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

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Abstract
MOS structures using La₂O₃ on Si substrate was fabricated using W electrode with NiSi, NiGe, Ge interfacial layers. It was confirmed that Vfb 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 La₂O₃ has been proposed. Because of the observed negative Vfb shift in W/La₂O₃/Si direct contact devices, Metal gate material p-MOSFET using La₂O₃/Si direct contact should be explored. In this paper, we fabricated MOSCAPs using La₂O₃ as gate insulator and using W as gate metal, and inserted NiSi, NiGe, Ge interfacial layers for Vfb shift control.

Experimental
Sample fabrication process is shown in Figure 1. La₂O₃ 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 1.5x10¹⁵ 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 F₂G ambient (N₂:H₂=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-Vfb characteristics for the samples of NiSi, NiGe layer insertion are shown in Figure 2. Vfb of NiGe inserted samples were shifted about +0.6eV compare to NiSi inserted samples. Further positive Vfb 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 La₂O₃/Si direct contact.
Fig. 1 Fabrication process of MOSCAP.

Fig. 2 EOT-V<sub>f</sub><sub>b</sub> Characteristics of the NiSi, NiGe gate electrode.

Fig. 3 EOT-V<sub>f</sub><sub>b</sub> Characteristics of the W, W with Ge layer insert, NiGe gate electrode.