INCIDENCE OF VARIOUS DEPOSITION PARAMETERS ON THE STRUCTURAL PROPERTIES OF Y_2O_3 GROWN BY PULSED INJECTION PE-MOCVD

C. Vallée, C. Durand, M. Bonvalot, O. Joubert
Laboratoire des Technologies de la Microélectronique (LTM/CNRS)
17 avenue des martyrs (CEA-LETI),
38054 Grenoble Cedex 09, France

C. Dubourdieu
LMGP
961 rue de la Houille Blanche, BP 46
38402 Saint Martin d'Hères cedex

Materials with high dielectric constant "k" have been introduced in integrated circuits as stated in the International Technology Roadmap for Semiconductors (ITRS). The aggressive scaling of CMOS devices is indeed driving SiO_2 based gate dielectrics to its physical limits. Currently several different dielectric materials as Al_2O_3, ZrO_2, HfO_2, Y_2O_3, La_2O_3 as well as mixed oxides containing SiO_2 (silicates) or Al_2O_3 (aluminates) or N-doped HfO_2 and ZrO_2 are being studied extensively. These dielectrics can be refereed as "medium-k" ($10<k<20$). Moreover, still following the ITRS, integration of Metal/Insulator/Metal (MIM) structure for the next generation of RF chips is needed. Increasing the dielectric constant of the dielectric used for the MIM structure permits to increase the capacity density and hence to lower the chip cost. Good results have already been obtained with a $TiN/TA_2O_5/TiN$ structure embedded in an Al-Interconnect technology. Efforts are made to obtain MIM structure with $SrTiO_3$ and $BaTiO_3$ as "high k" dielectrics. Among these high k materials, some authors try to obtain a MIM structure with a medium k, such as HfO_2, due to their large band gap (see table 1).

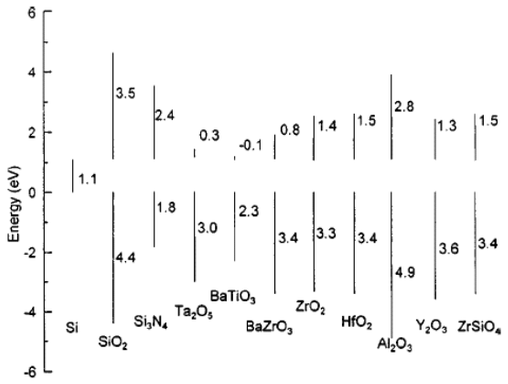

Table 1 : bandgap alignement (from Robertson [1])

Different innovative ways to deposit high k materials are being developed. HfO_2 has been successfully deposited using Atomic Layer Deposition (ALD), metal organic chemical vapor deposition (MOCVD) and physical vapor deposition (PVD). In this paper, we present results on the growth of thin Y_2O_3 films obtained by an innovative MOCVD process, which combines plasma assistance and an original liquid precursor supply set-up. Plasma assistance enables higher deposition rates to be achieved at much lower substrate temperatures and so performing; as an example, the deposition of dielectric film compatible with back-end thermal budget constraints (< 450 °C) for MIM structure. The liquid supply system used is based on the sequential injection of microamounts of precursors inside an evaporator maintained at high temperature. The MO precursor dissolved in a solvent is maintained at room temperature in a closed vessel under a 2 bar inert atmosphere (N_2), and is pushed inside the injector by the pressure. The injector is a very accurate high speed electrovalve driven by an electric pulse generator which allows only the amount of precursor solution needed for vapor pressure generation to be sequentially introduced into the evaporator held at 190°C, where a flash volatilization occurs. With this new CVD source, high vapor pressure of precursors stable over a long period of time can thus be obtained, even with thermally unstable precursors, whose aging is prevented. Dissolved active gaseous species in the evaporator and plasma gases (O_2/Ar) are then transferred to the plasma chamber through a heated showerhead via a heated line .
In this paper, we report the incidence of various deposition parameters on the Y_2O_3 physical structural properties and its interface with the Si substrate. We present the influence of plasma parameters (Low Frequency power, plasma pressure) as well as pulsed injection MOCVD parameters (injection frequency and electrical pulse width, nature of the solvent) on the dielectric properties. Results concerning the N-doping of Y_2O_3 by adding N_2 to the O_2/Ar gas, and the influence of the substrate cleaning on the interface formation are also presented. The interfacial oxide thickness is estimated by X-ray Photoelectron Spectroscopy with a SiO_2 escape depth model from Si2p. It is shown that his deposition method easily permits the deposition of mixed oxides as well as multiplayer high k dielectrics for MIM structure. Influence of post deposition treatment by O_2 plasma in the deposition chamber, on film stoechiometry and carbon contamination is also investigated and compared to a post deposition annealing effect.

[1] J. Robertson, *J. Vac. Sci. Technol. B*, Vol. 18, No 3, May/Jun 2000