Process development for next generation DRAM electrode using a new Ru-CVD/ALD precursor

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Abstract

In this research, process development on Ru electrode fabrication was examined for applying to next generation dynamic random access memory (DRAM) by Ru-CVD/ALD. A new Ru precursor was used to deposite Ru/RuO2 thin films. In situ monitoring technique using light reflectivity measurement was introduced to monitor the initial behavior of Ru/RuO2 film growth.

Introduction

To successfully integrate DRAM devices, it is important to maintain the certain memory capacitance (25–30 fF) to operate the device, which will be, however, very difficult since the cross-sectional area occupied by the capacitor is reduced as miniaturization. The development of the new high dielectric constant (high-k) material (HfO2, Ta2O5, STO, BST) and new electrode materials are essential to maintain the certain capacitance. The new electrode material, Ru, has a large work function (4.71 eV) and have conductivity even if it is oxidized. Those characteristics will reduce the leakage current and EOT values of memory capacitor.

Many Ru-CVD/ALD precursors for DRAM capacitor electrodes and Cu interconnect liner layers had been proposed, but none of them could satisfy the process requirements as shown below.

1) Ultra thin (2–3 nm) and continuous film should be grown in high-aspect ratio (~100) features.
2) Incubation period/cycles should be short on SiO2 and high-k materials.
3) Residual carbon impurity should be low to maintain high work function of Ru film.

In the present work, we have introduced new Ru precursor and examined the initial growth behavior of CVD process using in situ monitoring method.

Experimental

A newly developed ruthenium precursor was employed and oxygen was used as the oxidizing gas. He was used as the carrier gas and diluent. Si substrate with thermal oxide was used as the substrate. White light was illuminated on the growing surface and the reflected light was measured using a spectrum analyzer. Deposition runs were performed by changing the partial pressures of precursor and oxygen at substrate temperature of 230–240°C.

Fig. 1 In situ reflected light intensity change during Ru/RuO2 CVD.

Fig. 2 In situ reflected light spectrum from CVD-Ru/RuO2 surface.