MOCVD GROWTH OF Pr_2O_3 HIGH-K GATE DIELECTRIC FOR SILICON: SYNTHESIS AND STRUCTURAL INVESTIGATION

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Over the past two decades, the growth of oxide films on silicon has been investigated to fabricate highly integrated circuits. The aggressive scaling down of complementary metal-oxide semiconductor technology calls for identifying high K dielectrics to replace SiO_2 gate oxide, whose thickness is now approaching the quantum tunneling limit (about 10-15 Å).[1] One obvious way to reduce tunneling, while maintaining the required levels of gate oxide capacitance, is to substitute the SiO_2 gate oxide with thicker alternative materials having higher values of dielectric constant.[2] In recent years, Pr_2O_3[3] has received much attention because of the possible use as alternative gate dielectrics in CMOS devices. Physical vapour deposition methods have been successfully used to grow Pr_2O_3 films on silicon substrates,[4] while, to date, there are no studies on chemical vapour deposition methods.

We report on the results of a recent study on the deposition of praseodymium oxides thin films on silicon substrates by metal-organic chemical vapor deposition (MOCVD). Two different Pr(III) β-diketonate precursors have been investigated as candidates for Pr metal source and the deposition conditions have been carefully selected because of a large variety of possible PrO_{2-x} (x= 0-0.5) phases. Praseodymium oxide films have been deposited in an hot-wall MOCVD reactor at 750°C deposition temperature. A new praseodymium precursor has been synthesised, $Pr(hfa)_3$diglyme (H-hfa=1,1,1,5,5,5-hexafluoro-2,4-pentadione, diglyme= $CH_3O(CH_2CH_2O)_2CH_3$) and studied as praseodymium source. The fluorinated precursor yields an oxyfluoride phase, PrOF (figure 1), even under a water saturated oxygen flow. The $Pr(tmhd)_3$ (H-tmhd= 2,2,6,6,-tetramethyl-3,5-heptandione) precursor has been investigated as praseodymium source as well, and depending on the oxygen partial pressure, different praseodymium oxides have been obtained. PrO_2 films (figure 2) have been formed using P_{O2}=2 torr, while Pr_6O_{11} and Pr_2O_3 films (figure 3) have been deposited using P_{O2}=0.7 and 10^{-5} torr, respectively. In particular, the θ-2θ scan of Pr_2O_3 films deposited on Si (100) substrate, shows the formation of the Pr_2O_3 hexagonal random phase. Their complete structural and morphological characterization has been carried out by X-ray diffraction (XRD), transmission electron microscopy (TEM), and atomic force microscopy (AFM). Finally, preliminary electrical measurements point to MOCVD as a reliable growth technique to obtain good quality Pr_2O_3 films.

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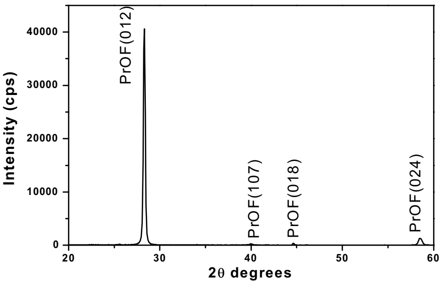
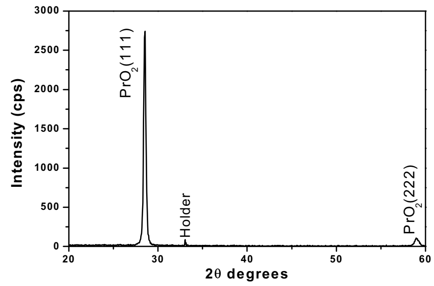


Figure 1. XRD spectrum of a PrOF film deposited on Si(100) substrate at 750°C using the $Pr(hfa)_3$diglyme



precursor.

Figure 2. XRD spectrum of a PrO_2 film deposited on Si(100) substrate at 750°C using the $Pr(tmhd)_3$ precursor at P_{O2}= 2 torr.

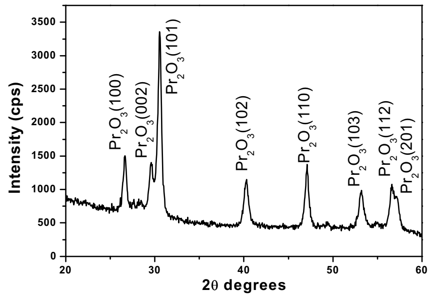


Figure 3. XRD spectrum of a Pr_2O_3 film deposited on Si(100) substrate at 750°C using the $Pr(tmhd)_3$ precursor at P_{O2}= 10^{-5} torr.