic nanowires [1] or nanowires, thin metal oxide films [2], wires [17], [18], or particles [19] 23] Examples of adsorbents used in these sensors. Because these sensors react to the electrical properties of adsorbents, this limits the flexibility of the sensors. As a result, most of the results are not specific or selective chemical sensors; therefore, a large number of adsorbents and sensors are needed to create a pattern for specific identification. Resonance sensors include quartz crystal gravity (QCM) [24] - [27], surface acoustic waveforms (SAW) [28], [29], and Microtower sensors [30]. These resonators are vibrating and vibrating with a natural frequency. If the external object is connected to the sensor surface, the resonance frequency will change. For example, QCM is very sensitive to changes in thickness at the surface, so that any change in the thickness of 3 angstroms causes a change of 5 Hz at the resonance frequency. The mass change can be achieved by changing the thickness. However, the sensor is susceptible to objects that are not two-dimensional (like particles or stains). The detection rate of these sensors is relatively high due to its flat geometry and its large surface. Although QCM is not very sensitive, it is well-developed and easily customizable. Therefore, it can be used to validate a small change in mass in a particular process. Like QCM, SAW also operates on radio frequencies. Its higher frequency (about 100 MHz) shows a better sensitivity than QCM [29] and is used for chemical evaluation studies. However, both QCM and SAW are in centimeters, which does not make them suitable for making multiple detection arrays. Following the introduction of microtubes as a new measurement method in the 1990s, [31] its numerous applications have been proven in the chemical, biological, and biomedical fields [32]. These microtoops are used to identify chemical and biological agents. The receptors are widely used at the microscope to combine the target chemical molecules, DNA, protein molecules, or bacteria.

problem statement

Microtowers have several advantages over other techniques. Microtowers have high sensitivity, low cost, no need for labeling, versatility and fast response. Microdermabrasion has been proven as a new measurement method in the 1990s for its use in chemical, physical, biological and biomedical fields. These microtubes are used to detect chemical and biological agents on microtiter surfaces to bond chemical molecules The target, DNA, protein molecules, or bacteria are widely used. Chemical sensors are often used to detect chemicals, in particular to detect organic gases. The basis of these sensors is that the chemical reactions between adsorbed gases and the sensor surface will alter the resistance at the lower levels of the sensor [1]. Metallic nanoparticles or nanowires, thin films of metal oxides, wires or particles, carbon nanotubes and polymer-based chemical sensors are examples of adsorbents used in these sensors. A chemical sensor is a sensory receptor that detects certain chemical stimuli in the environment [2]. The primary part is a chemical or biological sensor of its sensor element. The detector is in contact with a detector. This element is responsible for identifying and bonding to the desired species in a complex sample [3]. The detector then converts the chemical signals generated by the binding of the sensor element to the desired type into a measurable output signal [4]. Chemical sensors include a sensing layer that generates an electrical signal due to the interaction of the chemical species (analyte) with this layer [5]. Then this signal is amplified and processed, so the operation of the chemical sensors consists of two main steps: detection and amplification. In general, the device that performs this process is called a chemical sensor. This device collects information about the chemical composition of your operating environment and transmits it to the processor as an optical or electrical signal. The simplicity of using these sensors has led to their use in a variety of applications [6]. Chemical sensors in clinical chemistry are used to control the causes of diseases, such as diabetes, to detect and detect specific gases, such as oxygen and carbon monoxide. These sensors are also used to determine the amount of environmental pollutants, control and process of food industries and chemical gases from the industry and construction work [7]. Construction works include dam, airport, road, railway, tower, tunnel, telecommunication towers, buildings, etc. In this section, the gases emitted during drilling in the tunnels are investigated [8]. It is important to pay attention to the safety of the tunnel under normal and emergency conditions. The tunnels being built in the Zagros region, especially in the west of the country, are exposed to hydrogen sulfide, a very toxic and dangerous gas, as well as high solubility in water [9]. Generally, the dangerous gases in the digging of underground spaces and tunnels are made up of four main types of hydrogen sulfide (H2S hydrogen sulfide gas in shallow groundwater, chemical bacterial degradation of environmental materials and in anaerobic environment), methane (methane gas) Carbon dioxide (CO 2 gas) is commonly found in underground spaces due to bacterial chemical degradation under aerobic conditions [9] [10]. Often, this phenomenon occurs in the geothermal system (Earth Heat) due to the phenomenon of magnetism (molten rocks), thermal decomposition of carbonates And also from the dissolution reactions between acidic waters and carbonates) and the fossil fuel vapor separates. In the absence of hazardous gases, providing air and reducing the concentration of pollutants at a safe level, and in the presence of these gases, reducing the concentration of dangerous gas (s) plays a decisive role. The source of these gases can be geochemical, biochemical or a combination of these factors. Knowing the source of hazardous gas and its transfer factors to drilling space is one of the important factors in determining control methods [11]. Hazardous gases can carry out mining and construction operations such as tunnels, shafts and similar underground craft. These gases are released due to underground activities and the production of hydrostatic and hydrostatic pressures. Depleted gases may be combined with air and produce flammable, poisonous or strangulated compounds [11] [12]. Methane, hydrogen sulfide, and carbon dioxide, which are generally produced from tectonic biological processes, are among the most dangerous gases in digging underground spaces. In addition, vapors from gasoline and diesel engines, which are produced by inadequate machinery in the underground, are dangerous. These gases can penetrate into subterranean spaces (at depths less than 1000 m) and cause explosions, burns, poisoning or strangulation of underground personnel [1] in less than a minute. Hydrogen sulfide can be detected in the air with a sense of smell (smell like roughened eggs) even at very low concentrations (0.001 to 0.1 parts per million), however, people's smell is felt within 2 to 25 minutes And then it can not be detected.The physiological effects of these gases can be detected by a specific odor at various concentrations of 0.1 to 1 ppm. Concentration of 5 ppm. Boundary toxicity. 5-100 ppm. Short burning in the eyes and respiratory system. Headache after 15 minutes. This discharges gas, 200ppm burning nose and throat, 500ppm eye inflammation, nasal discharge, cough, palpitations, fainting, 600ppm chest pain due to scratches of the respiratory system, death possibility, 700ppm depression, coma, death probability , 1000ppm Paralysis of the nervous system leads to rapid death. Hydrogen sulfide is absorbed not only by breathing but also by skin contact with its water. This gas is explosive in the range of 3.4% (LEL) and 45% (UEL) volumes, as well as at the time of burning it, it produces a very toxic gas, sulfur dioxide (SO2) [13] , [14]. As soon as the gas enters the tunnel, sufficient air should be provided for immediate dilution of methane gas to a safe level. Methane is flammable when mixed between 5 and 15 percent of the gas is mixed with air. The 5% limit is a low explosion and methane density is not explosive. The amount of 15% is the upper limit of the explosion, and the gas mixture at a density above this limit is not explosive, but if blended with more air, it can be exploded. In the event of exposure to gas, the lack of capacity of chemical sensors and ventilation threatens the work of the tunnel [15]. The design, installation and proper operation of the system of chemical sensors and temporary ventilation can, in addition to eliminating all the above problems, provide the proper working conditions within the tunnel. Each method has advantages, limitations and disadvantages that should be considered when choosing them for use in a tunnel. The lack of a chemical sensor for timely identification lowers the downstream speed and creates bad working conditions for staff and machines in the tunnel. This issue in carbonated tunnels may also lead to explosions. Several bursts of methane and hydrogen sulfide have occurred in many places, which has caused Zabadi's physical and financial losses [15], [16].

Equations

The sensitivity is defined as the ratio of the output signal to the input quantity being measured. For a dynamical mode sensor based on microelectromechanical systems, mass sensitivity is the ratio of the magnitude of the resonant frequency change to the mass change mass, which is expressed as such.

$$f_{r,i}\ S\_(M,i) = |\ 〖\Delta f〗\ \_(r,i)/\Delta M| \qquad (١)$$

The resonant frequency is related to the vibration modulus. The resonance frequency and the mass are related to the microtree and also to the membrane (measurement layer). The mass inertia and inertia of the membrane are assumed to be small compared to the microtree.

$$f_{r,i} = f_{VisL,i} = \frac{2i-1}{4L}\sqrt{\frac{GK(1-2s_i^2}{\rho_P^J+g_{2,tocs}}} \qquad (٢)$$

The change in the resonant frequency is obtained by using a chain rule and its relationship is this.

$$\frac{\Delta f_{r,i}}{t_{r,i}} \approx -\frac{\Delta\left(\rho_P^J\right)}{2\left(P_P^J+g_{2,tors}\right)} + \frac{\Delta(GK)}{2(GK)} - \frac{2\ \ \Delta\ \ i}{1-2\varepsilon^2} - \frac{\Delta g_{2,tors}}{2(\rho_P^J+g_{2,tors)}} \qquad (٣)$$

The right terms of equation (3-66) are related to the change in the resonant frequency due to the rotational inertia change, hardness, damping ratio, and the inertial hydrodynamic torque per unit length. Generally, the hard variations, damping ratio and inertia torque per unit length are insignificant, so the change in the resonant frequency is mainly due to rotational inertia change. Since mass and inertial rotational inertia changes are related only to the membrane, which is the sensor of the sensing, the sensitivity and frequency variation are rewritten in opposite directions.

$$S_{M,i} = \left|\frac{\Delta f_{r,i}}{\Delta M_f}\right| \qquad (۴)$$

$$\Delta f_{r,i} \approx -\frac{f_{r,i}\Delta\left(\rho_f J_{p,f}\right)}{2(\rho_P^J)} \qquad (۵)$$

Here, Mf and Jp, f are respectively the mass and polar anchor of the cross-sectional membrane. The membrane is supposed to be divided on the surface of the microprint of the address layer and divided into two identical components, as seen in figure (1). Although it may not be practical because of the difficulty of the membrane, it is considered as a general case. Because the anchor of the central component level is negligible; consequently, as a result of replacing the central component with the middle gap, sensitivity increases. The mass and polar anchor of the cross-section of this membrane are determined in opposite directions.

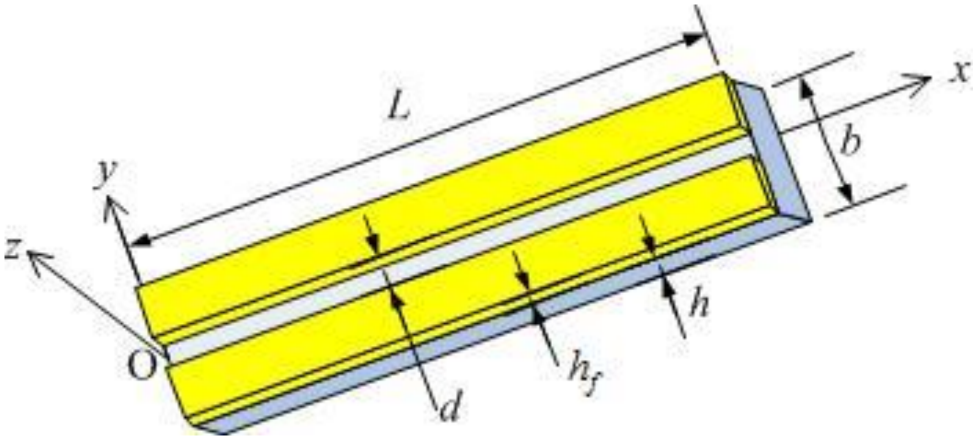

Figure (1) Membrane geometry (yellow) and microtree

$$M_f = P_f(b-d)h_f L, \quad (۶)$$

$$J_{P,f} = \left[bh_f\left(b^2+h_f^2+3h^2\right) - dh_f\left(d^2+h_f^2+3h^2\right)\right]/12, \quad (۷)$$

Here, ρf, d and hf are density, gap in width direction and thickness of membrane. The adsorption analyzer is assumed to only change the membrane density; it does not cause deformation and membrane size. Therefore, changes in mass inertia and inertial rotation of the relation are obtained.

$$\Delta M_f = (b-d)h_f L \Delta P_f, \quad (۸)$$

$$\Delta\left(P_f J_{p,f}\right) = J_{p,f}\Delta\left(P_f\right). \quad (۹)$$

$$S_{M,i}(d) = \frac{(b^2+3h^2+h_f^2+bd+d^2)f_{r,i}}{24L(\rho_P^J+g_{2,tors})}. \quad (۱۰)$$

The greater the thickness or membrane split, the greater its sensitivity. While improving sensitivity is possible by increasing the thickness of the membrane for microtubes acting in transverse, lateral or longitudinal modes, but improvement in sensitivity by increasing the gap is only valid for microtitudes with torsional vibration. If the membrane thickness is assumed to be much less than the beam and there is no gap in the membrane, the sensitivity relationship is summarized as follows.

$$S_{M.i}= \frac{(b^2+3h^2)f_{r,i}}{24L(\rho_P^J+g_{2,tocs})} \quad (۱۱)$$

This equation always estimates the mass sensitivity to be slightly less than actual. Mass sensitivity can be improved by adding a gap in the membrane. For example, if the aspect ratio (h / b) is 0.1, adding a half-width gap (d / b = 0.5) sensitivity increases by about 70%.

Results

Frequency sensitivity and resonant frequency analysis relative to microtriple dimensions:

The frequency sensitivity analysis and piezoelectric microwave amplification frequency relative to its dimensions in this section affects the effect of microfilm frequency sensitivity. Using the sensitivity analysis performed by Sobel statistical analysis, the effect of frequency sensitivity in the first three oscillatory modes is determined.

Piezoelectric thickness thickness analysis of frequency sensitivity and resonance frequency:

In Fig. 2 (c), the fluid environment and the form (2-d) of the air environment show how the thickness of different layers affects the resonance frequency. In the two above-mentioned forms, as in the frequency sensitivity, there is the highest amount in the air environment relative to the liquid medium. The thickness of 48 micrometers for each of the first three to three modes in the liquid medium is 1.2 MHz, 7.2 MHz and 11.9 MHz, and in the air, respectively, 2.4 MHz, 7.8 MHz and 12.8 MHz, respectively. There is the highest frequency of excitement. From the comparison of these two environments, it can be concluded that in the air environment, the piezoelectric layer thickness is the highest in relation to the resonance frequency.

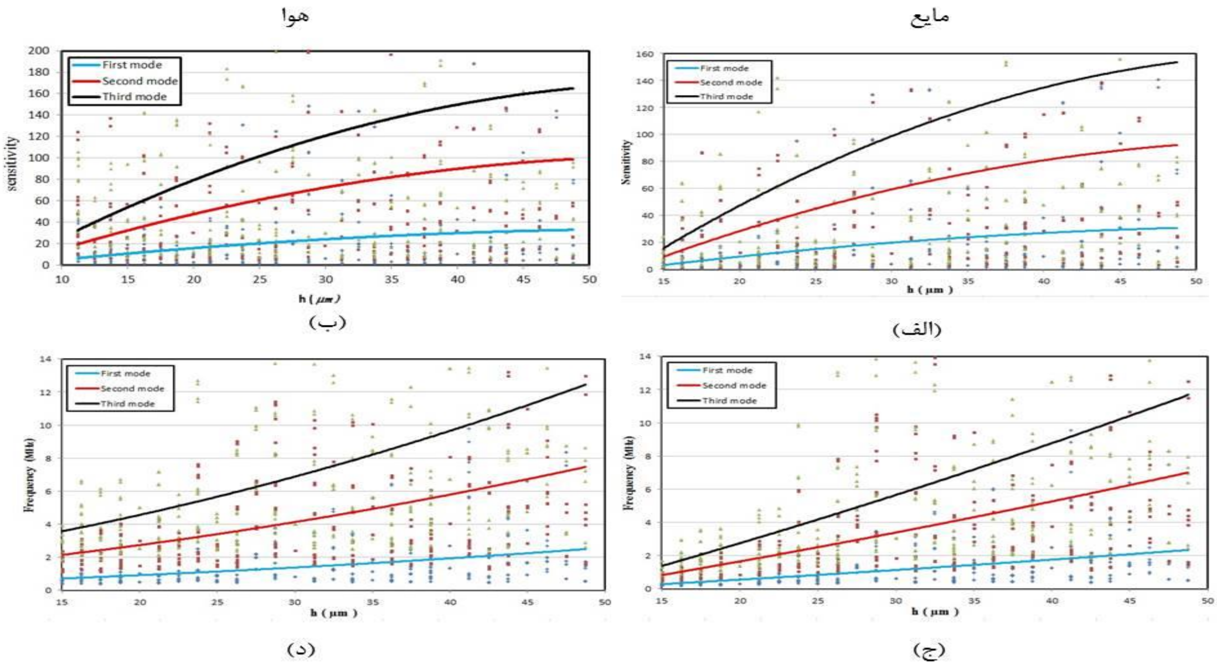

Figure 2: Piezoelectric layer thickness versus frequency sensitivity and resonant frequency

Piezoelectric Pulse Width Analysis of Frequency Sensitivity and Resonant Frequency:

Fig. 3 shows how the piezoelectric layer's width influence on frequency sensitivity is observed in the first three oscillatory modes. In Figure (a), the effect of the piezoelectric layer's width is shown on the frequency sensitivity in the liquid medium. According to the shape in all three oscillatory modes, the piezoelectric layer in the range of 30 to 45 micrometers increases the sensitivity of the frequency and has the lowest sensitivity in this range, but according to the form (B) that is in the air In the range of 30 to 45 micrometers, the piezoelectric layer has a minimum of 37 micrometers in all three modes, which increases the frequency sensitivity after increasing its width. With regard to the comparison of both fluid and air environments, with the increase in the piezoelectric layer at 35 micrometers, the frequency sensitivity decreased in all three modes, after which this value was increased in the ambient air and the frequency sensitivity was established in the fluid medium. In Fig. (C) and (d), the effect of the piezoelectric layer on the resonant frequency in the fluid and air environment is shown. Regarding both forms, it is observed that the frequency of the resonance is decreasing, which is because the resonance frequency decreases with the increase of the piezoelectric layer width. In all three fluctuating modes it has been shown that the increase of the piezoelectric layer in the ambient air has increased the resonance frequency from the liquid medium, and compared with each other, the first mode was constant in both environments, but in the air environment The second mode at its lowest frequency was 3 and the third mode was 4.8, which was 1.9 and 3.9 compared to the liquid medium.

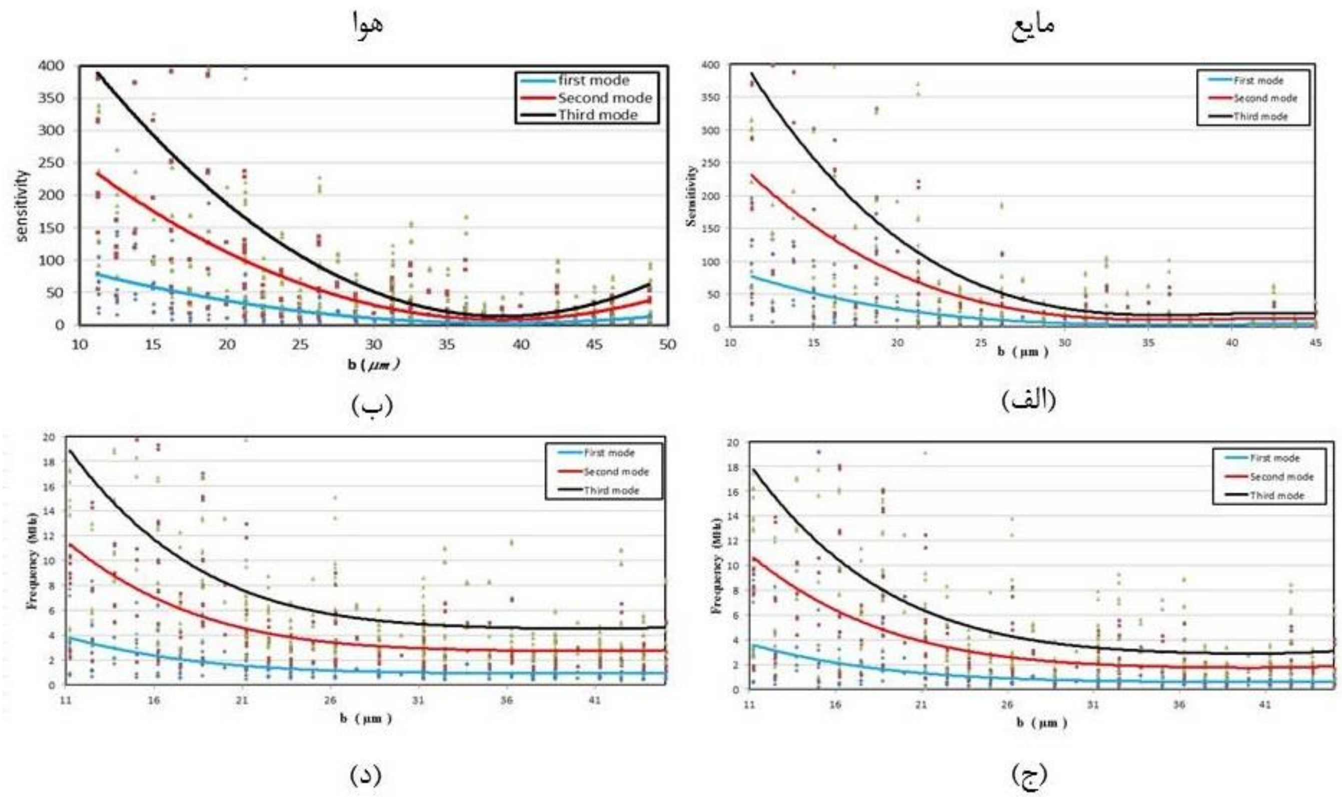

Figure (3) Piezoelectric layer width versus frequency sensitivity and resonant frequency

Piezoelectric layer length analysis of frequency sensitivity and resonant frequency:

Figure 4 shows how the length of the piezoelectric layer or the electrodes layer affects the frequency sensitivity. With regard to the form (4a) in the liquid medium, the pseudo-electric length of the lens increases in each of the three oscillatory modes. The frequency sensitivity decreases, and in the same way, in the form of (4b) in the air. . By comparing the two media with each other, the lowest frequency sensitivity of 460 in the fluid medium, the oscillatory mode of the first one to the third, is 9 µm, 22 µm and 38 µm respectively, and in the air, 10 µm, 30 µm and 45 µm respectively It can be concluded that in the liquid medium, the piezoelectric layer length is less than the air sensitivity of the ambient air. Fig. 4 (c) and Fig. 4 (d) show how the piezoelectric layer affects the resonant frequency. As in the frequency sensitivity, the piezoelectric layer length was lower than that of the air in the medium in the fluid medium, in all three modes of fluctuation from the first mode to the third mode in the liquid medium, the numerical values were 0.4, 0.9 and 3.2 And in the air environment 0.5, 2, and 4, has the lowest frequency of resonance.

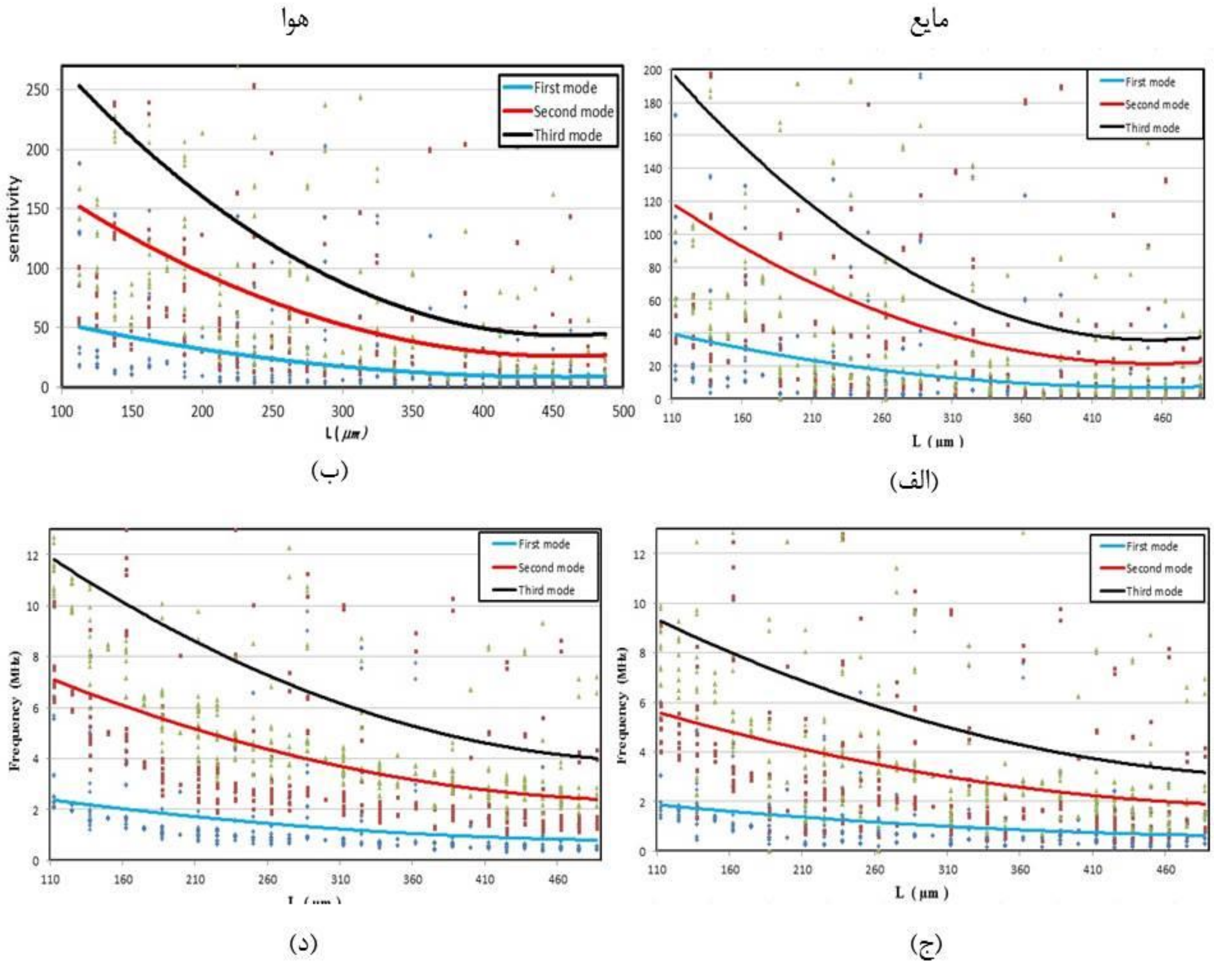

Figure 4: Piezoelectric layer length versus frequency sensitivity and resonance frequency

Thickness analysis between two piezoelectric layers relative to frequency sensitivity and resonance frequency:

Figure 5 shows how the thickness of the two microtour layers affects the sensitivity of the piezoelectric layer. It is seen in Fig. 5a that the frequency sensitivity of the piezoelectric layer is influenced by the thickness of the electrodes in the liquid medium rather than the air environment. According to simulated results, the thickness of the two piezoelectric layers in the first one to the third mode swings in the liquid medium at a thickness of 14.5 micrometers reaches their maximum value. Of course, it can be noted that frequency sensitivity in all three first to third modes is 25, 78 and 130, respectively, but in Fig. 5b, it shows that the sensitivity of the piezoelectric layer is influenced by The thickness of the electrode in the ambient air relative to the liquid medium has been greater in all three modes of oscillation. At the same thickness of 14.5 micrometer of oscillatory first to third modes, the frequency sensitivity is 30, 85, and 142, respectively. In this comparison, the thickness of the two piezoelectric layers is higher than that of the liquid medium relative to the frequency sensitivity in the air environment. In Figure 5 (c), the fluid medium and Figure 5d show the air environment how the thickness of the two layers affects the resonance frequency. In the two above-mentioned forms, as in the frequency sensitivity, there is the highest amount in the air environment relative to the liquid medium. The thickness of 15.5 micrometer for all three first to third modes in the liquid medium was 1.8 MHz, 2.5 MHz and 8.7 MHz, respectively, and in the air, respectively, 1.9 MHz, 5.7 MHz and 2.9 MHz has the highest frequency of resonance. From the comparison of these two environments, it can be concluded that in the air environment the thickness of the two piezoelectric layers is the highest of the resonant frequency.

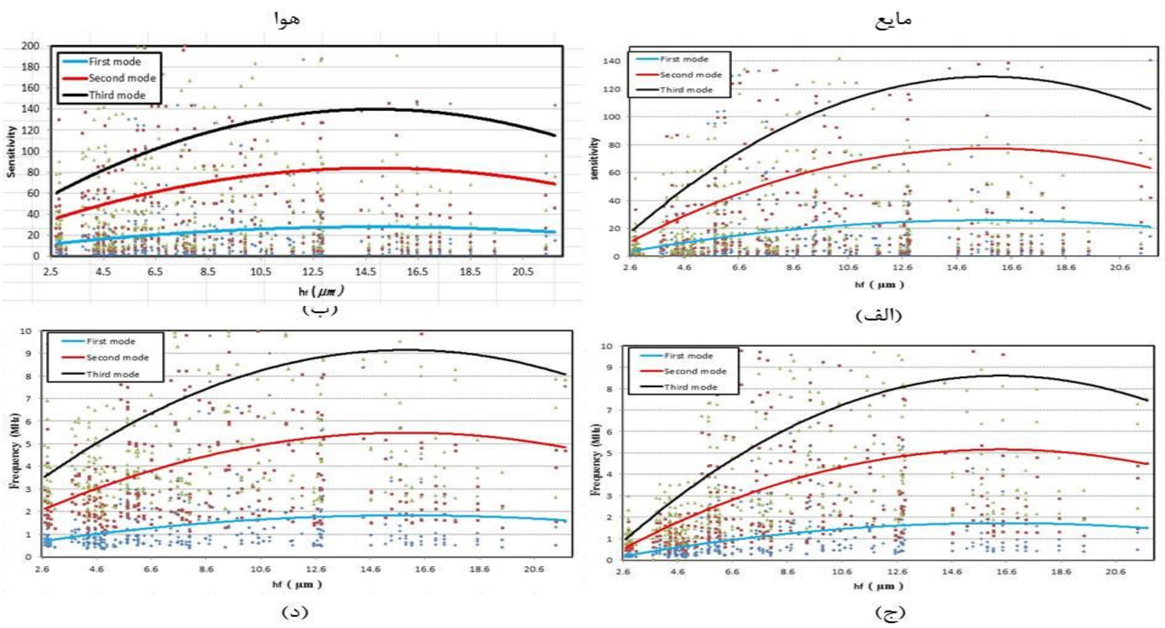

Figure 5: Thickness between two piezoelectric layers relative to frequency sensitivity and resonant frequency

Analysis of the distance between the piezoelectric layer and the frequency sensitivity and resonance frequency:

Figure 6 shows how the distance between the microtreatment layer is on the piezoelectric layer's frequency sensitivity. According to Fig. 6a, which is in the liquid medium, with the increase of the gap between the piezoelectric layer in each of the three oscillatory modes, the sensitivity of the frequency decreases and reaches its lowest in the range of 18 to 20, but according to Fig. 6b) Which is in the air. By increasing the distance between the piezoelectric layer in all three oscillatory modes, the sensitivity of the frequency to the lowest of 12.2 to 17.2 reaches its lowest value, which increases the sensitivity of the growth rate after increasing the gap between the piezoelectric layer. In Fig. 6 (c) and Fig. 6 (d), the effect of the distance between the microtreatment layer on the resonance frequency of the piezoelectric layer in the liquid and air environments is shown. With respect to the comparison of the two environments with each other, it is observed that all three oscillatory modes increase the gap between the piezoelectric layer and the resonant frequency decreases. In the fluid medium, the thickness of the gap between the layers in the 21 micrometer amplification frequency in the first to the third mode is oscillating to The order of 0.5 micrometer and 1.7 micrometer and 2.2 micrometers and in the air are 0.8 micrometer and 2 micrometers and 3.7 micrometers respectively, which can be concluded that in the liquid medium, the distance between the piezoelectric layer is less than the air intensification frequency of the air.

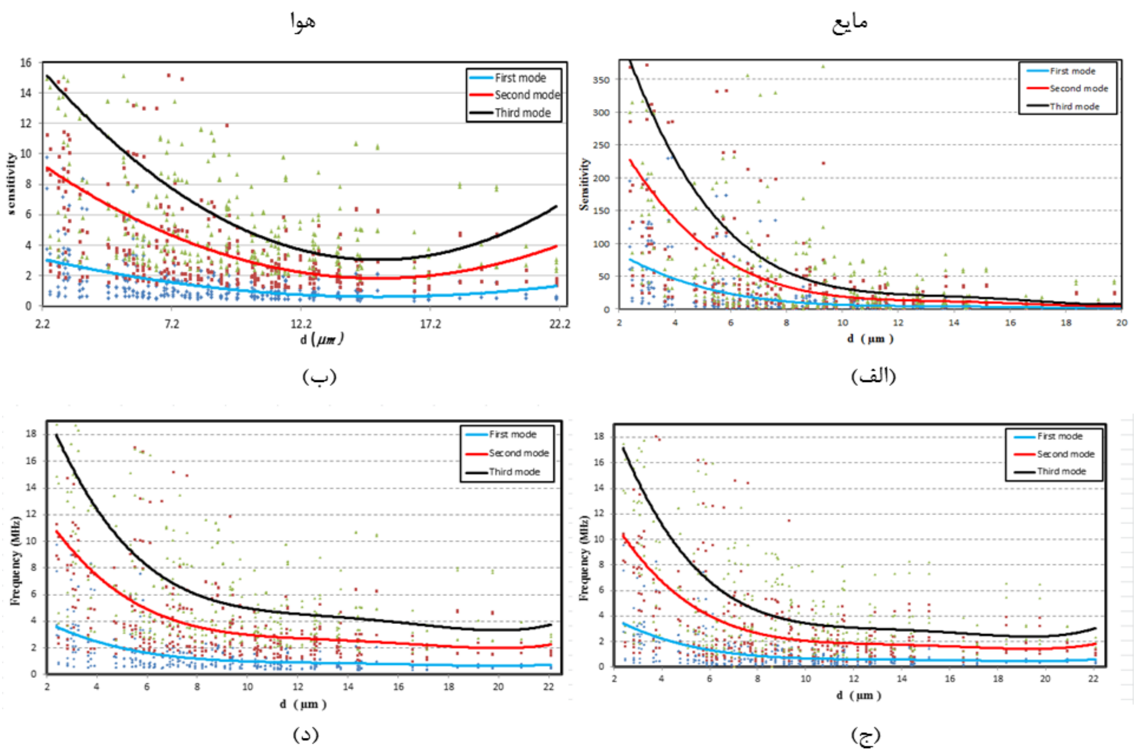

Figure 4-5: Devasal between the piezoelectric layer and the frequency sensitivity and resonance frequency

onclusion and Conclusion

Results and discussion

1- If the piezoelectric microscope moves from the air to the liquid medium, there will be significant changes in the curves. 2. In the air and liquid environment, due to the high sensitivity of the microtiter, the best way to stimulate the microtower in the first three modes of the first oscillation is the first fashion. Results of piezoelectric microscope sensitivity analysis The results obtained by simulating and analyzing the oscillatory motion sensitivity of a microtower composed of piezoelectric layers are as follows: 1- The larger the thickness or membrane gap, the greater its sensitivity. 2. Improvement of sensitivity by increasing the gap is only applied to microtowers with torsional vibration. 3. By increasing the thickness of the piezoelectric layer of the first vibrational mode in the air and liquid environment, the frequency sensitivity does not change with variations, but in the other two modes, the second and third modes of the oscillating air environment, to the maximum frequency of sensitivity to the medium. Come 4- Due to the piezoelectric layer thickness of the sensor, the resonant frequency studied in the second and third modes of the oscillating air environment is greater than that of the liquid medium. 5. The effect of the piezoelectric layer's width on the frequency sensitivity in the air and fluid environment is different. According to the analysis, with increasing the amount of the piezoelectric layer, the frequency sensitivity in the air environment reaches its minimum, and then increases, but in The fluid environment only decreases. 6. As the piezoelectric layer increases, the resonant frequency decreases. In the ambient air, the resonance frequency is higher than the liquid medium, and compared with each other, the first mode is constant in both environments, but in the fluid medium of the second and third modes of oscillation at its lowest frequency relative to the air environment. 7. In each of the three oscillatory modes, the length of the piezoelectric layer increases, the frequency sensitivity decreases, it can be concluded that in the liquid medium, the piezoelectric layer length is less than the air sensitivity of the ambient air. 8. The piezoelectric length of the resonant frequency, as well as the frequency sensitivity, increases with the increase in length, the resonance frequency decreases. 9. According to simulated results, the thickness of the two piezoelectric layers reaches the maximum value in the first-third mode of oscillation in the thickness of 14.5 micrometers relative to the frequency sensitivity in which the sensitivity was higher in the air than in the liquid medium. 10. In the thickness of 15.5 micrometer for all three first to third modes in the liquid medium and in the air environment, there is the highest frequency of resonance. From the comparison of these two environments, it can be concluded that in the air environment the thickness of the two piezoelectric layers is the highest of the resonant frequency. 11. In the range of 18 to 20, the ambient air and liquid environment, with increasing distance between the piezoelectric layer, decreased in all three oscillatory modes and decreased to the lowest, and in the fluid medium after the interval between the 20th layer, but increased in the air environment Is. 12- As the gap between the piezoelectric layer is increased in all three oscillatory modes, the frequency of the resonance is decreasing.

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