Low Temperature Deposition of Ruthenium Films using Novel MOCVD Precursor

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Abstract

Ruthenium films were prepared on SiO_2/Si substrate by metalorganic chemical vapor deposition (MOCVD) from novel ruthenium precursor (2.4-Dimethylpentadienyl) (Ethyl-cyclopentadienyl)Ruthenium $Ru(C_7H_{11})(C_7H_9)$.

The small amount of oxygen reduced the deposition temperature to form ruthenium films from novel precursor.

Introduction

For the application of these materials in a ULSI device, the selection of an electrode material is also important as much as the high dielectric material. The film of Ru is a one of the most promising material for capacitor electrodes because it has excellent characteristics, such as low resistivity, good susceptibility to dry eching, and a conductive oxide phase of RuO_2.

In this study, we discussed MOCVD using novel ruthenium precursor $Ru(C_7H_{11})(C_7H_9)$ and investigated the effect of O_2 gas for film characteristics, deposition rate and step coverage.

Experimental

Ruthenium films were deposited by using a horizontal cold-wall type rector with bubbling transfer on SiO_2/Si substrate with and without O_2 gas. The deposition temperature was varied from 225℃ to 400℃. The thickness and surface morphology of deposited films were measured by FE-SEM and AFM. The crystallinity and degree of film orientation were characterized by XRD.

Results and Discussion

Fig.1 shows a structure of the novel ruthenium precursor $Ru(C_7H_{11})(C_7H_9)$. It has so-called half-open ruthenocene structure and has lower decomposition temperature (about 80℃) than previous $Ru(EtCp)_2$ precursor.

Fig.2 shows the Arrhenius plots of the growth rate of the Ru film deposited on SiO_2/Si substrate from $Ru(C_7H_{11})(C_7H_9)$ precursor with and without O_2 flow condition.

The small amount of O_2 gas is effective to reduce the decomposition temperature of ruthenium precursor to form Ru films. Ruthenium films were directly deposited on SiO_2/Si substrate using $Ru(C_7H_{11})(C_7H_9)$ precursor with excellent surface morphology than previous $Ru(EtCp)_2$ precursor. (Fig.3)

Good step coverage characteristic is obtained under low temperature(250℃) deposition using small amount of O_2 gas. (Fig.4)

Fomula : $Ru(C_7H_{11})(C_7H_9)$

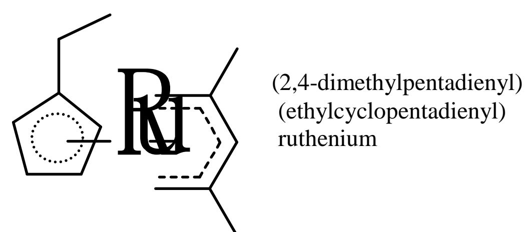

Fig. 1 Structure of novel precursor

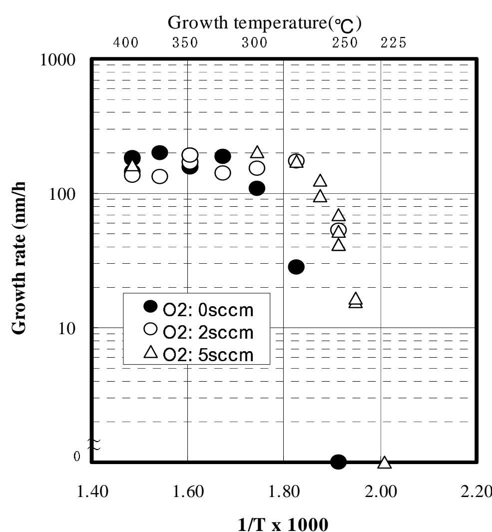

Fig.2 Arrhenius plots of the growth rate of the Ru film deposited on SiO_2/Si substrate from $Ru(C_7H_{11})(C_7H_9)$ precursor with and without O_2 flow condition.

a) b)

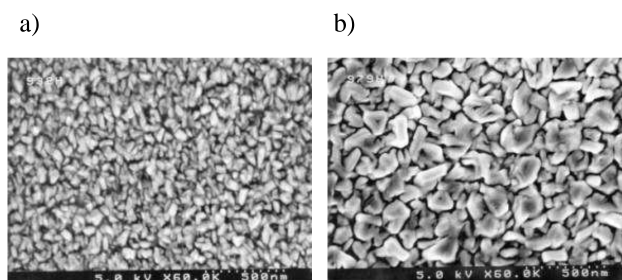

Fig.3 Scanning electron micrographs of Ru films deposited at 275℃ on SiO_2/Si substrate from precursor a) $Ru(C_7H_{11})(C_7H_9)$ and b)$Ru(EtCp)_2$.

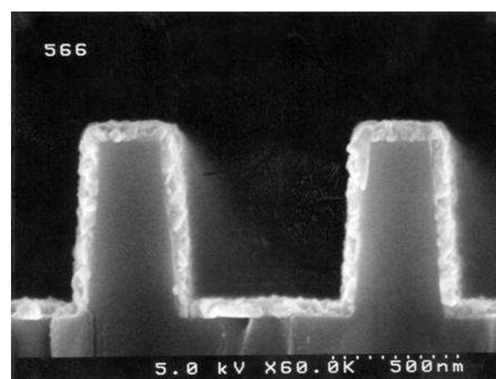

Fig.4 Cross-sectional Scanning electron micrographs of Ru films deposited at 250℃ on SiO_2/Si step substrate from novel precursor: $Ru(C_7H_{11})(C_7H_9)$ with 5sccm O_2 flow condition.