بیستمین کنفرانس اپتیک و فوتونیک ایران
و ششمین کنفرانس مهندسی و فناوری فوتونیک ایران
۸ تا ۱۰ بهمن ماه۱۳۹۲ - دانشگاه صنعتی شیراز

پروسه طراحی، شبیه سازی و تشکیل اکسید ضخیم 0.45 میکرو متری برروی ویفر سیلیکونی

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چکیده – در این مقاله روشی برای تشکیل لایه اکسید ضخیم ۰.۴۵ میکرومتری بر روی یک ویفر سیلیکونی ۴ اینچ پیشنهاد داده شده است. نشان داده ایم که نتایج شبیه سازی به طور بسیار مطلوبی با نتایج حاصل از پروسه عملی مطابقت دارد. برای انجام شبیه سازی های این پروسه از نرم افزار *Athena* ، برای انجام پروسه عملی از کوره های اکسیداسیون *Centrotherm* و جهت تست نتایج عملی از میکروسکوپ نوری به همراه دستگاه اندازه گیری ضخامت *α-step* استفاده کرده ایم.

کلید واژه- اکسیداسیون، سیلیکون

A Proposal for Design, Simulation and formation of a 0.45 µm thick Oxide on a Silicon Wafer

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Abstract- In this paper we propose a method for formation of a 0.45 µm thick oxide on a 4 inch silicon wafer. We show that the simulation results are in very good agreement with practical process. We have used Athena TCAD package, Centrotherm oxidation tubes and optical microscope and α-step thickness measuring devices to simulate, fabricate and testing of the oxide.

Keywords: Oxidation, silicon

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1 Introduction

Because of its great importance in planar silicon device technologies, the formation of silicon dioxide layers by thermal oxidation of silicon has been studied very extensively in the past several years [1-15]. So oxidation of silicon is an important step in silicon based devices and to develop a reliable process for oxidation is very important in fabrication of silicon based devices. Thick oxide is used for masking purposes. For example to prevent a diffusant from diffusing in one side of a wafer. In this work we wanted to design a reliable thick oxide process for masking purposes. To do this task we designed, simulated and did so many tests to have a reliable process of thick oxide on a silicon wafer. Simulation, practical and test results are included in the rest of this paper.

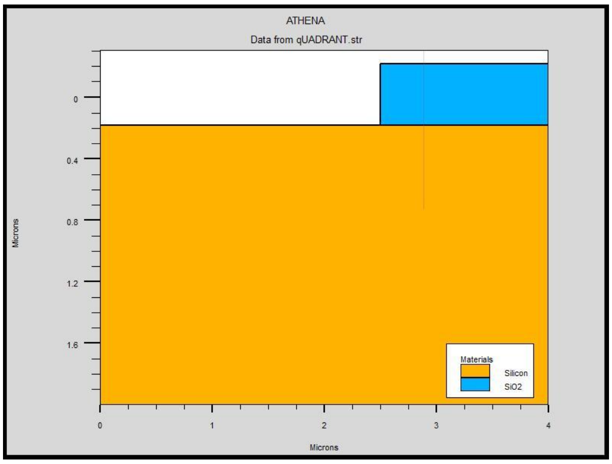
2 Simulation results

To simulate the oxidation process we have used the Athena TCAD package. We have shown that to have a 0.45 µm thick oxide we should use a dry-wet-dry process. The simulation steps are shown in table 1.

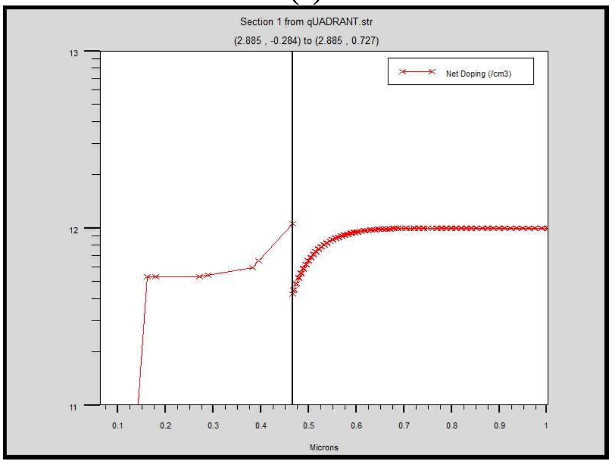
Table1: simulation steps of the 0.45 µm thick oxide

Step Name	Temperature	Time (min)	Gas	Flow
Heating Up	1100˚C, +10˚C/min	30	N_2	5 SLM
Stablization	1100˚C	2	N_2	5 SLM
Dry Oxide	1100˚C	10	O_2	5 SLM
Wet Oxide	1100˚C	30	O_2 H_2	3.2 SLM 6 SLM
Dry Oxide	1100˚C	5	O_2	5 SLM
Cooling Down	800˚C, -10˚C/min	30	N_2	5 SLM

Simulated structure and simulation result of the process of table 1 are depicted in figure 1.



(a)



(b)

Figure1: a) simulated structure b) thickness of the simulated oxide.

As we can see the thickness of the oxide is ~0.45 µm.

3 Practical results

To perform the designed steps in section 2 we have used centrotherm oxidation tubes.
Before to start the process we should clean the silicon wafers. So we have used the well-known RCA cleaning to perform this step. To have a good oxidation process we should clean the tubes too. To clean the tubes we did two steps. Organic solvents cleaning step with KOH and an etching step with HF.
After cleaning of the wafers and the tube, we cleaned the cassette of the silicon wafers with KOH and HF.
The process of oxidation is done as depicted in table 2.
First the wafers are loaded into the oxidation tube (steps 1, 2), and then the temperature rises to 1100 ˚C to perform the oxidation step (step3). Before the oxidation we have added a step to stabilize the temperature (step 4). After the stabilization is done the first step of oxidation begins (step 5) at the temperature of 1100 ˚C that is a dry oxide. Dry oxidation is done by a pure flow of O_2 gas with a flow of 5 SLM (Standard litter per minute). The second step of oxidation is a wet oxide that is done through combining of the O_2 (3.2 SLM) and H_2 (6 SLM) in a device called Hydrox in high temperature. The last step of oxidation is a dry oxide step that is done with a flow of 5 SLM of O_2 in the temperature of 1100 ˚C. After the oxidation process we should cool down the tube (step 8) and unload the wafers (10).

Table2. Practical flow chart of the 0.45 µm thick oxide

Step No.	Step Name	Temperature	Time (min)	Gas	Flow
01	Loading	800˚C	2	N_2	10 SLM
02	Loading	800˚C	2	N_2	10 SLM
03	Heating Up	1100˚C, +10˚C/min	30	N_2	5 SLM
04	Stablization	1100˚C	2	N_2	5 SLM
05	Dry Oxide	1100˚C	10	O_2	5 SLM
06	Wet Oxide	1100˚C	30	O_2 H_2	3.2 SLM 6 SLM
07	Dry Oxide	1100˚C	5	O_2	5 SLM
08	Cooling Down	800˚C, -10˚C/min	30	N_2	5 SLM
09	Unloading	800˚C	2	N_2	5 SLM
10	Unloading	800˚C	2	N_2	5 SLM
11	End of Recipe	800˚C		N_2	2 SLM

4 Testing results

After the oxidation process we should test our results. Two methods of testing are used to test the results of the oxidation process.
Method 1: Using an optical microscope we have measured thickness of the oxide at 10 different points (figure 2). But before this measurement we should etch a small portion of the oxide to reach the substrate, because we need both substrate and the oxide to measure the thickness of the oxide. After a lithography and an etching step the results were as table 3.
As we can see in the table 3 the thickness of the oxide in different places of the wafer is almost uniform and is in a good agreement with our simulation results. But to be sure we have done another test to measure this thickness.
Method 2: An α-step device is used to measure the thickness of the oxide. Before this test we have

etched and cleaned a portion of the wafer. The test results are shown in figure 3.

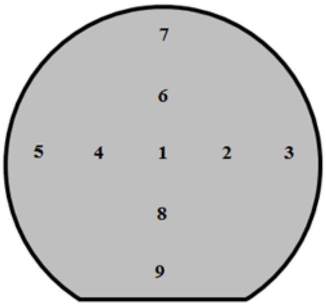


Figure2: Schematic of measured points on the wafer.

Table3. Thickness of the oxide at different positions of the wafer.

Position	Thickness (nm)
1	451.6
2	451.9
3	449.5
4	450.2
5	450.6
6	449.9
7	451.1
8	450.9
9	449.5
10	449.6

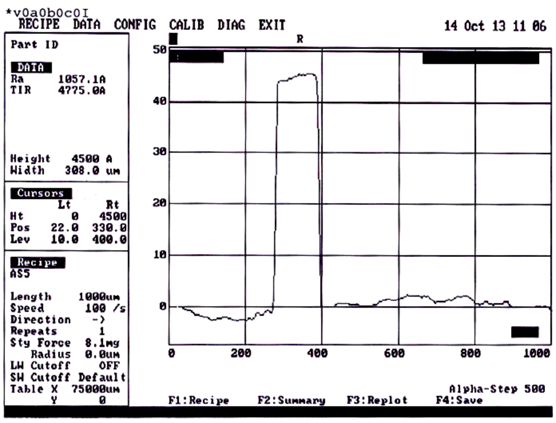


Figure3: α-step test result of the oxidation process.

As we can the α-step results are in a good agreement with the simulation too.

5 Conclusion

An oxidation process is designed, simulated and performed on a silicon wafer. Simulation and practical results are in a good agreement and this proposal can be used in any thick oxide process in silicon based devices.

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