Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 7, S. 68-71, 4, 2023

Araştırma Makalesi

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 7, pp. 68-71, 4, 2023

Research Article

Porous Silicon Fabry-Perot Sensor Fabrication

Elif Akarsu*, Tevhit Karacalı[2]

[1]*Electrical-Electronics Engineering /Faculty of Engineering, Ataturk University, Turkey*
[2] *Electrical-Electronics Engineering /Faculty of Engineering, Ataturk University, Turkey*

*(elif.akarsu@atauni.edu.tr) *Email of the corresponding author*

(Received: 18 April 2023, Accepted: 25 April 2023)

(DOI: 10.59287/ijanser.2023.7.4.559)

(1st International Conference on Scientific and Innovative Studies ICSIS 2023, April 18-20, 2023)

ATIF/REFERENCE: Akarsu, E. & Karacalı, T. (2023). Porous Silicon Fabry-Perot Sensor Fabrication. *International Journal of Advanced Natural Sciences and Engineering Researches,* 7(4), 68- 71.

***Abstract* –** Porous silicon structures are widely used in gas sensor applications. The reason for this is that the gas holding capacity of the porous structure is quite high. In this study, mesoporous structures were obtained. It has been proven by studies that mesoporous structures are superior to other pore structures in gas retention and gas detection. In addition, fabry-perot structures were obtained by impact etching. SEM images and XPS results of fabry-perot porous structures were obtained.

Keywords – Porous Silicon, Sensor, Fabry-Perot, Crystal Sensor, Electrochemical Etching

I. Introduction

Porous silicon (Porous Silicon) is obtained by deeply etching single crystal silicon from its surface with the effect of chemical, electrochemical, ion or light. GS is a spongy structure. Detection properties are based on a change in effective density within the pores. Effective density has been measured in the literature as a change in either electrical conductivity or capacitance. The quenching of photoluminescence and variations of reflectivity have also been used as optical measurement techniques. The indirect forbidden energy gap of silicon, which is an indispensable material in microelectronics, is an obstacle to its use in optoelectronics. However, nano-sized silicon, which is the result of shrinking the dimensions as much as possible, is a candidate to be a silicon-based light-emitting electronic circuit element. Porous Silicon (GS) is an example of nanosized silicon. As a result of the confinement of charge carriers in the nanometer-sized silicon crystallite mesh walls of the GS, which is formed by electrochemical etching, which is a very cheap and easy technique, there is a widening of the forbidden energy gap and an increase in the luminous transmission rate. Thus, effective light emission was produced from the GS.

The enormous surface area of GS due to its spongy structure changes its optical properties with chemical interaction, and with this feature, it takes its place in sensor applications. In addition, the spongy structure brings with it the effects of aging. A feature of GS produced by electrochemical anodic etching is that etching continues at the pore ends rather than at the pore walls. Due to this feature, GS layers with different porosity can be formed. By producing multilayer GS and microcavity GS, it is possible to create LED and surface radiating laser structures (VCSEL) that emit at the desired wavelength.

II. Materials and Method

Silicon refining process

Since the thickness of the silicon slices used is around 0.7 mm, it is thought that the permeability decreases with the effect of the thickness. Therefore, before the GS fabrication, the thinning process is carried out from the matte back side of the silicon. For this process, first of all, the apparatus placed on it is heated by using the heating system in the figure, and the 2 cm x 2 cm silicon slices that we have are adhered to this apparatus by applying resin. Then, the initial thickness of the silicon slices is measured using the measuring system. After the measurement process is performed, the thinning process of the eight different silicon slices we have is carried out by using sandpaper no. 800 and by operating the setup in Figure 3 for different times. With the help of the steel shaft in the assembly, the apparatus to which the silicon slices are attached is placed in the assembly. Thanks to the mechanism given in the figure, this apparatus both traveled a certain amount to the right and left, and the process of rotation around itself is performed. The rotation process is realized by using the I-II-III-IV positions determined on the apparatus, respectively, and by placing the used position to the front and operating the apparatus. After the device is operated for the specified time at the specified location, the wear process of the silicon slice takes place and its thickness is measured. This process is continued until the desired thickness is achieved and each slice is thinned up to approximately 0.3 mm.

GS Formation Mechanism

Each sample is p-type silicon oriented (100) with 0.01–0.02 ohm resistivity. The solution is a mixture of HF (%40) and ethanol (%95) with a 1:2 ratio. PSFP structures have been prepared by electrochemical anodic etching of a silicon wafer in solution.[1] Silicon samples and platinum are the anode and cathode. A hole is required for dissolution of Si in HF at initial time. Two mirrors with Fabry–Pérot (FP) cavity have been made by constructing low and high porosity PS layers for each sample. Divalent dissolution is initiated by a hole from the bulk approching the silicon-electrlyte interface wich allows for nucleophlic attack of the Si atom. n acidic electrolytes with fluroide, silicon is stable open circuits potential, while electrochemical dissolution take place for anodic potential. For anodic current densities below the critical current density PS is formed. The electrolyte-electrode interface is found to be Si-H covered. [2] The PSi structures are generally fabricated by electrochemical anodic etching of a silicon wafer in a solution mixture with HF and ethanol. Since the refractive index of a Psi (approximately 3.5 si n =) can be controlled by its porosity, one dimensional structure can be produced by periodically altering this parameter via mainly a change in the applied current.[3]

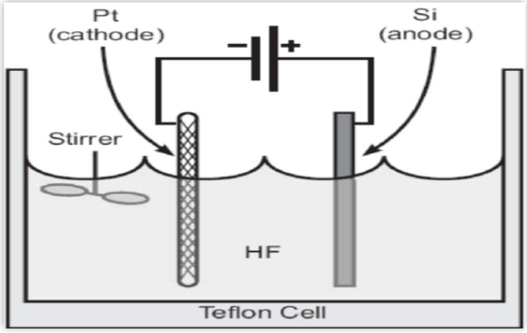

Fig 1. Electrochemical anodic etching mechanism Porous silicon formation times and current

First, index matching is done on the chart. A current of 2 mA is given for 26880 mS, a current of 75 mA is given for 7224 ms, this process continues 6 times, that is, Fabry-Perot structures are created with 6 layers on top and 6 layers on the bottom.

In addition, the area of the porous structure is a very important parameter. The current density depends on both the area of the porous structure and the applied current.

Carburizing and Annealing Process

The thinned and porous samples are subjected to carburization at 80 degrees for 24 hours in a solution called carburizing. After the carburizing process, the samples are annealed at 1000 degrees. The purpose of the annealing process is to passivate the surface. In other words, it is to destroy the oxidation in the porous made sensor. Thus, we prevent the chemical sent to the environment from reacting with the oxygen.

III. Results

Based on Fabry-Perot (FP) filter in semiconductor surface irradiated laser structures. Bragg reflectors are used. Due to the nature of the GS, Bragg reflectors and microcavities can be obtained by driving variable and variable. Bragg reflectors must be homogeneous in the GS sample in a good FP layer, and the interlayer surface must be necessary to obtain a filter from the GS layer. Conventional electrochemical anodic etching method is generally applied in FP filters made using GS. In this method, the chemical reaction of HF with silicon is slow due to the decrease in HF density in the pore. Also, the displacement of HF inside and outside the pore will be affected by the hydrogen gas evolution. This hydrogen gas will cling to the edges where the sample comes into contact with the cell, causing hydrogen bubbles to accumulate, thus preventing homogeneous GS distribution over the entire surface of the sample.

With Carburizing and Annealing process The thinned and porous samples are subjected to carburization at 80 degrees for 24 hours in a solution called carburizing. After the carburizing treatment, the samples are annealed at 1000 degrees. The purpose of the annealing process is to passivate the surface. In other words, it is to destroy the oxidation in the porus made sensor. Thus, we prevent the chemical sent to the environment from reacting with the oxygen. With the xps analysis, the information about the atoms in the structure has been reached and it has been seen that the carburizing process reduces the oxidation in the structure.

Table 1. Fabrication Parameters

Pre-Training Algorithm	**Accuracy**
Solution	HF (%48): EtOH(%95) , 1:2 (Volumetric)
Type	*p+ Silicon (0.01-0.02 ohm.cm)*
Current Density	2 mA/cm2 (for lower porosity) 75 mA/cm2 (for higher porosity)
Time	26.88 s (for lower porosity) 7.2 s (for higher porosity)
Period	6

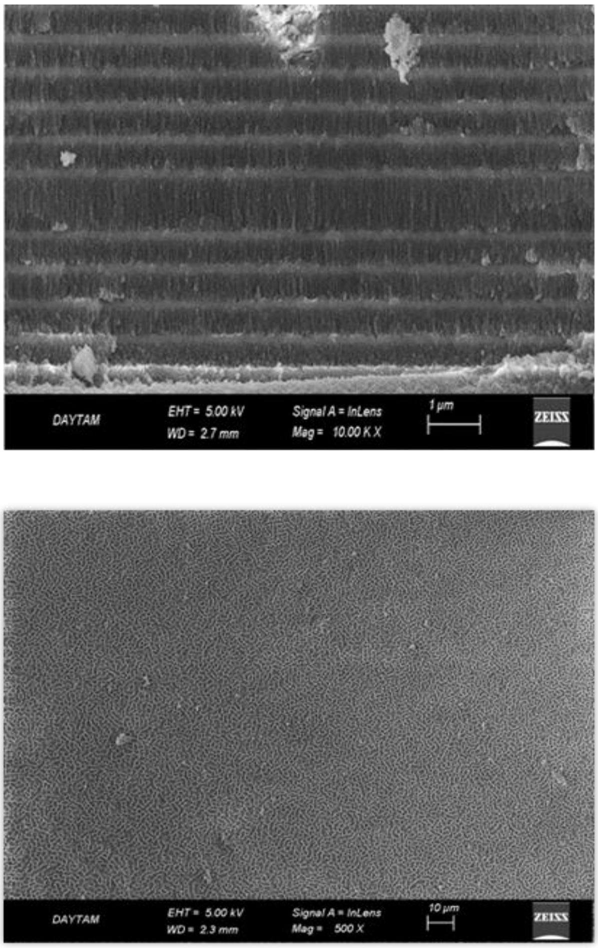

Fig. 2. SEM images of porus structures (a) porous silicon fabry-perot structure (b) top view of porous structure

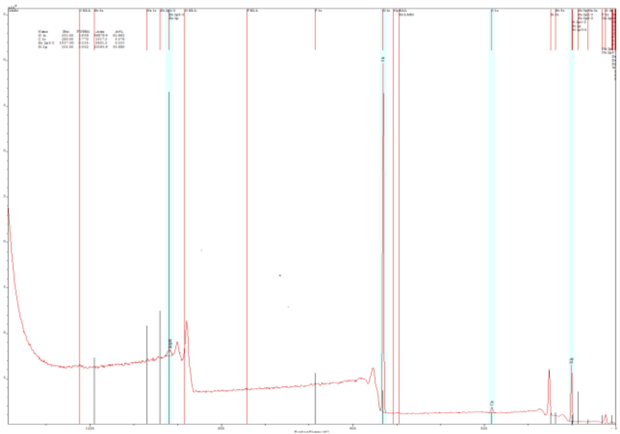

Fig. 3. XPS images of porus structures

IV. DISCUSSION

In this study, the fabrication of fabry-perot sensor production is emphasized. We have observed that it is also suitable for creating multi-layered structures where production is not limited only with porous structure. It has been seen that the reflection images of fabry- perot structures can be useful in sensor applications. these images represent the operating range of the sensor as well. It can be seen from the wavelength range in the reflection image that a sensor working in the infrared region has been fabricated. It was also observed that the "m" structure in the graph improved after annealing in the reflection spectrum. A more uniform and uniform structure was obtained.

CONCLUSION

As a result, the Fabry-Perot gas sensor structure that works in infrared wisdom and burns in that region has been obtained.

REFERENCES

[1] Karacali T., Alanyalioglu M., Efeoglu H., Single and Double Fabry–PÉrot Structure Based on Porous Silicon for Chemical Sensors, IEEE, December 2009, 1667 - 1672.

[2] Hasar U. C., Ozbek I. Y., Oral E. A., Karacali T., and Efeoglu H., The effect of silicon loss and fabrication tolerance on spectral properties of porous silicon Fabry-Perot cavities in sensing applications, OPTICS EXPRESS, 13 Sep 2012, 22208- 22223

[3] Dongoing L., electrochemıcal ınvestıgatıon ınto porous sılıcon formatıon, national university of singapore, 2013.