Electrical Characteristics of NO Nitrided SiO₂ Grown on p-type 4H-SiC

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Abstract — This paper presents the results of NO nitridation of SiO₂ grown on p-type 4H-SiC. NO nitridation has a beneficial effect on the quality of the oxides grown on p-type 4H-SiC. The C-V curves become smoother and sharper after NO annealing. Frequently observed interface ledge is also removed from NO annealed samples.

I. INTRODUCTION

SiC has recently attracted a lot of attention due to its excellent material properties which promise high temperature, high power, and high frequency applications. Because of the great success of MOSFET-based electronics in silicon and the fact that thermal silicon dioxide can be grown on SiC in the same way as silicon, it is desirable to implement high-performance MOSFETs in SiC. Obtaining high quality of SiO₂ grown on SiC is a key technology to reach these aims. Previous research results indicated that the quality of the SiO₂ thermally grown on n-type SiC is comparable to oxides thermally grown on Si, but oxides thermally grown on p-type SiC exhibited poorer characteristics. Researchers have investigated the effect of post-annealing in argon[1], wafer load and withdraw procedure[2], and reoxidation[3] on the interface characteristics of SiO₂/SiC. These methods proved to be effective in improving the interface characteristics of SiO₂/SiC. We have investigated the effect of nitridation in NO and N₂O on the interface characteristics of SiO₂ on 6H-SiC[4], [5]. NO annealed samples showed improved interface of SiO₂/n-type 6H-SiC while NO annealing adversely affect the interface characteristics. In this paper we present the results of NO annealed interface characteristics of oxides grown on p-type 4H-SiC.

II. EXPERIMENTAL DETAILS

The aluminum doped p-type 4H-SiC wafer used in this paper had a doping concentration of 3.4 × 10¹⁸ cm⁻³ which is commercially available from CREE Research, Durham, NC, USA. The wafer was cleaned in a mixture of H₂SO₄ and H₂O₂ followed by a standard RCA cleaning procedure. Between the cleaning steps, the wafers were kept in running DI water. Immediately before the oxidation, the wafer was dipped in 1% HF for 60 s. The wafer was oxidized in quartz furnace at 1150°C for 1.5 h. After the oxidation, the wafer was cut and one set of samples was annealed in NO in an AG610 rapid thermal processing (RTP) unit. The NO annealing was performed in three 5—min steps (to allow cooling of the RTP unit) at about 1100°C. After the oxidation and annealing, aluminum was evaporated on the top of the samples. MOS capacitors were formed by defining the circular dots by photolithography process. Aluminum was also evaporated on the back of the sample to make a large contact.

III. RESULTS AND DISCUSSION

Electrical measurements were performed using a computer-controlled HP4284 LCR meter. The p-type 4H-SiC MOS capacitors were characterized by the high-frequency capacitance (C-V) curves which were measured in dark and with UV illumination. Fig. 1 shows the typical high-frequency C-V curves for the as-grown and NO annealed samples measured in dark. The sweep rate was 0.1V/s for all measurements. The voltage sweep was performed in both directions (accumulation to inversion and inversion to accumulation) as
shown in the figure. The as-grown sample shows poorer C-V characteristics, while NO annealing improves the C-V characteristics. Compared to the C-V curves of the as-grown sample, the C-V curves of the NO annealed sample are shifted positively, and are smoother and sharper. A hysteresis is also observed in the C-V curves of the as-grown sample for the two sweeping directions. NO annealed sample shows little hysteresis. The flat band voltages of the as-grown and NO annealed samples are -10.10V and -8.36V, respectively. The fixed positive oxide charge \( Q_F \) of the as-grown and NO annealed samples calculated from the flat band shift are \( 11.45 \times 10^{12} \text{cm}^{-2} \) and \( 9.27 \times 10^{12} \text{cm}^{-2} \), respectively. To examine the interface characteristics thoroughly, high frequency C-V measurements were performed under UV illumination which are shown in Fig. 2 and Fig. 3 for the as-grown sample and NO annealed sample, respectively. The

![Graph](image_url)

**Fig. 2.** High-frequency C-V characteristics of the as-grown p-type 4H-SiC MOS capacitors measured in dark and with UV illumination.

The electrical characteristics of NO annealed oxides grown on p-type 4H-SiC have been investigated. The results show that the quality of the oxides thermally grown on p-type 4H-SiC can be improved by annealing in NO environment.

### IV. Conclusions

The electrical characteristics of NO annealed oxides grown on p-type 4H-SiC have been investigated. The results show that the quality of the oxides thermally grown on p-type 4H-SiC can be improved by annealing in NO environment.

### References


