Design of Mechanical Multi-Sensor for Contaminated Water Filter Applications

Hussein Inayah Sharhan*, Ali Jabbar Salim and Asmaa Hadi Mohammed*
*Al-Mustansiriyah University, College of Science, Department of Chemistry
** Al-Mustansiriyah University, College of Science, Department of Physics
Email: asmaahadimohammed@yahoo.com

Abstract: Effect of addition (salts, soil and bacteria) on piezoelectric detecting a signal of a specific liquid like water has been inspected here in the project. Identifying signals (piezoelectric) categorized and accomplished by usage of transducer that conducts a mechanical signal in the direction of the water liquid cell, and then the receptor collects the weakened indications. The quartz cell (contains water solution) embedded between the two piezo crystals and piezo crystals with silver (Ag) nanowire thin film prepared using hydrothermal method. It is clear that the formation of the yield is rope-similar and close to be uniform in width (60 ± 10 nm) whereas the extent is in a moderately wide range (from 0.2 to 4 µm) with an average at 2.5µm. Four peaks can be recognized in XRD results, it is clear according to the ASTM cards that the film is polycrystalline at which (111), (200) and (220) silver (Ag) respectively. The range of functioning frequencies was (400 kHz - 40MHz), for all specimens, the measurement outcomes that involved reporting the first order resonance frequencies. The data presented shifting the resonance frequency to the higher order frequency for additive cases (salts+soil+bacteria) of water.

Keyword: Salt water; Ag nanowire; Pizosensor; bacteria; Resonance Frequency, Damping Coefficient.

I. Introduction

In 1880, typical properties of crystalline minerals discovered by Jacques and Pierre Curie (avatar): When a crystal is exposed to mechanical strength, it becomes electrically polarized. The stress and pressure caused by polarity voltages prevent the inverse relationship at a later time. These results were characterized by the influence of the piezoelectric piezoelectric effect as well as the piezoelectric reverse effect [1]. Piezoelectric sensors are mainly used in applications However, due to the small size and fragile nature of some piezoelectric materials, can it not provide furnished crystals sometimes, Unreliable, but unreliable for robots in your medical applications or Military or automation, etc. due to its strong substrates, intricate wires, or fragile elements [2]. When piezoelectric materials mechanically distort the so-called direct piezoelectric effect, they summarize the characteristics of the production of electrical charges. These features make piezoelectric power adapters suitable for sensor applications. Some benefits of piezoelectric detectors are their upper noise signals, compactness and ease of inclusion; they allow logical signal circuits [3]. During the First World War, engineered by Paul Langven and his French team, an ultrasonic submarine device was the first significant development of piezoelectric materials. This system was used to transmit a chirping high frequency pulse in water and to measure depth by calculating the response echo. In several typical implementations, such as infrared implementations, frequency
stabilisers, ultrasound inverters, microphones, gyroscopes, microphones, piezo ignition structures, delicate hydrophones and ceramic turntable casings, etc. Then they used piezoelectric crystals [4]. In addition, the piezo film is characterized by slow density and great sensitivity, and is mechanically difficult. Piezolayer compliance is 10 times higher than ceramic compliance. Piezoelectric polymers can be attached directly to a structure without affecting mechanical movement. However, polymers exhibit mild photovoltaic coefficients compared to ceramic piezoelectric with acoustic resistance similar to those in water and other liquids. The Piezo film is suitable for decompression of sensor applications requiring very wide frequency range and high sensitivity. As an engine, the low acoustic impedance of the polymer allows efficient transfer of a wide range of energy to air and other gases [5]. Many properties of light puzzles may change with the frequency and temperature of the excitation. Additionally, these properties are reversible and can be repeated with both temperature and frequency cycling. Generally, piezoelectric behavior can be demonstrated by a “direct” impact piezoelectric and an “inverse” piezoelectric impact in two ways. There is a specific piezoelectric impact when subjected to excessive pressure, if electrostatic piezoelectric material is indicated. You use these machines to identify stress, motion, force, stress or noise, such as strength and ultrasonic or ultrasonic sensors. Designing suitable electrical reactions. Once placed in an electric field, a piezoelectric substance is strained and thus can have a piezoelectric effect. This feature the necessary electrical field can be used to produce stress, motion, stress or vibration [6].

One-Dimensional (1D) metal nanostructures play as well as provide model architecture for experimental exploration of physical phenomena such as quantum pro- and localization effects [7]. Because of the high electrical conductivity, silver has been commonly viewed as conductive materials. Certain silver shapes were produced under certain conditions, such as nanoparticles, nanoparticles, etc., and silver NW is an example [8, 29]. Due to its interesting electrical, thermal and optical properties, silver nanowires attracted more silver enjoying the highest conductivity (6.3 x 10^7 S / m) and thermal conductivity (429 W/mK) among all metals, current review Ag NWs including two filters Very promising in the field of flexible electronics [10]. 1D Ag, including electro-chemical, electrochemical, template-guided, and chemical methods [11, 12]. There are a wide variety of characteristics and implementations in metal nanostructures. The design, size, composition and structure of nanostructures determine these qualities and implementations. It has been shown that the presence of different ions in the form and size of metal nanostructures [13].

II. Experimental Method:

Ag nanowire-like vertically aligned grown on FTO coated quartz substrate by using hydrothermal method. A template Ag thin film with a 350 nm thickness was deposited as a seed layer on FTO/quartz substrate. Next step process, Ag nanowire-like were grown on Ag seed layer coated FTO-coated quartz substrate by hydrothermal method, which are 50 ml aqueous solution included silver nitrate and polyvinylpyrrolidone (PVP) were dissolved in distilled water with continuous stirring for 30 minutes in a glass beaker without heating (at room temperature) until the mixture solution became transparent. The effect of addition FeCl3 and Na2CO3 as salt solution to the above mixture solution were investigated in this work at room temperature. Then, the solution transferred into a sealed Teflon lined autoclave was kept in a laboratory oven at a constant temperature of 180 °C for 8 hr. After completion of reaction, the autoclave cooled down naturally and gradually. Finally, Ag NWs products were grown on FTO coated quartz substrate which were dipped carefully in ethanol and stored in air at room temperature.

Silver nanowire structure obtained through Field Emission Scanning Electron Microscope “FE-SEM”, carried out by “Hitachi model (S-4160), Japan-dayptronics Company” in “Tehran” country at optimum condition (15 kV). The structure properties of silver nano wire was Examined by such a LabX XRD (6000 SHIMADZU XR – Cu Kα radioactive diffractometer (wavelength 1.54059 Å, voltage 30 kV, current 15 mA, imaging rate = 4 ° /min)).

Piezo sensor setup Such a work involves two normal piezo device crystals (Design Number: (3B12 + 9.0EAWC), Sort: Piezoelectric Ceramics Content: Piezoceramics, Metal Kind: Brass, Electrode Kind: (Thin) Transistor, Communication Terminal: Soldier wire or not, Variable value: (Distance=12 mm, Thickness=0.15 mm and Frequency=9 kHz) closely positioned on the copper foil.
The quartz cell (contains water solution) embedded between the two piezo crystals and piezo crystals with Ag nanowire thin film, pressure signal was produced by using function generator type (B+K precision (3020)) supplied an electrical pulse of frequency in the availability between (1–100000) kHz. The stress pulse passing through in liquid carried out by oscilloscope type ((KENWOOD 20 MHz CS – 1021)).

**III. Results and Discussion:**

Field Emission Scanning Electron Microscopy (FESEM) pictures given in figure (1), it is shown that structure for silver is wire-like, nearly uniform and width found to be (60 ± 10 nm) while the distance is in a relatively broad availability (found to be 0.2 to 4 µm) with an average at 2.5 µm. MBF Image J. program.software was used in this work.

![Figure (1): FESEM of silver NWs deposited on FTO coated quartz substrate.](image)

The crystallinity of the components generated using X-ray diffraction (XRD) was defined. For Ag nanowire films deposited on FTO coated quartz substrate. It is clear that The film is ASTM normal polycrystalline where (111), (200) and (220) Ag respectively, four peaks can be recognized in figure (2)(a). And that’s the confirmation silver NWs are formed. Four peaks The Face-Centered Cubic (fcc) silver phase (JCPDS file No.(04-0783) can be observed. From this figure, no impurities can be identified. The lattice straight continual parameter calculated on the basis of the strong peak (111), which is 4.086 Å close to the normal value (4.086 Å). Figure (2) (b) given FTIR for sliver nanowire.

![Figure (2): (a) XRD pattern of silver NWs synthesized on FTO-coated quartz substrate and (b) FTIR of silver NWs.](image)
Oscillation frequency can be calculated by measuring the output voltage as a variable of frequency as shown in Figure (3); the oscillation frequency may vary from 400 kHz to 40 MHz under different conditions; this variability may be due to a number of factors such as temperature, air pressure and mechanical charging.

\[ h(t) = A_0 \exp(-t/\tau) \sin(\omega t') \]  

where:
\( A_0 \) = Amplitude at Oscillation,
\( t' = 1/f \),
\( f \) = Frequency,
\( \omega = 2\pi f \),
\( \tau \) = Oscillation time.

Figure (4) shows the behavior of the wave as a function of time for water at different cases. Damping coefficient \( \delta_D \) of solution (water) at varies heating periods using the equation:

\[ \delta_D = \frac{A_1}{A_2} \]  

\( \delta = 1.3 \)
Figure (4): The period of resonance and $\delta_D$ for solution at optimum condition.
IV. Conclusion

In this work, the effect of adding water solution was investigated on piezoelectric sensing. The results observed that frequency of resonance Moving to higher scores of solution at different additions. Also the damping coefficient increased (from 1.3 to 1.9).

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