HfON Formation on 3-Dimensional Structure
Utilizing ECR Sputtering
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1. Introduction

Scale down of MOSFET
- High integration
- High performance
- Low power consumption

Problems of planar MOSFET
- Short-channel effect
- Direct tunnel current through the insulator
- Drive current

In order to suppress the short-channel effect and acquire higher drive current, MOSFET with 3D GATE STRUCTURE is necessary. High-k insulator is necessary, even for 3D MOSFET.

Dependence on oxidation duration of HfN thin film

Problems of in-situ HfN deposition by ECR sputtering

- HF-last
- Dry-etched by ICP-RIE process
- HfN deposition by ECR sputtering
- PDA at RTA

HfON (1nm) / HfN (65nm) / HfN (65nm) / HfON (1nm)

Plasma with
- High-density and low-damage
- High-quality films
- In-situ plasma oxidation → Reduce contamination

Adaptable to form ultra thin film

Uniform HfON formation on 3D Si structure

2. Experimental Procedure

- Post Etching Annealing (PEA) 1000°C/1 min
- HfN deposition by ECR sputtering
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- HfN oxidation by HfN oxidation process
- PDA at RTA
- Lithography process
- Wet etching process

3. Study on formation of HfON by HfN oxidation process

C-V characteristics of the HfON films formed led at different deposition pressures

- EOT: 0.94 nm at 0.19 Pa. ΔVFB was slightly reduced as pressure was increased.
- Pressure of 0.19 Pa is the best in this case.
- ΔVFB was reduced because of improvement of interfacial property.

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The increase in oxidation duration up to 60 s forms a SiO2-rich IL. The ΔVFB behavior was considered to be due to negative fixed charges caused by N incorporation into the HfON/Si interface.

4. Dependence on post etching annealing (PEA)

In order to suppress the enhanced oxidation during PDA caused by dry-etching damage, PEA (Post Etching Annealing) was investigated.

In case of etching depth of 50 nm, an EOT was decreased by PEA and frequency dispersions of all samples were improved.

Interface properties were improved by PEA (1000°C/1 min).

5. In-situ formation of HfN/HfON gate stacks

Study on selective etching of HfN
Dependence on oxidation duration of HfN thin film

The leakage current of HfN/HfON gate stack structure was 2 orders of magnitude smaller than the ex-situ formed Al/HfON structure with HfON formed by similar condition, and EOT was decreased from 1.0 nm (Al gate) to 0.7 nm (HfN gate).

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