Threshold Voltage Control in p-MOSFET with High-k Gate dielectric

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Abstract

MOS structures using La_2O_3 on Si substrate was fabricated using W electrode with NiSi, NiGe, Ge interfacial layers. It was confirmed that V_{fb} can be shifted to +0.2eV by interfacial layer insertion.

Introduction

Aggressive scaling of MOSFET devices requires a Metal gate/High-k gate stack. To achieve low EOT, high-k/Si direct contact using La_2O_3 has been proposed. Because of the observed negative V_{fb} shift in W/ La_2O_3/Si direct contact devices, Metal gate material p-MOSFET using La_2O_3/Si direct contact should be explored. In this paper, we fabricated MOSCAPs using La_2O_3 as gate insulator and using W as gate metal, and inserted NiSi, NiGe, Ge interfacial layers for V_{fb} shift control.

Experimental

Sample fabrication process is shown in Figure 1. La_2O_3 films were deposited on HF-last, n-Si (100), by e-beam evaporation in an ultra high vacuum chamber (~10^{-6} Pa). The dopant density of the substrate was 1.5×10^{15} cm^{-2}. Si, Ge and Ni thin layers were deposited by e-beam evaporation or RF sputtering. At last W film were deposited as gate electrode by RF sputtering. Annealing was performed using RTA at 500°C in F.G. ambient (N_2:H_2=97:3). Capacitance-Voltage (CV) characteristics of the MOSCAPs were measured at 100 kHz using Agilent4284A precision LCR meter and EOT value was calculated from CV characteristics using the NCSU CVC program.

Result and Discussion

Obtained EOT-V_{fb} characteristics for the samples of NiSi, NiGe layer insertion are shown in Figure 2. V_{fb} of NiGe inserted samples were shifted about +0.6eV compare to NiSi inserted samples. Further positive V_{fb} shift of about +0.4eV compare to NiGe inserted samples was observed in Ge layer insert samples as shown in shown in Figure 3. Our results show that Ge layer insertion is one of the promising method in metal gate materials research for p-MOSFETs using La_2O_3/Si direct contact.

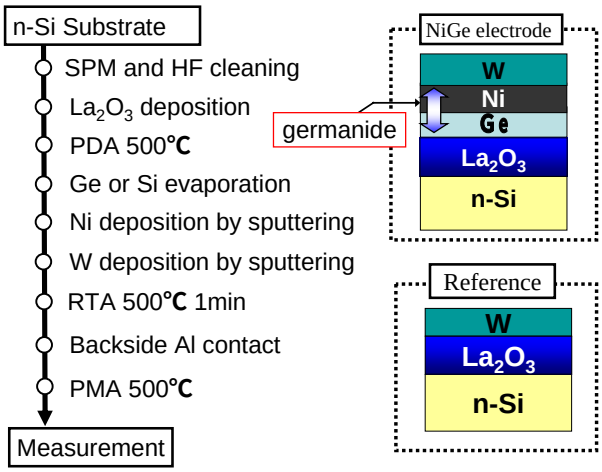

Fig.1 Fabrication process of MOSCAP.

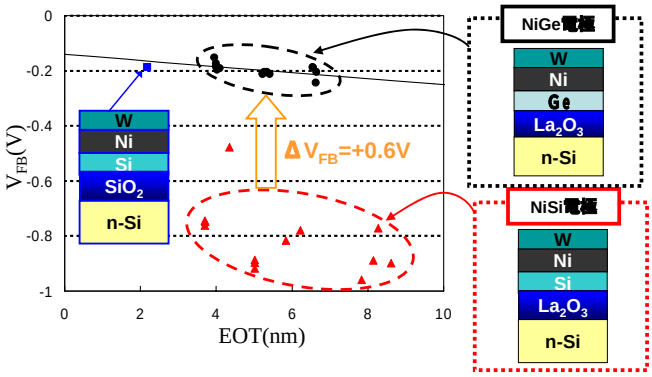

Fig.2 EOT-V_{fb} Characteristics of the NiSi, NiGe gate electrode

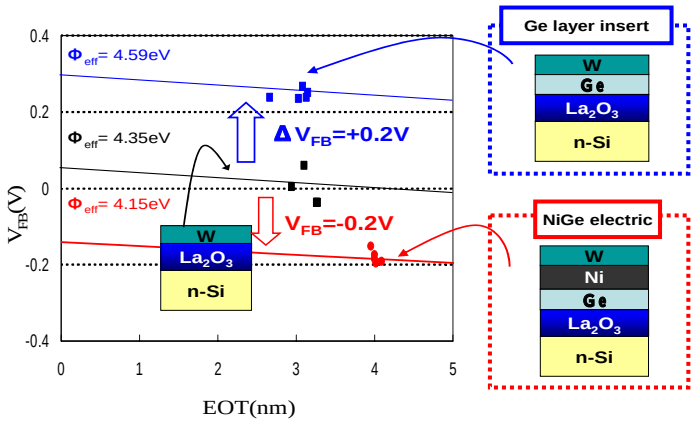

Fig.3 EOT-V_{fb} Characteristics of the W, W with Ge layer insert, NiGe gate electrode