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# Formation of ultra Si/Ti nano thin film for enhancing silicon solar cell efficiency

T Adam<sup>1</sup>, T S Dhahi<sup>2</sup>, M Mohammed<sup>3</sup>, A M Al-Hajj<sup>4</sup>, U Hashim<sup>4</sup>

<sup>1</sup>Faculty of Technology, Universiti Malaysia Perlis (UniMAP), Kampus Uniciti Alam Sg. Chuchuh, 02100 Padang Besar (U), Perlis, Malaysia.

<sup>2</sup>Department of physics, University of Basra, Basra, Iraq.

<sup>3</sup>Center of Excellence Geopolymer and Green Technology, School of Materials Engineering, Universiti Malaysia Perlis (UniMAP), 01007, P.O Box 77, D/A PejabatPosBesar, Kangar, Perlis, Malaysia.

<sup>4</sup>School of Electrical system Engineering, Universiti Malaysia Perlis (UniMAP)Malaysia.

<sup>5</sup>Institute of Nano Electronic Engineering, University Malaysia Perlis, Perlis, 01000 Kangar, Malaysia.

tijjani@unimap.edu.my

**Abstract.** An alternative electrical source has become the major quest of every researchers due to its numerous advantages and applications of power supply and as electronic devices are becoming more and more portable. A highly efficient power supply is becoming inevitable. Thus, in this study, present ultrasonic based assisted fabrication of electrochemical silicon-Titanium nano thin film by in-house simple technique, uniformly silicon Nano film was fabricated and etched with HF (40%): C<sub>2</sub>H<sub>5</sub>OH (99%):1:1, < 20 nm pore diameter of silicon was fabricated. The surface and morphology reveal that the method produce uniform nano silicon porous layer with smaller silicon pores with high etching efficiency. The silicon-Titanium integrated nano porous exhibited excellent observation properties with low reflection index ~ 1.1 compared to silicon alone thin film.

## 1. Introduction

Solar cell is one of the most recent development that has attracted [1-5]], due to its potential, the quest several material has kept up growing especially 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. However, fabrication of this device poses some challenges that researcher find it necessary to solve [6-11]. 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 tends 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 [12-17]. 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 [1].

The previous study presented using an ultrasonically enhanced anodic electrochemical Etching which is developed by [1, 18-20] to fabricate light-emitting PS material. They study took the advantage of the ultrasonic press effect and the diffusion of the dissolved species and H<sub>2</sub> bubbles from silicon pores was accelerated [1, 21-24]. 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 etc[25, 26]. The study demonstrates a simple in-house fabrication of enhanced silicon solar cell using ultrasonic vibration etching. Well distributed photovoltaic cell can be produced in just 5 simple steps. The Experimental study results show that the silicon based fabricated photovoltaic devices using titanium as anti-reflector exhibit high photo energy absorption with high voltage when exposed to the spectrum of the solar radiation. The high efficiency obtained as a result of structures of Ti in which it shows the surface layers energy greatly enhanced the light-absorption capability of cell is greatly increased. Hence the methods are simple and at no cost, a stable solar cell can be produced.

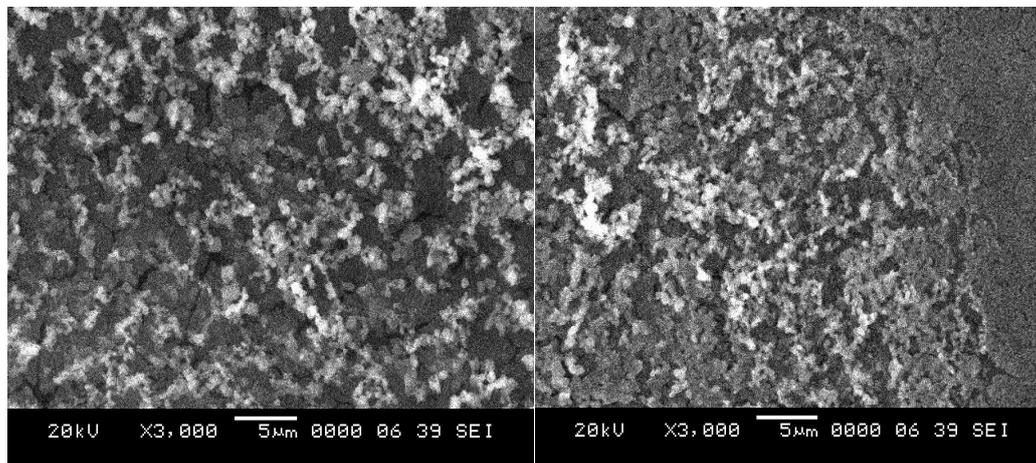
## 2. Methods

The silicon wafer was cleaned using Standard Cleaning (SC) or RCA and Buffered Oxide Etch (BOE) solution. There are four (4) steps of procedure for wafer cleaning process. First, the wafer was dipped into RCA 1 at 70oC to 80oC for 10 minutes. Then, the wafer was dipped into BOE solution for 10 to 15 seconds to remove native oxide. After that, the wafer was dipped into RCA 2 solution for 10 to 15 minutes while the solution was heated to 75oC to 80oC., Then the wafer was rinsed in DI water or distilled water. Finally, the wafer was dried by blowing with spin dry. 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%): C<sub>2</sub>H<sub>5</sub>OH (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<sup>2</sup>) for 1 minute and duty cycle of 0.7.

Single-side polished P/Boron	Silicon	P Type
<1-0-0>	Silicon	Orientation
0.01-0.02 ohm-cm (low)	Silicon	Resistivity
500+10 μm	Silicon	Thickness
100 mm	Silicon	Diameter

### 3. Results and Discussion

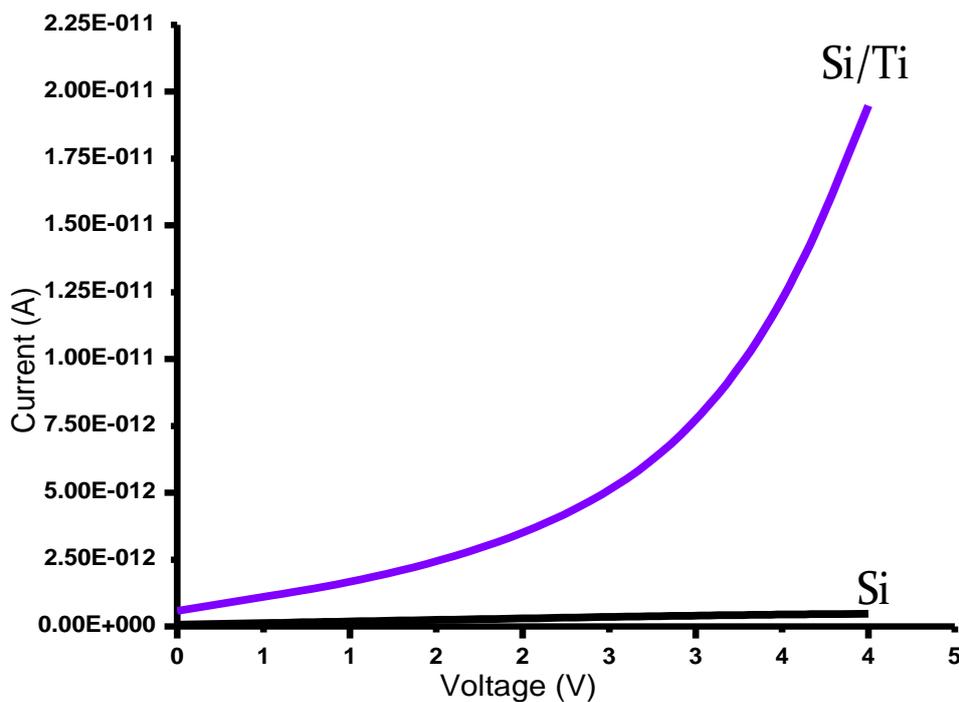
The study has successfully demonstrated fabrication and testing of the device, the figure 1, the SEM image of the fabricated silicon based solar cell, as it can be observed, there is uniform distribution of size and approximately, 1 $\mu$ m is obtained, thus it demonstrated a simple in-house fabrication of enhanced silicon solar cell using ultrasonic vibration etching. Well distributed photovoltaic cell can be produced in just 5 simple steps. The Experimental study results show that the silicon based fabricated photovoltaic devices using titanium as anti-reflector exhibit high photo energy absorption with high voltage when exposed to the spectrum of the solar radiation. The high efficiency obtained as a result of structures of Ti in which it shows the surface layers energy greatly enhanced the light-absorption capability of cell is greatly increased. Hence the methods are simple and at no cost, a stable solar cell can be produced.



**Figure 1.** SEM image show the result of the silicon etch for 1 minute.

The figure 1, show the etch profile and the behavior of charged molecules present in the sensor surface, from the series of the modification step, the device electrical profile are continue to altered as at any time when device is subjected surface treatment. This behavior is resultant from the presence of two distinct polarized charges groups that are promoted to come closer with each other as results of minimizing distance of each electrode, thus the band energy gap is reduced there by higher electrons exchanges occurred, the exchange is further becomes higher with modification elements are in aqueous form, this claim can be observed form figure where the silicon application, is normally in aqueous and upon drop in, it was subject to test before fully dried and this has allowed a higher current to be recorded with Si/Ti compared with si, the reason is simple be at the aqueous the charge accumulation increase becomes eligible to jump from one electrode to another resulting in higher negative charge on the Ti/Si surface. The increase in ion charge enhance the charge accumulation on each electrode and this behavior consistent with many results of a similar experiment performed. The study has successfully demonstrated fabrication and testing of the device, the figure 1, the SEM image of the fabricated silicon based solar cell, as it can be observed, there is uniform distribution of size and approximately, 1 $\mu$ m is obtained, thus it demonstrated a simple in-house fabrication of enhanced silicon solar cell using ultrasonic vibration etching. Well distributed photovoltaic cell can be produced in just 5 simple steps. The Experimental study results show that the silicon based fabricated

photovoltaic devices using titanium as anti-reflector exhibit high photo energy absorption with high voltage when exposed to the spectrum of the solar radiation. The high efficiency obtained as a result of structures of Ti in which it shows the surface layers energy greatly enhanced the light-absorption capability of cell is greatly increased. Hence the methods are simple and at no cost, a stable solar cell can be produced.



**Figure 2.** Photo absorbed current-voltage (I–V) density characteristics of photovoltaic devices based on the Si structures and the Si/Ti structure.

The voltages were swept from 0V to 5V using semiconductor analyzer with Volt internal 40mV input signal (0 V D.C Offset). The reference point probe is calibrated with reference gauge of step 0.04V and probing stations are set up fully to smooth and reliable measurements with vacuums environment. The measurement of current–voltage curve for two devices Si and Si/T layers have been conducted with a four-terminal micro-probing Keithley, 6487. Thus, current response of the structures has been measured. In order the to test the device and validate, the two devices were exposed to high bright of tungsten lamp as the energy source because the bright lamp have similar radiation as solar energy do have from the sun photocurrent, after the exposure and upon measuring of the two devices, the resultant voltage obtained from Si/Ti is much higher compared to the one obtained with Si alone and this light-absorption ability coming from its improved photo absorption as a result of the anti-reflection activity of the Ti figure 2. To examine response of the devices silicon configuration was prepared, the traced curved was recorded prior to surface prior deposition, the deposition could allow and enhance the silicon electrical properties by allowing the polarized charged molecules attached to the sensor surface, the modified silicon device was tested in UV with putting gold electrode, the curve in figure above indicated the range of the electrical response of Si/Ti, it exhibited increases in conductance in turn allow more electrons to jump the ide barriers electrode, this is repressed in red curves with  $\sim 1\text{nA}$ . The highest curve with indicating highest current values recorded, this wonderful behavior was seen with first light radiation dropped on treated Si/Ti, The curve shown the enhancement achieved as a result of the Ti application to the surface hence the study has successfully demonstrated fabrication and testing of the device, the figure 1, the sem image of the fabricated

silicon based solar cell, as it can be observed, there is uniform distribution of size and approximately, 1  $\mu\text{m}$  is obtained, thus it demonstrated a simple in-house fabrication of enhanced silicon solar cell using ultrasonic vibration etching. Well distributed photovoltaic cell can be produced in just 5 simple steps. The Experimental study results show that the silicon based fabricated photovoltaic devices using titanium as anti-reflector exhibit high photo energy absorption with high voltage when exposed to the spectrum of the solar radiation. The high efficiency obtained as a result of structures of Ti in which it shows the surface layers energy greatly enhanced the light-absorption capability of cell is greatly increased. Hence the methods are simple and at no cost, a stable solar cell can be produced. The increase in the photo voltage indicates higher conversion efficiency will be obtained by application of The Ti structure. The photons ray incident which is projected to on the surface of silicon will be generally reflected from the top surface due silicon low absorption capabilities of the bulk silicon substrate.

#### 4. Conclusions

The study demonstrates a simple in-house fabrication of enhanced silicon solar cell using ultrasonic vibration etching. Well distributed photovoltaic cell can be produced in just 5 simple steps. The Experimental study results show that the silicon based fabricated photovoltaic devices using titanium as anti-reflector exhibit high photo energy absorption with high voltage when exposed to the spectrum of the solar radiation. The high efficiency obtained as a result of structures of Ti in which it shows the surface layers energy greatly enhanced the light-absorption capability of cell is greatly increased. Hence the methods are simple and at no cost, a stable solar cell can be produced.

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