Interface analysis and phase transition of HfO_2 film on Si substrate after thermal treatment

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Hafnium oxide (HfO_2) thin films on Si (100) substrate was prepared by radio frequency sputtering technique. XRD patterns show that the grown films are amorphous and transform into stable monoclinic phase after annealing treatment[1]. The position and width of Raman modes vary nonlinearly with increasing temperature due to the anharmonic interaction of hafnium and oxygen [2]. XPS of the film reveals that no silicide is found after thermal treatment. However, Si_{2p} suggests the occurrence of a SiO_2 interface between HfO_2 layer and Si substrate[3-4]. Ellipsometry spectroscopy results show that amorphous HfO_2 thin films crystallize into a monoclinic phase in the range of 300~ 400 ^oC. This observation is consistent with that of XRD and Raman spectroscopy at variable temperature. Thickness and refractive index of HfO_2 thin film are obtained by fitting ES parmeters. The total thickness of the HfO_2 thin film increases by 1.02 nm and refractive index decreases from 2.3 to 1.9 during the formation of the SiO_2 interface layer after thermal treatment. In this study, we investigated the temperature effects on the crystal structure, interface growth and optical properties of HfO_2 thin film. Furthermore, the correlations between temperature, interface growth, and optical properties have been established.

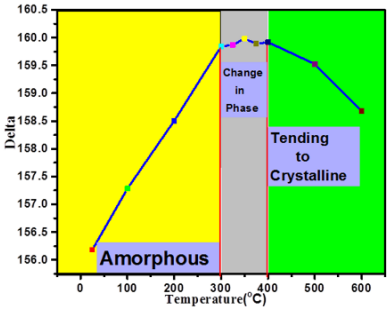

Figure 1 Phase digram of HfO_2

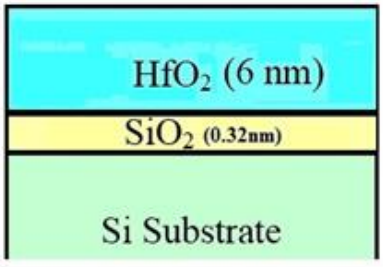

Figure 2 Schematic diagram of $HfO_2/SiO_2/Si$

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[2] Li, Mckerns et al. Physical Review B 80, 054304 (2009)
[3] Ou, Ralph et al. Appl. Phys. Lett. 110, 192403 (2017)
[4] Jiang et al. Applied Physics Letters 108, 061905 (2016)

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