Effect of Thermal Annealing on the Agglomeration Behavior of Ru Thin Films Prepared by Metal-Organic Chemical Vapor Deposition

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Ruthenium (Ru) has been considered as the most promising electrode materials for capacitors in giga-bit scale dynamic random access memory devices . However, it was reported that the thin metallic films tend to agglomerate after high temperature annealing to reduce the total free energy of the system. Therefore, the agglomeration of the Ru thin films with high surface energy (~3.05 J/m^2) should be evaluated to guarantee the thermal stability during the post-deposition annealing. Because the Ru thin films should be deposited on TiN and SiO_2 surfaces in the 3-dimensional concave-type capacitors, the agglomeration behavior of the Ru films on these two types of surfaces was intensively investigated using rapid thermal annealing (RTA) process under various ambients.

The thermal stability of 24-nm-thick Ru films deposited on SiO_2 surface was so poor in Ar ambient that the agglomeration of Ru has occurred even at the temperature of 500C. But, the thicker Ru films tend to maintain morphological stability at higher annealing temperatures. The tensile stress of deposited Ru films were negligibly affected the agglomeration behavior due the fact that the agglomeration was mitigated by the increase in film thickness. The agglomeration was hardly occurred in the Ru films deposited on TiN surface or annealed in H_2 ambient. For H_2 annealing, the pinning effect or the change in the surface energy by hydrogen was supposed to the origin of such a phenomenon, whereas for the Ru on TiN, the thermal stability was understood from the standpoint of the surface energy.