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ELECTROCHEMICAL ETCHING: An Ultrasonic Enhanced Method of Silicon Nano Porous Fabrication

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ABTRACT

As nano material has become the major quest of every researchers due to it numerous advantages and applications, nano porous devices constitute emerging platforms that allowing wider room for exploration. Here in this study, an ultrasonic enhanced anodic electrochemical etching fabrication of silicon nano porous by simple technique, uniform silicon nanopores with pore diameter of < 20 nm were fabricated. The surface and cross-sectional morphology reveal that the method produce uniform nano silicon porous layer with smaller silicon pores with high etching efficiency. The study also demostrated that the silicon nano porous exhibited excellent optical

properties which shows a reflection and PL spectra with PL peak located between 800-860 nm.

Keywords: Silicon Nano Porous, Ultrasonic, Anodic Electrochemical Etching, fabrication, PL spectra, NSP

1. INTRODUCTION

A silicon nano porous has a potential to play an important role in visible light emission related applications, moreover, silicon nano porous (PS) devices constitute emerging platforms for including selective molecule separation and sensing, with great potential for high throughput and economy in manufacturing and operation (Dhahi et al, 2012; Hashim et al, 2012). However, fabrication of this device poses some challenges that researcher find it necessary to solve. The most commonly used method of fabricating PS is direct current (DC) anodic electrochemical etching and during the DC anodic etching process, the reaction results in silicon fluoride. This product tend to cover the pore tips during deposition process, hydrogen gas bubbles are adsorbed at the surface of silicon pillars because of interfacial constraint, blocking the silicon pores and leading to a reduction of HF concentration inside the pores. This will lead to the etching process slowing down and dissolved species will increase the resistance of silicon wafer and hence decrease the current density (Liu et al, 2003).

The previous study presented using an ultrasonically enhanced anodic electrochemical Etching which is developed by to fabricate light-emitting PS material. They study took the advantage of the ultrasonic press effect and the diffusion of the dissolved species and H2 bubbles from silicon pores was accelerated. They results has improved qualities in surface morphology, layer interface smoothness etching efficiency and optical characteristic compared with the sample prepared by DC etching. However, the current study presented and improve results smoothness etching efficiency, improved qualities in surface morphology and pore size that could increase it application in various field including biomedical, environment and life sciences such as water filtration (Huang et al, 2009) etc.

2. MATERIAL METHOD

A single crystal p-type with (100)-oriented highly doped silicon substrate is used an it was placed in a Teflon etching cell and etched in the dark with a HF (40%): C2H5OH (99%):1:1 (by volume) electrolyte solutions were prepared for ultrasonic anodic etching using the ultrasonic wave frequency of the ultrasonic generator was 33 ^ 3 kHz. After the etching process, all the samples was immediately rinsed by deionized water and dried, for drying, a vacuum dryer was used. The etching current density was 55 (mA/cm^2) for 1 minute and duty cycle of 0.7

3. RESULTS AND DISCUSSION

The surface and cross-sectional structures were investigated with analytical Scanning electron microscope (ASEM) at UniMAP clean Room. Analysis of surface morphology was carried out using the and AFM in the same clean room, Fig. 1 shows the surface SEM images of silicon porous, the pores can be seen as mall dots folded and distributed themselves randomly but relatively regular in shaped. Most pores have small dimension <10nm is far better results.

Atomic force microscope (AFM) results below indicated clearer evidence silicon nano porous fabricated using ultrasonic wave are presented in figure 2 and 3 . The pore diameters are much smaller and the shapes are more as circular and more uniform distributions as indicated in ASEM image although the homogeneous pores have appeared in not in all wafer surface however, in general the PS layer thickness produced is quiet impressive.

The dielectric properties of silicon nano porous is a function of its porosity, a Bragg reflector and PS multilayer structure can be constructed to manipulate the light transmission through silicon nano porous. Thus, the surface and interface smoothness and uniformity is one of the most important elements in determining optical characteristics of silicon nano porous surface single or multilayer. Smooth surface obtained in this study was measured by AFM which shown is shown in Fig. 2 and 3. From the result in the micrograph showing the silicon pillar dimension increases existent in some area of the wafer. The surface and cross-sectional morphology obtained in the study of by using ultrasonic anodic etching, a sample has a more uniform PS layer with smaller silicon pores and the etching efficiency is also higher than those prepared which they compared with four different samples and claimed the reason is believed to be that when employing simply the direct current etching method, the chemical reaction products will deposit at silicon pores, furthermore, this could also be explained in term of zero charge constraint where the movement of the charge potential restricted and mostly the at pore tips, and this prevent the dissolution of silicon wafer, consequently enlarging the both radial and lateral etching. A considerable amount of micro-bubbles will appear in the electrolyte solution when the ultrasonic wave acts on it. These bubbles will shrink and expand repeatedly with the variety of sound pressure and result in desorbing of the chemical products from silicon pillars. If the bubble is broken, an extreme high pressure will be produced. This pressure will bring the dissolved species out of the silicon pores. In addition, the other ultrasonic effects, such as vibration, will also speed up the diffusion of chemical products. All these reasons cause the chemical reaction to concentrate on the pore tips, thereby reducing the lateral studies of the samples etching and improving the uniformity and etching, the fabrication of nano porous silicon using the ultrasonic etching process wave makes all the nano porous silicon micro cavity layers thicker and with larger refractive index, which results in the modulation waveband of PS micro cavity moving to long-wavelength region and resulting in red-shift of PL peak. The study Q values obtained are more than 300, much higher than the result reported by. The interface smoothness of silicon nano porous and the PS nano cavities were fabricated the full width at half maximum (FWHM) of the resonant PL peak from the PS nano cavity can be regarded as a reflection of PS multilayer interface quality (Liu et al, 2003). Fig. 4 is the reflection and PL spectra. In present study The PL peak is located between 800-860 nm.

CONCLUSION

An Ultrasonic Enhanced Anodic Electrochemical Etching Fabrication of Silicon Nano porous by simple technique is demostrated, a uniformly nanopores in silicon with pore diameter <20 nm was fabricated. The surface and cross-sectional morphology reveal that the method produce uniform nano silicon porous layer with smaller silicon pores with high etching efficiency. The study also demostrated that the silicon nano porous exhibited excellent optical properties which shows a reflection and PL spectra with PL peak located between 800-860 nm. These results lay a foundation for exploiting of NPS devices, particularly in realizing PS laser.

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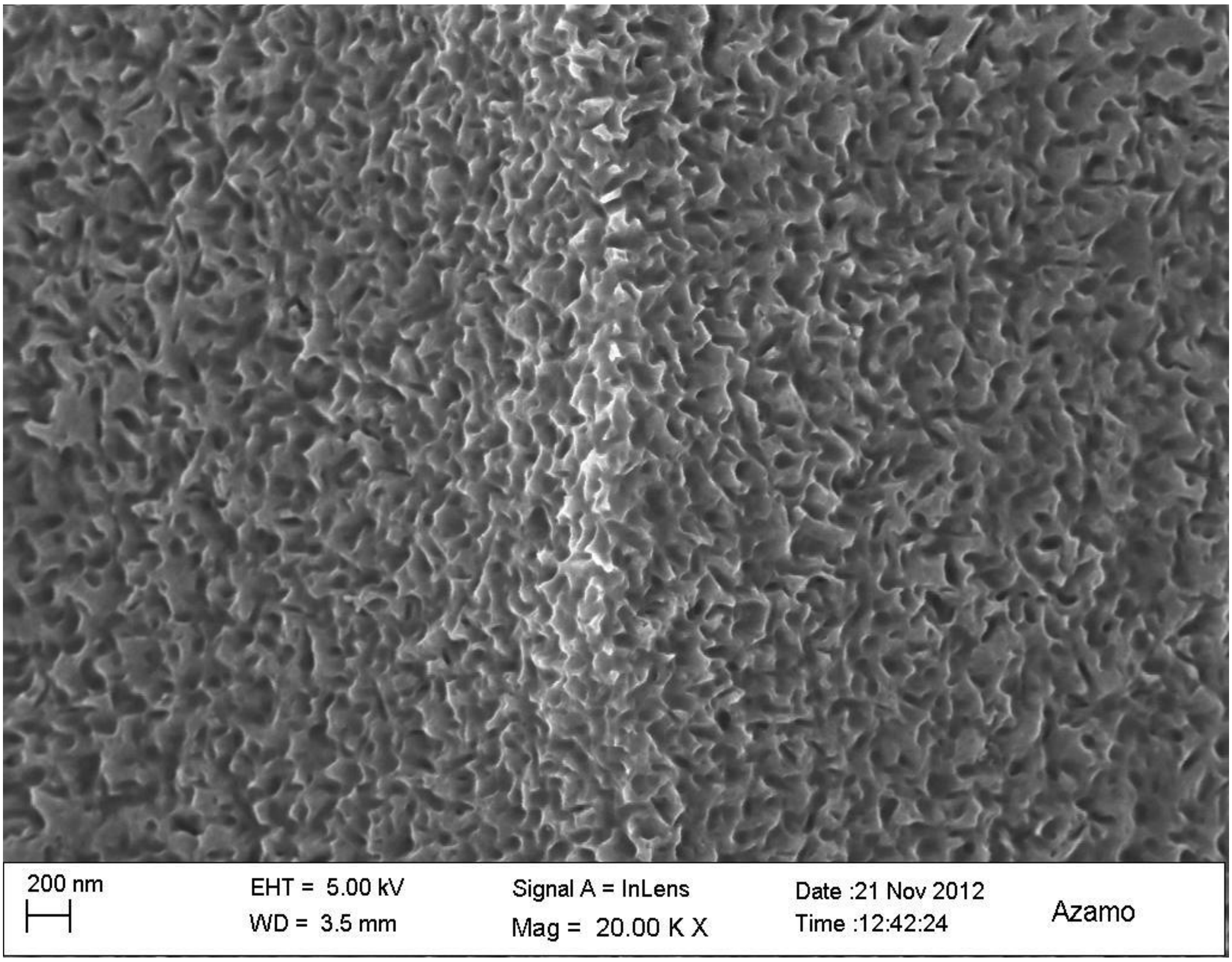
Figures



Figu1. Surface SEM micrographs of porous silicon samples fabricated ultrasonic etching

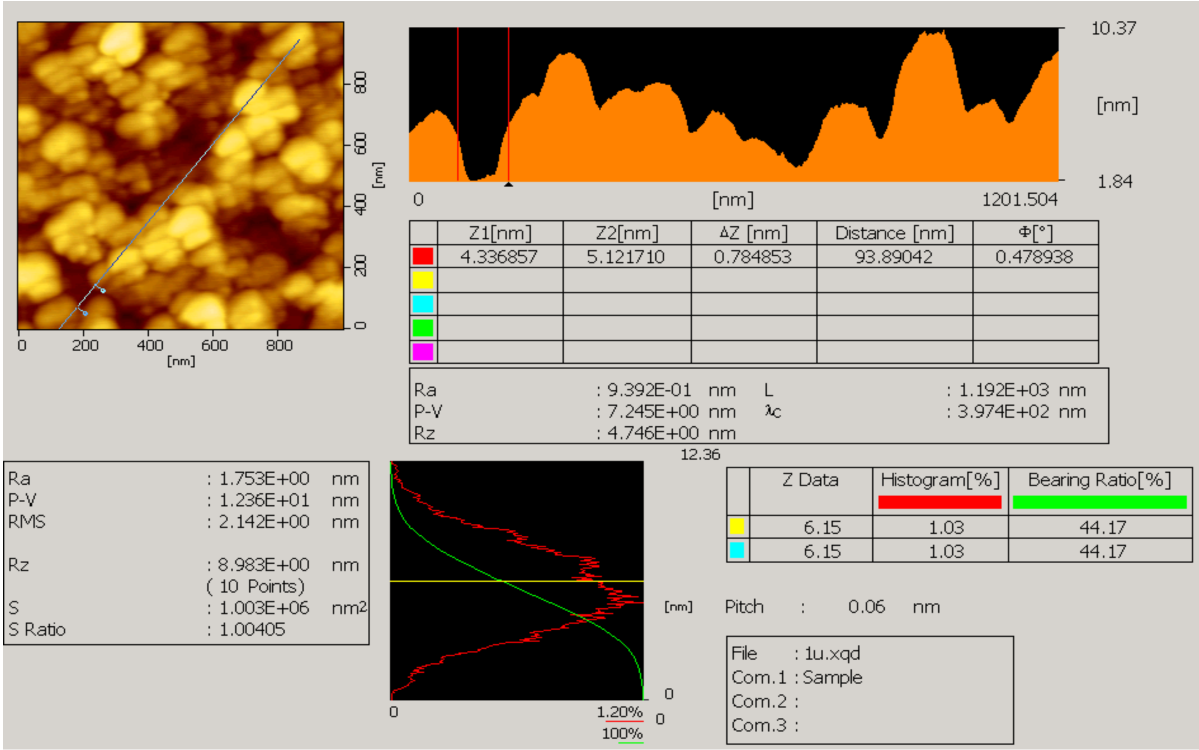


Fig. 2 AFM images of Ultrasonic pulsed etching fabricated silicon nano porous showing some portion of the sample.

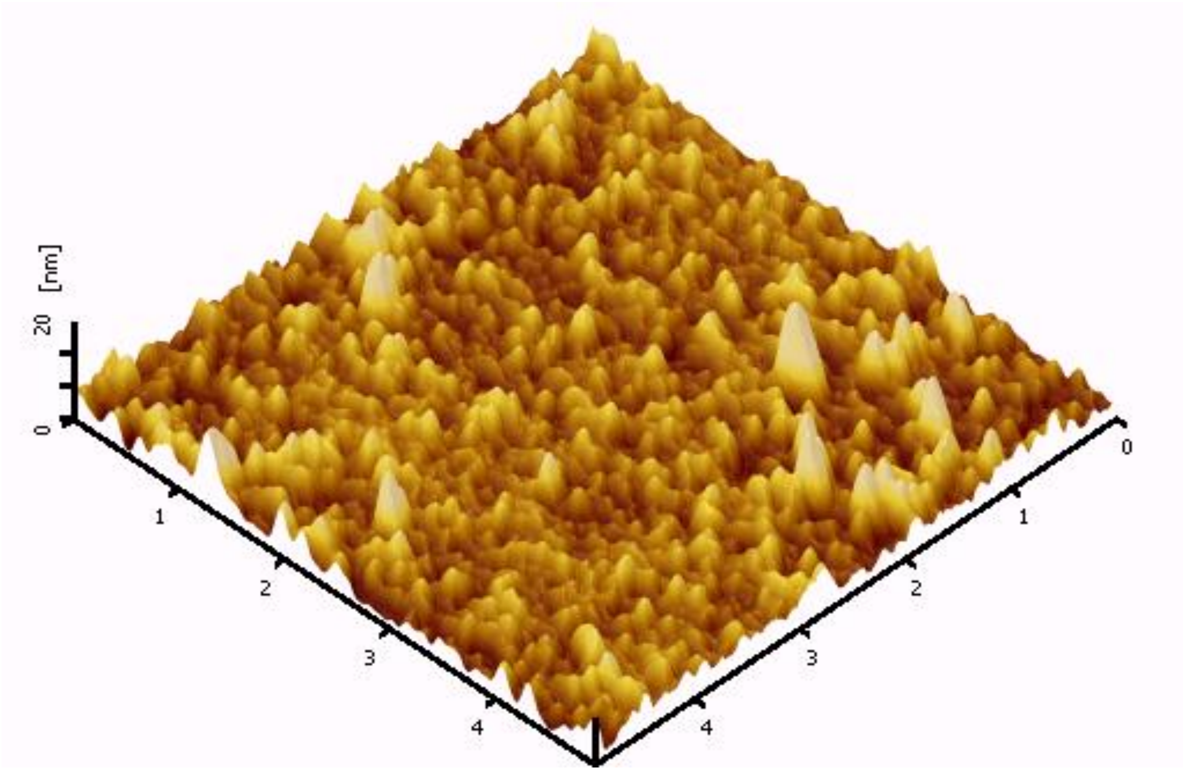


Fig. 3 AFM images of Ultrasonic pulsed etching fabricated silicon nano porous

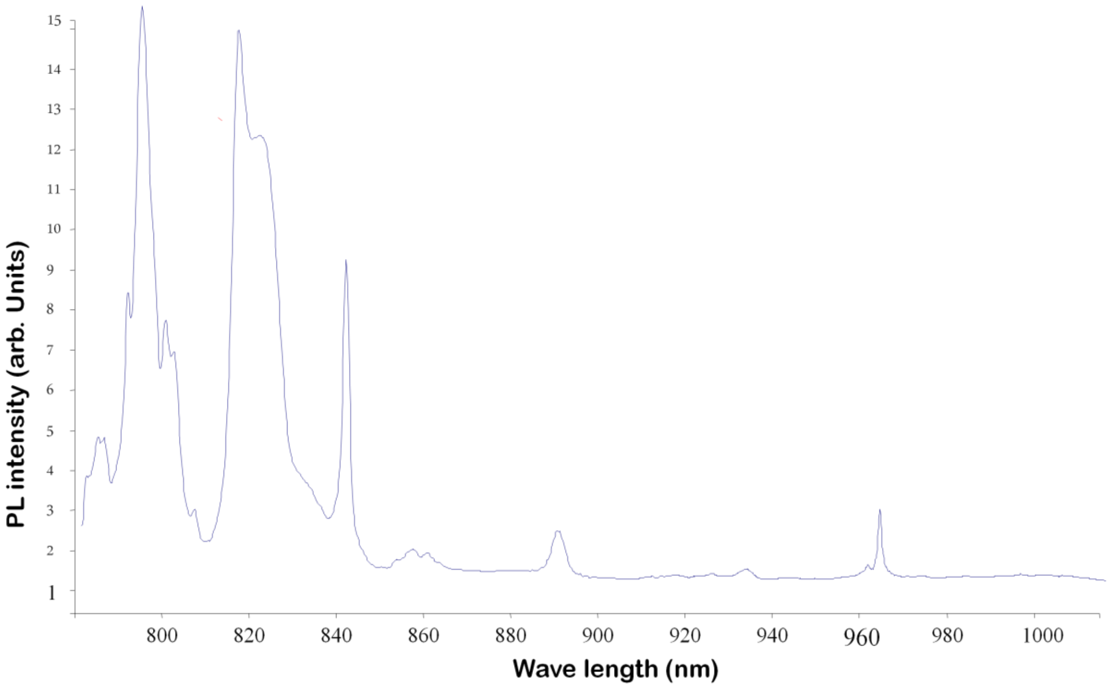


Fig.4: PL spectra of the fabricated silicon nonporous