TT-P050

New Ruthenium Complexes for Semiconductor Device Using Atomic Layer Deposition

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Ruthenium (Ru) has attractive material properties due to its promising characteristics such as a low resistivity (7.1 $\mu\Omega\cdot$cm in the bulk), a high work function of 4.7 eV, and feasibility for the dry etch process. These properties make Ru films appropriate for various applications in the state-of-art semiconductor device technologies. Thus, it has been widely investigated as an electrode for capacitor in the dynamic random access memory (DRAM), a metal gate for metal-oxide semiconductor field effect transistor (MOSFET), and a seed layer for Cu metallization. Due to the continuous shrinkage of microelectronic devices, better deposition processes for Ru thin films are critically required with excellent step coverages in high aspect ratio (AR) structures. In these respects, atomic layer deposition (ALD) is a viable solution for preparing Ru thin films because it enables atomic-scale control of the film thickness with excellent conformality. A recent investigation reported that the nucleation of ALD-Ru film was enhanced considerably by using a zero-valent metallorganic precursor, compared to the utilization of precursors with higher metal valences. In this study, we will present our research results on the synthesis and characterization of novel ruthenium complexes. The ruthenium compounds were easy synthesized by the reaction of ruthenium halide with appropriate organic ligands in protic solvent, and characterized by NMR, elemental analysis and thermogravimetric analysis. The molecular structures of the complexes were studied by single crystal diffraction. ALD of Ru film was demonstrated using the new Ru metallorganic precursor and O2 as the Ru source and reactant, respectively, at the deposition temperatures of 300-350°C. Self-limited reaction behavior was observed as increasing Ru precursor and O2 pulse time, suggesting that newly developed Ru precursor is applicable for ALD process. Detailed discussions on the chemical and structural properties of Ru thin films as well as its growth behavior using new Ru precursor will be also presented.

Keywords: Ruthenium, precursor, ALD