1. Introduction

![Image of IT-FeRAM with Orthorhombic HfO2]

**Advantages of HfO2**
- Scalability
- Compatibility with Si

**Metastable Orthorhombic HfO2 (Pca21)**

**Issue for Hf-based Ferroelectrics on Si Substrate**

Interfacial layer formed by high temperature annealing

Formation of depolarization field

![Image of Capacitance vs Voltage](image)

2. Objective

- Si substrate orientation dependence on the formation of undoped HfO2 with metastable orthorhombic phase
- Direct deposition of ferroelectric HfO2 on Si substrates with relatively low annealing temperature.

3. Experimental Procedure

- **Cleaning p-Si(100), p-Si(111)** SPM / DHF
- **HfO2 deposition (24 nm) @ RT** RF Magnetron Sputtering: 100W Ar/O2 = 2.0/0.2 sccm (0.35 Pa -0.4 Pa) Hf target
- **Post deposition annealing** 600°C / 30 s in N2 (1 SLM)
- Al or Pt evaporation

4. XRD Patterns

![Image of XRD Patterns](image)

- Low oxygen flow was effective to induce orthorhombic phase.

5. Electrical Characteristics

![Image of Capacitance vs Voltage](image)

- MW of 0.61 V and 0.67 V was obtained on p-Si(100) and p-Si(111) substrate.
- Hump in accumulation region was observed in the Al/HfO2/p-Si(111) diode with low frequency.

**Memory Window**

- Regardless of gate electrode, the diode on Si(111) showed larger memory window than Si(100) substrate.

5. Conclusion

- Si substrate orientation dependence of undoped ferroelectric HfO2 was investigated for the first time.
- Low temperature annealing at 600 °C induced ferroelectricity of HfO2 directly deposited on Si substrates.
- Si(111) induced larger memory window than Si(100) probably because of improvement of the crystallinity.

Acknowledgement

The authors would like to thank Prof. H. Funakubo, Mr. H. Inoue of Tokyo Institute of Technology, J. J. Liao of Xiangtan University for their support and useful discussion. This research is based on the Cooperative Research Project of Research Center for Biomedical Engineering, Ministry of Education, Culture, Sports, Science and Technology, M. G. Kim acknowledges Honjo International Scholarship Foundation (HISF) for financial support.