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Chemical Changes of Silicon Dioxide Film in Nano Scale

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Abstract: Chemical changes in nano structures of materials have an important role in carriers' control in silicon dioxide gates in transistors. In this work, we study the ultra fin structure of silicon dioxide over two silicon layers with (100) and (111) Miller indexes, by using their x-ray Photon Spectroscopy (XPS) spectrum. The importance of these layers was discussed.
Keywords: Nano structure, Miller indexes, (100) and (111) layers, (XPS) spectrum.

Introduction

Silicon and silicon dioxide have many uses in electronic devices. This is, because of large abundance of silicon in nature, its relatively low price, and its easy and low cost oxidizing. These properties make many much uses of silicon and silicon dioxide in solar cells, pharmaceuticals, and electronic devices [1-5].

One of silicon dioxide uses, for example, is in mono polar field effect transistors as dielectric gate. The layer of silicon which was oxidized by researchers for this mean is mostly the layer with (100) Miller indexes. Because it has the easy cutting, not many incomplete bindings, and dangling bound of silicon atoms in (100) layer [6-11]. For this reasons the layers with other Miller indexes have had the least interest for working.

In this work we have oxidized (111) layer and have compared, at different steps of oxidation, SiO_2/Si (100) to SiO_2/Si (111).

Experimental method and results

The samples of Si (111) and Si (100) have prepared by cutting from a sheet of Si with specific resistance of 5 ω cm and the thickness of 2mm. The surface which will be subject for irradiation of oxygen atoms, have been polished and oxidizing process will be done over this polished surface. Obtaining a clean surface, we have washed two samples by ethanol and acetone in a becker. Then we have cleaned these samples by means of an ultra sound bath room for about 1 hour. Then we have brought out the samples from bath room and straight away have put into a furnace at 500 ^{o}C and have injected very pure argon gas into the furnace for about 10 minutes. This process has done for elimination of any probable undesirable contaminating either by carbon or by oxygen atoms during transmits of samples into the furnace. Then we have finished injecting of argon gas and have started to inject very pure oxygen gas (99.999%) into the furnace for about 20 minutes at 500 ^{o}C. By this oxidizing process an ultra thin film of silicon oxide forms on surface of both two films.

XPS spectrums of two oxidized surfaces show that the procedure of oxidizing for both two layers (111) and (100) is identical. The variation of thickness of both two silicon oxides SiO_2/Si (111) and SiO_2/Si (100), against oxygen exposure time has plotted in figure 1.

In figure 1, the thickness of silicon oxide against oxygen exposure time has compared for two different oxide layers SiO_2/Si (111) and SiO_2/Si (100). The plot shows that the processes of oxidation of both two layers are identical, but the thickness of SiO_2/Si (111) layer is less than thickness of SiO_2/Si (100) layer in the same condition. As we see SiO_2/Si (111) layer more thinly than SiO_2/Si (100) layer. This interesting property has many interests for the dielectric gates. This interesting property has many interests for the dielectric gates.

Figure 2 shows XPS spectrum of Silicon oxide (111). The abscissa of plotted spectrum shows increase of energy in eV and the ordinate shows increase of intensity. As the figure 1 show, we can see O_{1s} electrons which accompanied by O_{KLL} Auger electrons. The existence of O_{1s} peak shows that there is formation of bindings between oxygen and silicon.

Conclusion

The obtained results from the plot of figure 2 explain that, in spite of choosing two different layers SiO_2/Si (111) and SiO_2/Si (100), the procedure of oxidation is identical for them. Indeed, beginning the process the rate of oxidation which has shown by intensity of O_{1s} peak is fast. This phenomenon can be attributing to the existence of much many incomplete bounds in silicon atoms for binding with oxygen atoms. In the end of the oxidizing process, combining with oxygen atoms tends to saturation, and the rate of oxidation tends to remain constant. This effect explains that, despite exposure of silicon atoms to the radiation of more oxygen atoms, the process don't tend to form the more thick oxide film. Moreover, the thickness of SiO_2/Si (111) film is less than SiO_2/Si (100) film which may be gives it certain favorable uses as a dielectric gate in transistors.

Another subject which can discuses as a result of this work is that the Si (111) is as useful as Si (100) and may be used in electronic devices the same as Si (100).

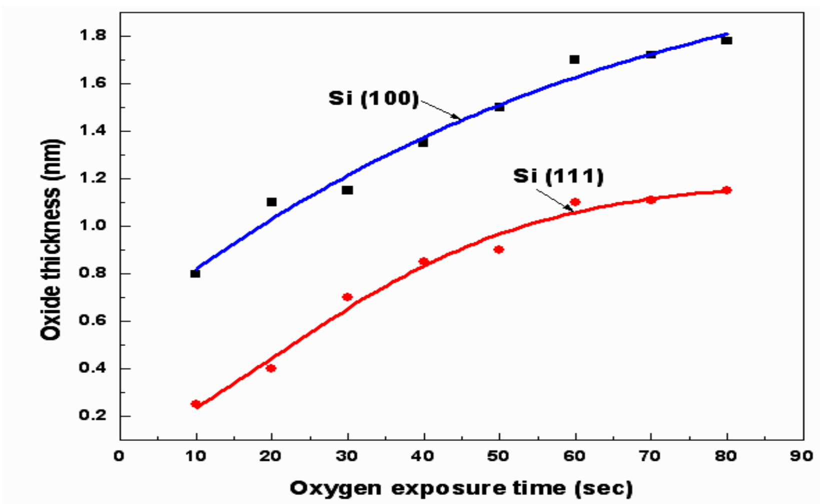

Figure 1. Variation of thickness of SiO_2/Si (111) and SiO_2/Si (100) against oxygen exposure time

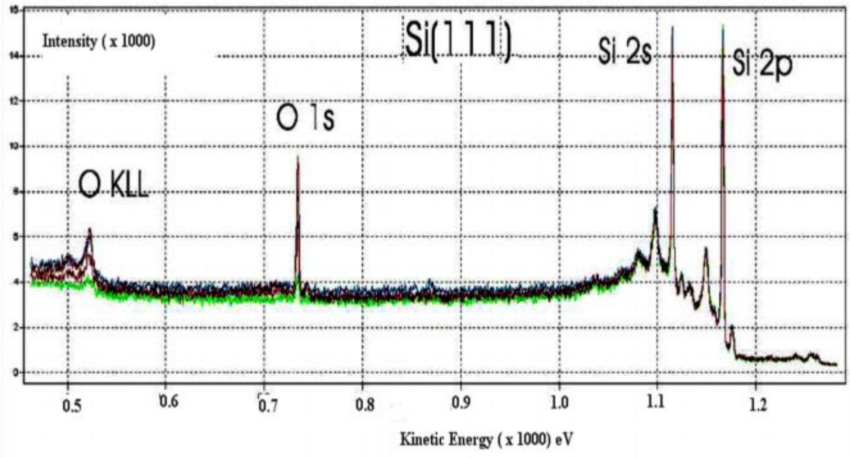

Figure 2. XPS spectrum of silicon oxide (111)

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