# Nano Structure of Silicon Nitride in Nano-electronic

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## ABSTRACT

*The shrinking of the gate dielectric is so fast in that ultra-thin oxide cannot be used as a good dielectric in the future of CMOS generation .We analyzed and convoluted the synchrotron spectra with FitXPS. We found an amorphous interface between Nitride Silicon film and Silicon substrate. The results show that Nnitride Silicon can be as a good gate dielectric of CMIS*

**Keyword**: *CMIS,CMOS, Nnitride Silicon*

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## 1 Introduction

Today, CMOS requires a thickness of less than 1 nm in the dielectric gate [1-2]. Because the ultra-thin layer of silicon oxide is more of an intermediate layer than a mass that can act as a good insulator, as well as increased tunneling current, leakage current and boron penetration of the silicon electrode from the oxide layer prevents its use in transistor gates Are CMOS [3-8]. Therefore, it is necessary to think of an alternative to silicon oxide that does not have the above problems or reduce them.

One of the candidates that can be replaced in silicon oxide in CMOS transistor gates is silicon nitride. You know that $N_2$ is not a gas that can be used to grow silicon nitride. Therefore, we were able to grow a substantially thicker thickness of silicon oxide under super-vacuum conditions and at low temperatures using a new method by directly irradiating nitrogen atoms on Si (111).

Studies with FitXPS in the Physics Department of Kabul University show that the middle layer between silicon nitride and silicon substrate is amorphous, so silicon nitride is able to tunnel current and leakage due to its thicker and higher dielectric constant reduce [7,8]. In addition, because the bonds are very strong in silicon nitride mass [8-10] Atoms such as Bourne are difficult to pass through. With the mentioned advantages, silicon nitride can be suggested as an alternative to silicon oxide in future gates of CMOS transistors.

## 2 Experimental details

The silicon samples $(n-type, 5\Omega-cm,\ 1cm\times 3cm)$ were cut from 1mm thick silicon sheets and after rinsing with ethanol, we immersed it in a human container containing ethanol and placed it in an ultrasonic bath. We then placed the samples with Ta holders in a chamber with an initial $10^{-10}$ Torr pressure and passed a current of 20 amps several times and very quickly through the wires at both ends of the samples, and thus we were able to obtain very clean samples.

In the next step, the nitrogen gas molecules ($N_2$) are introduced into the discharge tube that is connected to the UHV chamber and through which the capillary tube passes, causing a pressure difference between the discharge tube and the vacuum chamber.

These gases are excited by 2.5 GHz microwave radiation, resulting in the formation of nitrogen atoms, which are irradiated (N) directly onto the Si (111) substrate, whereby silicon nitride is grown. Measurements with quadrupole mass spectrometry (QMS) show that a high atomic percentage of N (<50%) is produced in this process where pressure is reached $2 \times 10^{-7}$ Torr, and the temperature of the Si substrate (111) is about $300$ ℃ or higher. An optical thermometer is used to measure temperatures $400$ ℃ above the substrates.

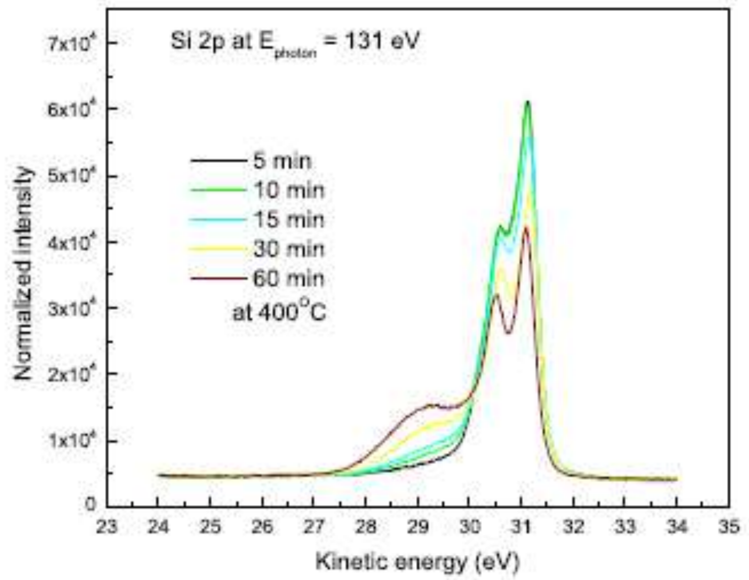

Figure 1: Diagrams of silicon nitride on Si (111) at synchrotron radiation, temperature is $400$ ℃

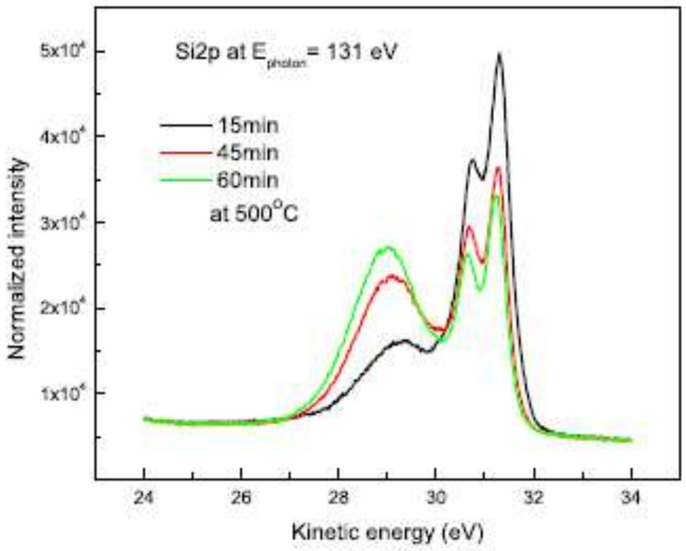

Figure 2: Diagrams of silicon nitride on Si (111) at synchrotron radiation, temperature is $500$ ℃.

As shown in Figures (1) and (2), the structure is transferred by increasing the nitride layers to lower kinetic energy than the peaks of the silicon mass) (and the peaks corresponding to the large nitride mass and It gets bigger and eventually stays the same, which means that as long as we continue to shine nitrogen atoms on the silicon, we will not see an increase in the thickness of the nitride, and the so-called nitride becomes saturated and the growth reaches saturation.

Apart from this, the displacement of the peaks towards lower kinetic energies confirms the theory that chemical bonds have been formed between nitrogen and silicon atoms, which has increased the dependence energy according to the relation $h\nu = E_B - E_K$, and since the energy dependence of silicon is about 99 eV and $h\nu = 131\ eV$, we expect silicone peaks at $E_K = 31\ eV$, and by noting to angular momentum relation, $J = L \pm S = 1 \pm \frac{1}{2}$, we will have two peaks.

## 3. Results and discussion

In order to better analyze the results, the spectrum of silicon nitride samples is shown using silicon nitride components at a temperature of $400\ ℃$ with 130 eV photon energy, for one hour using the standard FitXPS program [10].

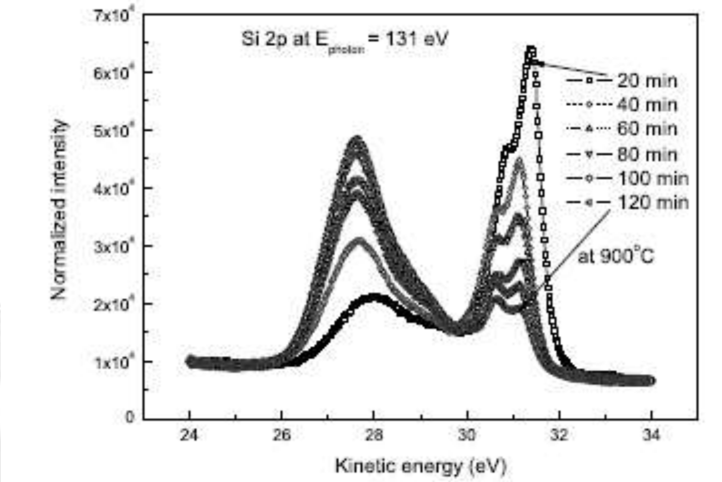

Figure 3: Diagrams of silicon nitride on Si (111) at syncretron radiation, temperature is $900\ ℃$.

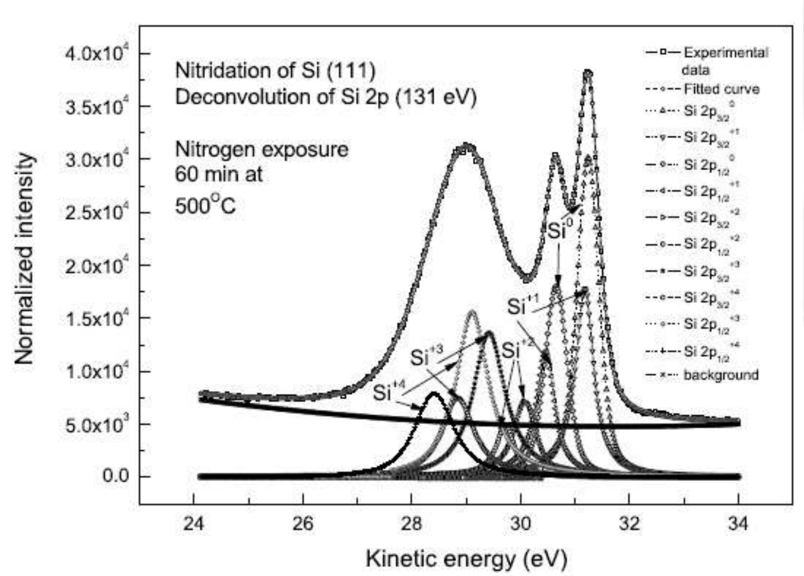

Figure 4: Decomposition of silicon nitride on Si (111) at 60 min for exposure to nitrogen and decomposition into sub-peaks using the standard FitXPS program [6], Temprature is: $500\ ℃$.

This separation is based on the components of nitride, ie $Si^{+1}$,$Si^{+2}$, $Si^{+3}$, $Si^{+4}$, (which indicates the bond of silicon with one, two, three and four nitrogen atoms, respectively) next to $Si^{o}$ (silicon masses). The presence of $Si^{+2}$ and $Si^{+3}$ components indicates the amorphous middle layer of silicon nitride. Therefore, silicon nitride is amorphous like silicon oxide and will be able to greatly reduce the flow of leachate and leakage.

On the other hand, according to Figures (3) and (4), silicon nitride is thicker than natural silicon oxide, which this thicker layer can further prevent tunneling and leakage flow.

## 4. Conclusion

Due to its properties such as reducing tunneling current and preventing the penetration of boron in silicon nitride, it can be suggested as a suitable alternative to silicon oxide in CMOS gates. Of course, silicon nitride grown in vacuum conditions and at low temperatures has a higher potential due to its absence of any impurities and dirt, and therefore this silicon nano nitride can be used with more confidence in the future production of nano-transistors.

## 5. References

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