Effect of Forming Porous Silicon with Different Electrochemical Etching Cell to Porosity Layer Under Various Anodization Current Density

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***Abstract*— In this research is purpose to study effect of forming porous silicon with different electrochemical etching cell to porosity layer under various anodization current density (10, 15, 20 and 25 mA/cm^2). Three method of forming porous silicon were prepared by forming in single tank electrochemical etching cell without coating Al at backside of silicon wafer, forming in single tank electrochemical etching cell with coating Al at backside of silicon wafer and forming in double tank electrochemical etching cell without coating Al at backside of silicon wafer. After that investigate porous silicon by test photoluminescence with irradiate UV- Light on samples. The porosity of porous silicon was measure by gravimetric method. The result was found that the porous layer from forming by double tank electrochemical etching cell without coating Al at backside are most homogeneity and porosity of porous silicon are increase with the increase of current density.**

***Index Terms*— porous silicon, porosity layer, different electrochemical etching cell**

I. Introduction

Porous silicon is a silicon crystalline which a lot of small pore on surface. It was discovered in 1956s by Ulhir[1] at Bell Laboratory in the U.S. during the studies of the electropolishing surface of silicon. At the present the porous silicon was applied to humidity sensor[2], optoelectronics devices[3] and biomedical sensor[4].

There are several methods for formation the porous silicon including stain-etching, electrochemical etching as we know anodization. In general was formation by anodization in single tank electrochemical etching cell. In process the current distribution is important factor is affected to uniformity layer and percentage of porosity. The formation the porous silicon by anodization in single tank electrochemical etching we cell observer the porous layer is not uniformity because this method has strain at the O – ring area the electric current not distributed is affected to porous silicon is not uniformity and low porosity percentage. Phatthanaphong P. et al[5] are studies the effect of coating aluminum at backside of silicon for formation of porous silicon by anodization in single tank electrochemical etching cell the result have shown the porosity layer more uniform than without coating aluminum at backside of silicon because the current distributed is better but the most of porosity layer still at the O – ring area because this point has a lot of electric current density. However, There is not information about formation of porous silicon by anodization in double tank electrochemical etching cell because it has not been investigate yet.

The purpose of this study was to investigate percentage of porosity and uniformity layer of porous silicon from formation by anodization in double tank electrochemical etching cell compare with anodization in single tank electrochemical etching cell without coating aluminium at backside of Si wafer and without coating aluminium at backside of Si wafer and.

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II. EXPERIMENTAL

This experiment, the porous silicon were forming by three methods including forming in single tank electrochemical without coating aluminum at backside of silicon, forming in single tank electrochemical with coating aluminum at backside of silicon and forming in double tank electrochemical without coating aluminum at backside of silicon to study of porosity layer from forming with three different electrochemical etching cell.

All Silicon wafer were prepared by p – type Si with orientation (100) resistivity 10 Ω-cm and thickness 625 μm. Silicon wafer were cut approximately 1 cm^2. After that, we cleaned Silicon wafer by DI wafer, Acetone in ultrasonic cleaner for 5 min and dipped HF concentration 5% to remove native oxide. After that, forming porous silicon by anodization in three electrochemical etching cell (Made from Teflon) by various current density 10, 15, 20, 25 mA/cm^2 respectively. Next, sample were rinsed in DI water and blow dry with nitrogen gas. Finally, investigated uniformity of porous silicon by beaming ultraviolet on surface of silicon and measure porosity by gravimetric method [6] was described in Figure 1.

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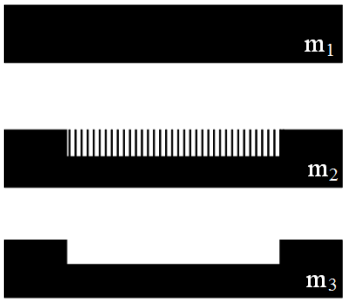

$$porositiy\% = \frac{m_1 - m_2}{m_1 - m_3} x100 \quad (1)$$

Fig. 1. gravimetric method for measure porosity of porous silicon

m_1 is a mass of silicon wafer, m_2 is a mass of silicon wafer after formation porous silicon and m_3 is a mass of silicon after remove porous silicon layer by NaOH

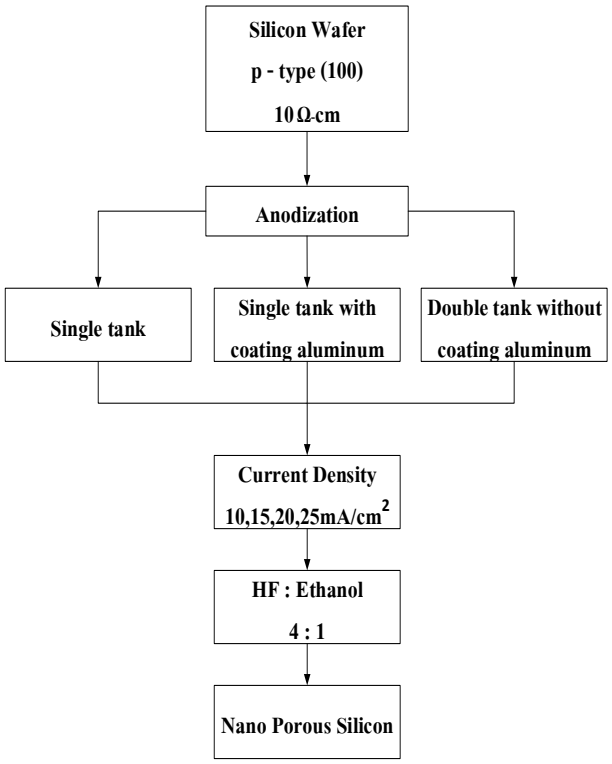

Fig. 2. Process of Formation Porous silicon

In Fig 2. was describe a process of formation porous silicon in this research by flowchart.

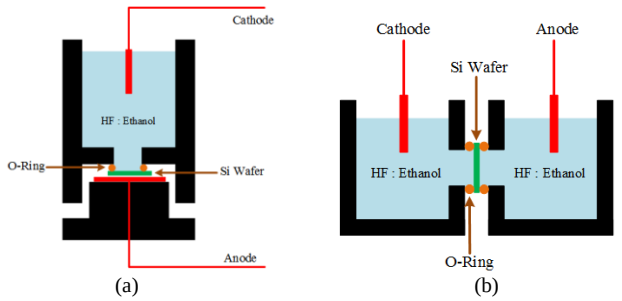

Fig 3. Cross section of single tank (a) and double tank (b) electrochemical etching cell.

In part of forming in double tank electrochemical etching cell with coating aluminium at backside of silicon wafer method, aluminium was coated by vacuum evaporator as you can see in figure 4.

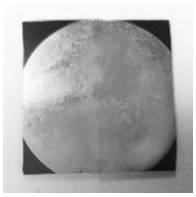

Fig 3. Si wafer with coating aluminum at backside

III. RESULTS AND DISCUSSION

A. Photoluminescence characteristics of porous silicon from formation with different electrochemical etching cell

After finishing of formation porous silicon, ultraviolet was irradiate on samples to investigate porous layer and porosity layer of porous silicon by photoluminescence characteristics.

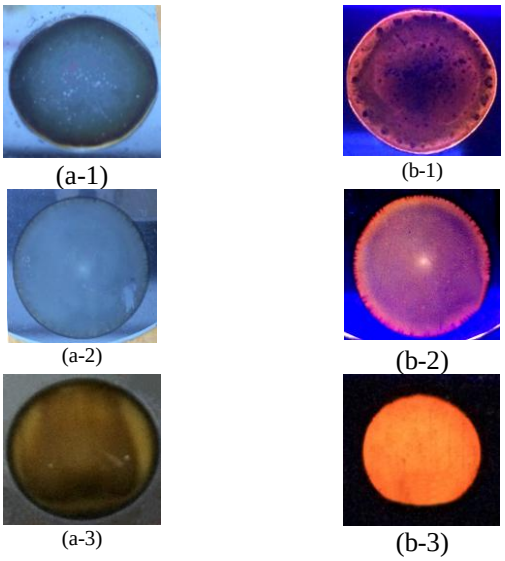

Fig 4. Porous silicon samples and Photoluminescence of porous silicon form from formation with different electrochemical etching cell at current density 10 mA/cm^2

From Fig.4 the result have shown photoluminescence of porous silicon form from formation with different electrochemical etching cell. Fig.4 (b-1) porous layer form formed by single tank electrochemical etching cell without coating aluminum at backside of Si wafer, the porosity layer have not uniformed and most porosity at edge (at O – ring area), because of this area was pressed with o - ring (a lot of stress at this area) is affect to electric current distribution poor. Fig.4 (b-2) porous layer form formed by single tank electrochemical etching cell with coating aluminum at backside of Si wafer, we can see the porosity layer are uniformed than formed by single tank electrochemical etching cell without coating Al at backside of Si wafer because aluminum at backside of Si wafer improve electric current distribution better, However, the porosity layer still on the edge of sample. Fig.4 (b-3) porous layer form formed by double tank electrochemical etching cell without coating aluminum at backside of Si wafer, the porosity layer are most uniformed were compared with forming by single tank

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electrochemical etching cell without coating aluminum and with coating aluminum at backside of Si wafer, because both of front side and backside of silicon wafer were touch hydrofluoric acid is affected to electric current distribution better than two method as mentioned above.

B. Porosity of porous silicon from formation with different electrochemical etching cell by gravimetric method

The porosity layer (porosity percentage) from formation with different electrochemical etching are calculated by gravimetric method according equation (1). The result from measure was shown in Table 1.

TABLE I
POROSITY PERCENTAGE OF POROUS SILICON

	Type of electrochemical etching cell	Current density (mA/cm^2)	Porosity (%)
1	Single tank electrochemical etching cell without coating Al at backside of Si wafer	10	31.1
		15	39.42
		20	52.15
		25	64.22
2	Single tank electrochemical etching cell with coating Al at backside of Si wafer	10	34.4
		15	42.77
		20	55.55
		25	69.42
3	Double tank electrochemical etching cell with coating Al at backside of Si wafer	10	46.15
		15	58.53
		20	71.42
		25	80.55

From table 1, porous silicon from formed by double tank electrochemical etching cell without coating aluminum at backside of Si wafer are highest porosity percentage when compared with formed by single tank electrochemical etching cell without coating aluminum at backside of Si wafer and formed by single tank electrochemical etching cell with coating aluminum at backside of Si wafer and data from table 1 was described by graph format in Fig 5.

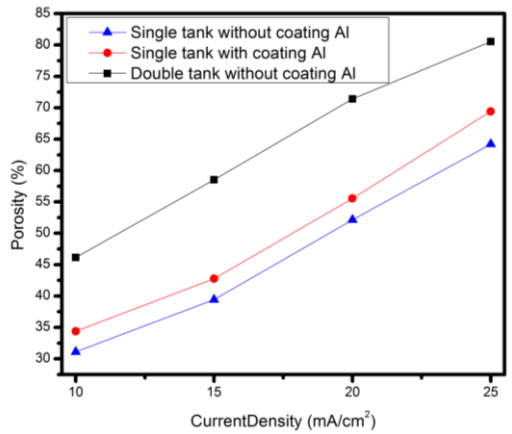

Fig 5. Porosity percentage of porous silicon form forming with different electrochemical etching cell

Fig 5. Demonstrate the effect of different current density on porosity percentage of porous silicon under different electrochemical etching cell. The porosity percentage from formed by double tank electrochemical etching cell without coating aluminum at backside of Si wafer was found in range 46.15%, 58.53%, 71.42 and 80.55% , from formed by single tank electrochemical etching cell with coating aluminum at backside of Si wafer porosity percentage in range 34.4%, 42.77%, 55.55% and 69.42%, from formed by single tank electrochemical etching cell without coating aluminum at backside of Si wafer was found in range 31.1%, 39.42%, 52.15% and 64.22% with increasing with current density 10 mA/cm^2 to 25 mA/cm^2 respectively, As we can see that the porosity from forming by double tank electrochemical etching cell without coating aluminum at backside of Si wafer was highest porosity because the double tank electrochemical etching cell silicon wafer were touch the hydrofluoric acid both of front side and backside. Therefore, electric current distributed better.

IV. Conclusion

Porous silicon were formed by electrochemical etching with different electrochemical etching cell including forming in single tank electrochemical without coating aluminum at backside of silicon wafer, forming in single tank electrochemical with coating aluminum at backside of silicon wafer and forming in double tank electrochemical without coating aluminum at backside of silicon wafer. The result have shown the porous layer form forming by double tank electrochemical etching cell without coating aluminum at backside of Si wafer are uniformed and best homogeneity layer. The porosity percentage increase from 31.1% to 64.22% by forming with single tank electrochemical etching cell without coating aluminum at backside of Si wafer, from 34.4% to 69.42% by forming with single tank electrochemical etching cell with coating aluminum at backside of Si wafer and increased from 46.15% to 80.55% by forming with double tank electrochemical etching cell without coating aluminum at backside of Si wafer. Moreover, porosity was increased with the increase of electric current density.

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