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OBSERVING ACTIVE AREA ON NATIVE OXIDE GROWTH: MICROFABRICATION & FAILURE ANALYSIS LAB

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Abstract

Native oxide is a very thin layer of silicon dioxide (SiO2) that formed on the surface of a silicon wafer whenever the wafer is exposed to air under ambient conditions. Native oxide growth is also affected by the environmental, humidity conditions, the fluids implied on the wafer and other parameters. To avoid the native oxide growth at its climax time, and the degradation of the good properties of silicon thin film, the research has been done to measure the native oxide growth in Microfabrication and Failure Analysis Laboratory at University Malaysia Perlis, UniMAP during peak hour. Peak hours refer to the time where the maximum number of students using the lab. Silicon bare wafer is used as sample to test the native oxide growth on surface. The measurement and observation on the growth were done in afternoon and evening by using Spectrophotometer. As a results, Microfabrication Laboratory (Changing Room) exhibits the most active native oxide formation in both afternoon and evening.

Keywords: Native oxide, Silicon wafer, Oxide growth

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Introduction

Silicon wafer is a material used for producing semiconductors, which can be found in all types of electronic devices. Most silicon in nature exists in the form of silicon dioxide, (SiO2), because it is particularly reactive to oxygen. It reacts with oxygen very quickly and form SiO2 on the silicon surface (Xiou, 2001; Morita, et. al., 1990). As native oxide is a very thin layer of amorphous SiO2, it has an entirely different growth mechanism compared to that of thermal oxides (Steinrück, et. al., 2014). However, the native oxide on the silicon is of poor quality and must be removed, especially for the gate oxide, which require a high-quality oxide film (Xiou, 2001). Native oxide that formed on Si substrates also increases contact resistance and degrades precise control of ultra-thin gate oxide film thickness and electrical characteristics (Maeda, & Ogino, 1986).

The growth of SiO2 films is due to a combination of the natural passivation in air and the effect of several production steps, such as washing and thermal treatments etc. The oxide film, developed under such conditions, soon ceases to thicken because it forms a solid barrier between the metal and atmospheric oxygen through which ions have difficulty in moving (Hoar, 1967). The measurements of very thin oxide thickness have been performed using X-ray Photoelectron Spectroscopy (XPS) (Ebel, & Liebl, 1979) and Auger Electron Spectroscopy (Chang, & Boulin, 1977) without ion milling, taking advantage in both cases of the occurrence of distinct peaks for the oxide and elemental states.

In this work, 3 samples (silicon bare wafer) were used to test the native oxide growth in 2 different labs in University Malaysia Perlis (UniMAP). The samples are chemically cleaned with Buffered Oxide Etched (BOE) solution, rinsed with ultrapure water and measured native oxide growth by using Spectrophotometer, before and after one hour left.

Methods

The silicon wafer [1 0 0] had cleaned and divided into 3 pieces by using the Diamond Scriber JFP Microtechnic. These silicon bare wafers (samples) were then placing on Spectrophotometer to measure the present of native oxide. The two samples were separated in two different room named, Yellow Room and Changing Room. The sample was placed on the table beside the jumpsuit rack in Changing room. The second sample was placed on the table near Photoresist (Pr) in Yellow Room. The third sample was put on the table near Pr coating equipment in Failure Analysis Lab. All samples were left 1 hour before measured under Spectrophotometer for oxide measurements and were cleaned using BOE chemical and ultrapure water to remove native oxide growth. Measurements for 1 hour were carried out to observe the difference in the rate of oxide growth between noon and evening and to determine which time the oxide growth rate is most active. Table 1 show the data of class, temperature, and humidity of the labs during the works.

Table 1. The temperature and humidity of labs

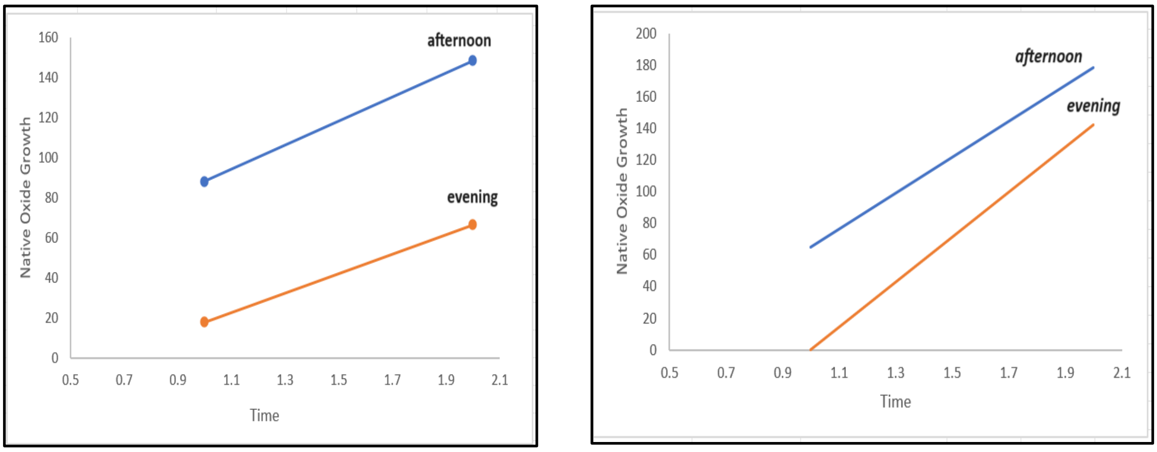
Lab	Class	Temperature	humidity
Changing Room	10,000	23.7°C	68%
Yellow Room	1,000	21.0°C	68%
Failure Analysis	-	22.4°C	60%

Result and Discussion

The test/experiment was done in Changing Room and Yellow Room in Microfabrication Lab, and, in an open area in Failure Analysis Lab. The reason for the 1-hour setting is that when exposed to the environment, native oxide forms in very thin layers (10 to 20 Å) (Xiou, 2001). The measurement of native oxide growth on Changing Room and Yellow Room is depends on cleanroom classification even the temperature and humidity are similar. Five points of data were taken before and after one hour left to get an accurate value.

Microfabrication Lab

Figure 1 shows an average reading for native oxide growth in Yellow Room and Changing Room in afternoon at 11 am to 12 am and at 3 pm to 4 pm in the evening. The total average of native oxide growth in Yellow Room in afternoon were 88.08 Å before and increased to 148.34 Å after one hour left. In the evening, the reading was 17.86 Å before and increase to 66.34 Å after one hour. In Changing Room, the total average of native oxide growth in afternoon shows the reading before were 65 Å and after were 177.94 Å, while in the evening the average before were 0 Å and after were 142.1 Å. The differences average growth in the Yellow Room in afternoon show the growth is increased 60.26 Å and in the evening also increases to 48.48 Å. Meanwhile the differences average growth in Changing Room in afternoon and evening show both sessions were increased 112.94 Å and 142.1 Å.



(a) (b)

Figure 1. Average native oxide growth of bare wafer: (a) Yellow Room (b) Changing Room

Failure Analysis Lab

Figure 2 shows the results of average native oxide growth in the afternoon and evening for Failure Analysis Lab. Result in the afternoon shows total average of native oxide growth for sample was 326.16 Å before and increased to 355.06 Å in one hour. In the evening, the reading of total average shows the reading before was 0 Å and after was 109.86 Å. The differences between average growth in the afternoon and evening show both reading was increased by 28.9 Å and 109.86 Å each.

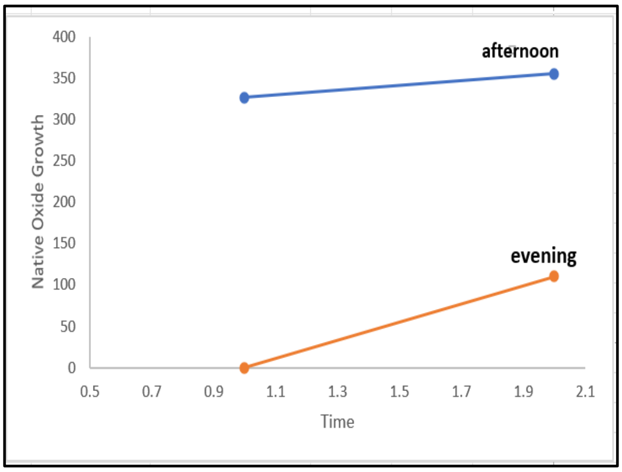


Figure 2. Average native oxide growth in afternoon and evening of bare wafer

Analysis data from Microfabrication Lab (Changing Room, Yellow Room) and Failure Analysis Lab show native oxide growth increased in the afternoon and evening. The increase in native oxide is due to wafer exposure to air and internal humidity temperatures in both labs, and also the using of ultrapure water for cleaning. According to (Sherman,1990; Massoud, 1995) the factor that determines the growth of native oxide on Silicon (Si) surface are the existence of oxygen and moisture in the air and the using of ultrapure water. Another factor that affects the increasing of native oxide is wafer orientation. Following the reference paper of (Kuroki, et. al., 1993), it has been found that the oxidation rate of Si [1 0 0] is greater than that of Si [1 1 1] in the native oxide growth.

Conclusion

Microfabrication Lab shows the active area compared to Failure Analysis Lab. In Microfabrication Lab the Changing Room shows the most active area with the highest potential native oxide growth.

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Author Contribution

Norlida Bt Abu Bakar – Supervision, writing; Faradilla Bt Aziz – Writing – review & editing; Hazila Bt Othman – Writing – review; Muhammad Ikhwan Shafiq B Ramli – Data collecting; Mohd Norhafiz B Hashim – Data collecting; Mohd Sallehudin B Saad – Lab observation; Mohd Rosydi B Zakaria – Data analysation; Ahmad Syahir B Ahmad Bakhit – Data analysation.

Conflict of Interest

Authors declare no conflict of interest.

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