INVESTIGATION OF RU THIN FILMS PREPARED BY CHEMICAL VAPOR DEPOSITION AS BOTTOM ELECTRODES FOR MEMORY APPLICATIONS

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The requirement for the chemical vapor deposition (CVD) of metal electrodes for the Ta_2O_5 and $(Ba,Sr)TiO_3$ [BST] capacitors for dynamic random access memory (DRAM) devices becomes more critical as the storage node height increases more than 0.3 ㎛ with a 0.1-㎛ spacing between them[1]. One candidate for use as an electrode is Ru, because it has excellent characteristics, such as low resistivity, good susceptibility to dry etching, and a conductive oxide phase of RuO_2[2]. Ru bottom electrode is located between TiN diffusion barrier and high-k dielectric layer. Post-annealing on the capacitor induces to roughen Ru surface and to form TiOx layer at the Ru/TiN interface and the changes affect on the electrical property of the capacitor. Therefore, the stability of the two interfaces, Ru/TiN and high-k layer/Ru, should be necessarily investigated. In this study, we deposited Ru thin films using Cyclopentadienylpropylcyclopentadienlyl ruthenium (II) [RuCp(i-PrCp)], and investigated the stability of Ru/TiN and high-k layer/Ru during annealing.

Figure 1 shows a schematic diagram of the MOCVD system which consists of a vertical warm wall reactor, a resistive substrate heater 6" in diameter, the bubbler system and the DLI system. Ar gas was used as a carrier gas as well as a diluent gas, and O_2 gas was introduced into the reactor in order to eliminate carbon incorporation into the film and also to enhance the decomposition of the metalorganic precursors. To deposit Ru-Ti alloy films, $Ti(O\text{-}iPr)_4$ was injected to the reactor through the DLI system during the delivery of RuCp(i-PrCp) by the bubbler system

Figure 2 shows variation of electrical resistivity of Ru-Ti film(30nm). At the high Ti source flow rate, the film seems to be an insulator due to networking of TiO_2 phases in the film. Figure 3 shows variation of surface roughness of Ru(30nm) films deposited with various Ti source flow rate and their N_2-annealed (at 700ºC) films. In Figure 3, we can find out the addition of Ti prevents roughening of the films' surface below 0.15ccm of Ti source addition. It is believed that at the small amount of Ti content, TiOx phases distributed at the grain boundaries of Ru film, suppress the grain growth of the Ru grains during annealing. Figure 4 (a) and (b) show cross-sectional TEM images of the as-deposited and post-annealed under H_2 atmosphere at 400℃ followed by a N_2 atmosphere at 600 ℃, respectively. The slightly light contrast effect on the TiN surface is due to the initially high oxygen concentration. It can be confirmed that post-annealing does not induce any structural change at the interface

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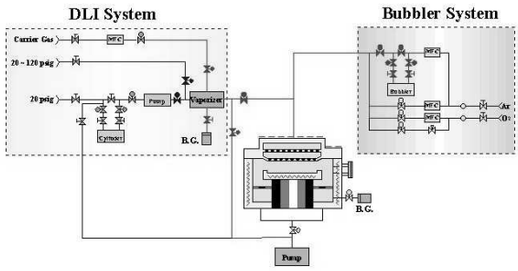

Figure 1. Schematic diagram of MOCVD system

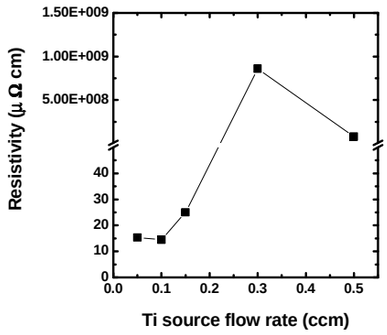

Figure 2. Variation of electrical resistivities of Ru-Ti films deposited with various Ti source flow rate.

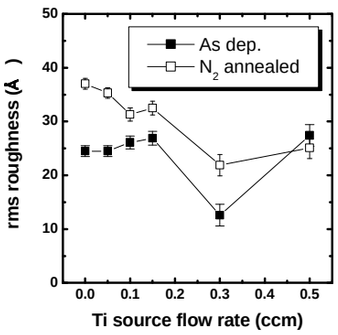

Figure 3. Variation of surface roughness of Ru-Ti films deposited with various Ti source flow rate

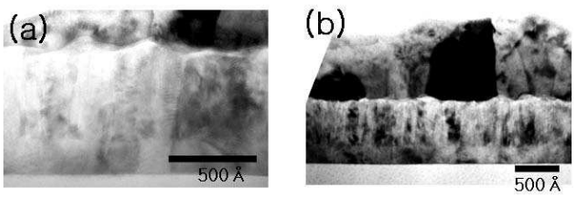

Figure 4. The cross-sectional TEM images of the Ru films deposited (a) at 375℃ with 50sccm of oxygen flow rate on $TiN/TiO_2/SiO_2/Si$ substrate and (b) annealed under H_2 atmosphere at 400℃ and then N_2 atmosphere at 600℃