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Effect of photo chemical etching and electro chemical etching on the topography of porous silicon wafers surfaces

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ABSTRACT

In This research we study the effect of photo chemical etching and electrochemical etching on topography of porous silicon surfaces, the results showed that photo chemical etching produced roughness silicon layer which can have thickness be less of porous silicon layer which is produced by electro chemical etching When all the wafers have same etching time and hydrofluoric solution (HF) concentration, the wafers have same resistance (10 Ω.cm).

Also the results showed the roughness of porous silicon layers produced by electro chemical method which is bigger than the roughness of porous silicon layers produced by photo chemical method and the results of roughness of porous silicon layers, Pore diameter and porous layer thickness were produced by electro chemical method (1.55(μm) ((0.99(μm)) and ((1.21(μm) respectively), the results of roughness of porous silicon layers, Pore diameter and porous layer thickness were produced by photo chemical method (0.63) nm -(1.55) (μm)),so the (84.9 (nm)- and (3.94(nm) respectively .

This is reinforces because of using the electro chemical to etching the wafer surf ace of bulk silicon and changing it to roughness silicon surface be share in success of many practicalities.

1 . Introduction

The porous silicon wafers may be used to produce solar cells and detectors, when the wafers etching is made from its solar cells, it is noted that the rise in their efficiency because increasing the surface area of the solar cell exposed to light, all of this would encourage entry into such research's, The photochemical etching process was studied also by Koker and Kolasinki ,They demonstrate that there are two distinct photochemical processes induced by illumination of the silicon wafer, one is anisotropic etching, which leads to pore formation and propagation, and the other is isotropic etching, which removes the porous silicon, in comparison with the other published methods, electrochemical and photochemical processes are found to be more efficient in producing a homogeneous porous silicon layer, with thick, large surface area and low cost, the whole work, and the results in this search are congruent with [1,2,3].

It is worth mentioning that the size of the mitral approached the dimensions of atomic so it is based to laws of quantum mechanics instead of the classical physics laws [4,5].

The adoption behavior of the material on its size enables us to control the engineering of its properties, There are two ways to manufacture a nanoscale size of the material, one of them, top to bottom and the other from the bottom up [6].

The methods used in this work is the photochemical method, and electrochemical method, these are from the important methods of forming a porous layer on the silicon wafer by using a Teflon Cup (acid-resistant material) and the silicon wafer and backers are immersed in (HF) and at a certain concentration, A specific light source (halogen light) 1000 (watt / cm^2) .

1. 2 Nano porous silicon

The development of porous silicon gave a new dimension to technologies which based on porous silicon, in 1990 and the discovery of photoluminescence at room temperature of porous silicon by Canham [7], did not use bulk silicon in the field of light sources (LED), Because silicon is a semi-conductor material, with an indirect band gap, therefore the light fluorescence occurs at room temperature very small .

The importance of porous silicon is not limited by photovoltaic applications but depends on its properties as a crystal with a bright light , which changes the optical properties and absorption, optical reflectivity, making it sensitive to specific wavelengths and useful in optical applications. By controlling the etching methods (photo chemical and photo electro chemical etching) so that a suitable crystalline structure for porous silicon nanoparticles can be obtained with different porous layers[8]. The large surface area of nanoparticle silicon and its unique surface structure provided ideal conditions for use as an optical sensor or a diode due to the difference between the number of surface carriers and base carriers. The importance of using porous silicon nanoparticles in manufacture of photoconductor and diodes and their properties, especially in terms of industrial use compared to other materials used in this field and the possibility of preparing the surface for high selectivity [9]. The small size of manufacturing gave the lack of energy loss and the provision of raw materials.

Each direction of inventory corresponds to a change in the promoter's causative properties and as a result a series of discrete levels appears. Bearing in mind that the charge carrier is free of movement in all directions in crystal size, the (2-D) structure can be moved freely only in two directions while third direction determines the direction of quantitative restriction. In the single-dimensional structure (1-D), there is only one possible direction for free movement and two directions in which quantification can occur. In the zero structure (0-D) is obtained completely quantitatively in all directions and given particle cannot move free movement at all [10].

2 . Experimental details

2.1 Preparation samples:

The methods for preparing porous silicon are: (A) Photochemical etching. (B) Electrochemical etching ,which used in this research .

2.1 .1 Photochemical etching

This method was chosen in this study because it controls the properties of produced porous silicon and producing large and homogeneous surface areas. The light on the models is uniformly distributed and vertically producing relatively similar nanostructures.

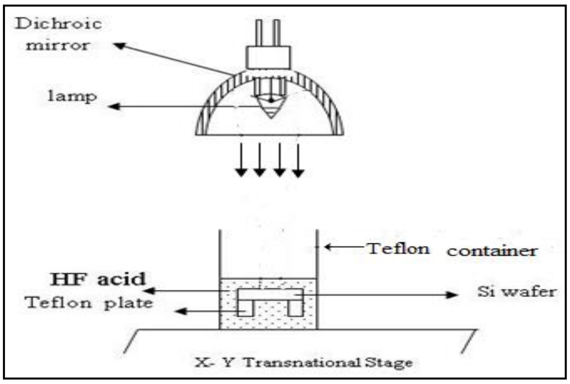

Figure (1) A schematic diagram of the photochemical cell [11].

During process of forming, freckles there are two atoms of hydrogen synchronized with the silicon atom and the ratio of hydrogen atoms decreases, when they reach the electronic polishing system at the surface and disappear during this process, the semi-spherical interaction of the anode during the process of the formation of the hole is written equivalent to this formula:

$Si + 6HF \rightarrow H_2SiF_6 + H_2 + 2H^+ + 2e^-$ ..... (1)

During the process of electronic refinement,, the equation is written in this format:

$Si + 6HF \rightarrow H_2SiF_6 + 4H^+ + 4e^-$ ..... (2)

The final and constant output of presence of silicon inside HF and their interaction together can produce H_2SiF_6 or the formation of some ions. This means that during the process of the hole formation, two of the four electrons on silicon atom leave the atom and move with the removed part while other two remain adhered to the silicon atom and undergo corrosion later. In contrast, during the electronic polishing process all four silicon electrons are chemically effective.

Electrochemical Method: .1.22

The method of electrochemical etching was chosen also in this study to produce porous silicon layer. The current which is the different item of the Photochemical method, and some things, like electrode.

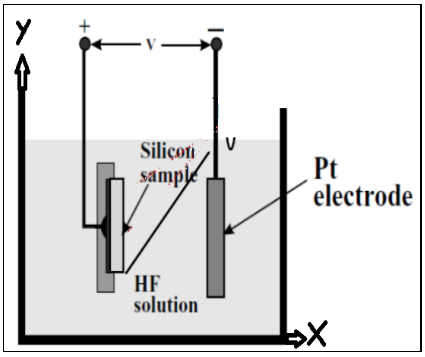

Figure (2) A schematic diagram of the electrochemical cell.

The n-type silicon wafer were selected with (1 0 0) and one resistance (ρ=10 Ω. cm) respectively to study the effect of resistance (qualitative resistance) on chemical scaling processes (250 ± 10 μm) and cut in dimensions (1 x 0.5 cm^2). Cleaning the samples with acetone, and ethanol to remove the suspended materials, and then to put it in HF and 10% concentration for 15 seconds to remove oxide layer on the silicon surface.

After cleaning the silicon sample, it is immersed in HF 40% inside a teflon cup based on same Teflon material Fig.(2) with its glossy surface facing the light source. The light source used in this experiment is a Phillips halogen lamp (1000W), which provides uniformly distributed illumination intensity on the sample surface, to ensure the smoothness of the flattened layer. The illumination is highly controlled by moving light source by approximating the sample to the intensity of the light (1 ×10^5) LUX which can be obtained when It lied just (6) cm of the sample, This study focused on the following:

2.2 Studies of morphology by AFM .

2.2.1 AFM of morphology for sample surfaces produced by the photochemical method

The sample of n-type and directional silicon (1 0 0) can have the resistivity of (10) Ω. cm and light intensity (1×10 ^{5}) LUX was selected and the (20 min) was studied to study the effect of light intensity on the topography of silicon surfaces by the photochemical method.

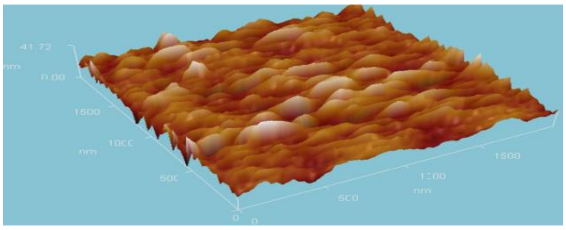

Figure (3) Shows AFM of Sample for silicon wafer n-type (1 0 0) and resistivity of (ρ=10 Ω. cm) Using the conditions of the method are different in terms of light intensity (1×10 ^{5}) LUX and HF 40% and time (20) min.

2.2.2 AFM of morphology for sample surfaces produced by the electrochemical method

The samples were selected n-type and directional (100) with resistivity ($\rho_=$ 10) Ω. cm and the magnification time (20 min) was performed under conditions (HF40%) and intensity of current (24mA/cm^2) mA to study the difference in Morphology on the produced porous layer.

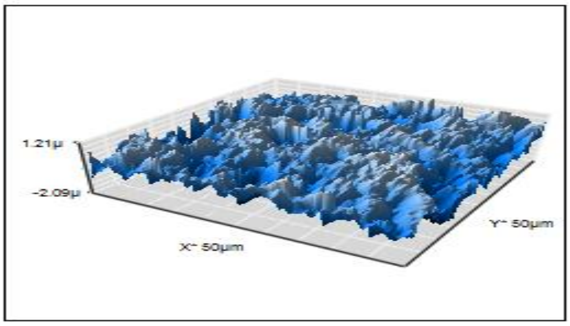

Figure (4) Shows AFM of Sample for sample of n-type and directional silicon (1 0 0) was carried out by Electrochemical method under Current intensity (24mA/cm^2) and by using 40% HF and (20) min ($\rho_=$ 10) Ω. cm

3. Results and Discussion

In this part of the research, Atomic Force Microscope (AFM) in Fig(3) and Fig(4) showed the topography of samples which was carried out by electrochemical and photochemical methods, it is also studied and analyzed by studying shapes and sizes of the formed nanoparticles, most of which ranged from (60 - 120nm),and the thickness of porous layers from (3.94 (nm) - 1.21(µm) which are within the dimensions of nanotube particles, As well as the statistical distribution of size of these particles and the development of scientific explanations to form, and the results of the atomic force microscope is conclusive because of richness in the information it provides such as average roughness and the value of the average root square object (Root Mean Square) and the value of surface torsion (Surface Skewness) and the distance between Peak-Peak and a lot of information on which characteristics of manufactured devices can be explained. The control of producing porous layers with certain specifications is provided for use in their appropriate applications. this work is focused in comparing between the effect of etching methods which used in this work , on morphology of wafer surface, the results (AFM) shows that the electrochemical method and effect on surface morphology like thickness of porous layer, roughness, higher than the photo chemical method Table (1) when two methods have same conditions, HF, etching time and resistivity of wafers ,that is occur because the electrochemical method produced big current moving inside the wafer from negative to positive so it helping to drilling the surface of wafer with higher than velocity of photochemical method .

While the little of thickness porous layer produced by the photochemical method its backed to the current, which produced is very little comparing with the current of electrochemical method, at the end the electrochemical method was more than the photochemical method in effecting to produce porous layer.

Table (1) Comparison The effect of Electrochemical method and photochemical method porous silicon surface morphology parameters

The etching methods	roughness	root mean square	The statistical distribution	Pore diameter	porous layer thickness
photochemical method	0.63(nm)	0.74(nm)	115-70(nm)	84.9(nm)	3.94(nm)
Electrochemical method	1.55×10^3(nm)	1.79×10^3 (nm)	(120 -85) $\times10^3$ (nm)	0.99 (nm) $\times10^3$	1.21×10^3 (nm)

We conclude from Table (1) that by the Electrochemical method, the processes of etching are increased, so it was given as the nano structure with all numbers that's maybe back to the current of the curers in to the wafer which is applied as shown by the increase in the tops and heads thickness of the porous layer, but this process may be counterproductive as the drilling processes disappear by increasing the optical intensity applied to the surface of the wafer to be reclaimed. May be exposed to the porous layer produced because the drilling may be created on the grooves and walls itself, which is the layer of porosity, thus uprooting the layer with the increased intensity of lighted and shows the etching as if we start to resurgence again.

4. Conclusions

1- The etching method has affected the porosity, The roughness layer increased in the silicon wafer surfaces by electrochemical method , because the current of the curriers from the far side to the opposite side, which leads to increase the etching processes in the surface of the wafers.

2- The roughness layer has decreased in the silicon wafer surfaces by photochemical method, because the current of the curriers from the far side to the opposite side which facing the light be smaller than the ratio of curriers in the electrochemical method , which leads to decrease the etching processes in the surface of the wafers.

3- impedes the mechanism of uprooting and the intensity of light enter as urges for the produced the electron hole pairs begin to generate by absorption of light inside the wafer , there was a percentage of both types of electrons and holes from a indirectly - energy gap silicon, by the current of these curriers the surface atoms of the wafer will be removed and the etching process was occurs .

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تأثير التنميش الكيميائي الضوئي والتنميش الكهروكيميائي على طبوغرافية سطوح شرائح السليكون المسامي

امجد حسين جاسم

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الملخص

تم في هذا البحث دراسة تأثير التنميش الكيميائي الضوئي والتنميش الكهروكيميائي على طبوغرافية سطوح السليكون المسامي، اذ اظهرت النتائج ان التنميش الكيميائي الضوئي انتج طبقة سطحية ذات خشونة اقل سمكا مما انتجه التنميش بالطريقة الكهروكيميائية وعند ظروف التصنيع نفسها من تركز HF و زمن تنميش ومقاوميه نفسها (10 Ω .cm).

كما تبين ان الخشونة كانت اكبر لسطوح شرائح السليكون المسامي المنتجة بالطريقة الكهروكيميائية مما هي عليه سطوح السليكون المسامي المنتجة بالطريقة الكيميائية الضوئية اذ اظهرت النتائج ان قيم الخشونة وقطر المسام وسمك الطبقة المسامية للسطوح السليكونية المنتجة بالطريقة الكهروكيميائية كانت (1.55(μm) و (0.99)(μm) و (1.21)(μm) على التوالي، بينما اظهرت النتائج ان قيم الخشونة وقطر المسام وسمك الطبقة المسامية للسطوح السليكونية المنتجة بالطريقة الفوتوكيميائية كانت (0.63(nm) و ((84.9)(nm) و (3.94)(nm) على التوالي.

وهذا يعزز من امكانية استعمال الطريقة الكهرو كيميائية الضوئية لحفر سطوح شرائح السليكون الكتلي وتحويلها الى شرائح سليكون ذات سطوح خشنة تسهم في انجاح عدة تطبيقات عملية.