OPTICAL CHARACTERISATION OF HIGH-κ MATERIALS DEPOSITED BY ALCVD

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One of the most promising techniques for the deposition of high κ materials is the Atomic Layer Chemical Vapor Deposition (ALCVD). This technique uses different precursors for the components of the oxides.

In this paper it is presented an ellipsometric characterization of high κ materials (alumina, zirconium and hafnium oxides) and compound materials (zirconium and hafnium aluminates).

Spectroscopic Ellipsometry (SE) consists on analyzing the change of light polarization after reflection on a sample surface, over a wide spectral range, obtaining precise information about physical properties of layers.

SE measurements were carried on using a SOPRA ES4G with a DUV extension in the 1.5-6.5eV spectral range. Some samples were also measured by a N_2 purged SOPRA UV system (PUV), which allows to measure in the VUV region up to 8.5eV.

Figure 1 reports the refractive index obtained on the thicker Al_2O_3 sample (about 510Å). Extinction coefficient is significative for energies higher than 7eV. Therefore the PUV system allows to get much more information about this kind of material.

After an HF last before ALCVD deposition, a “native oxide” exists between the Al_2O_3 layer and the bare silicon. The thickness decreases vs. Al_2O_3 layer thickness. The presence of this layer is due to the oxygen diffusion through the alumina layer (Figure 2). This behavior is confirmed by TEM analysis and XPS analyses.

The refractive index and the extinction coefficient of several zirconium aluminates are represented (Figure 3). Refractive index of compound materials moves from Al_2O_3 to ZrO_2.

Optical properties of HfO_2 are reported in figure 4. We note the difference between an amorphous layer and a slightly polycrystalline one. The last one presents a singular absorption peak in UV region.

In case of polycrystalline materials the surface roughness is also very important and it is necessary to take it into account in the fitting stack. For zirconium oxide and hafnium oxide we used a BEMA mixture of the high κ material itself and voids (n=1, k=0). Table 1 shows a comparison of surface roughness measurement between AFM and SE.

DUV Ellipsometry allows, by means of a non-destructive and fast measurement, to observe different physical properties of high κ materials, such as cristallinity, roughness and thickness of interfacial layers between silicon and the deposited high κ layer.

SE also shows a good correlation with other physical techniques, such as AFM and XRF.

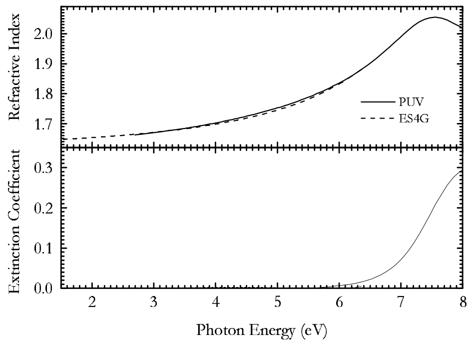

Figure 1: Optical properties of Al_2O_3

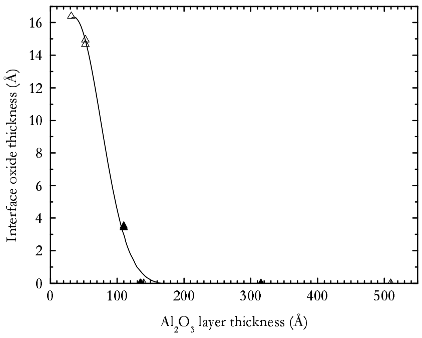

Figure 2: Interface layer thickness Vs Al_2O_3 layer thickness

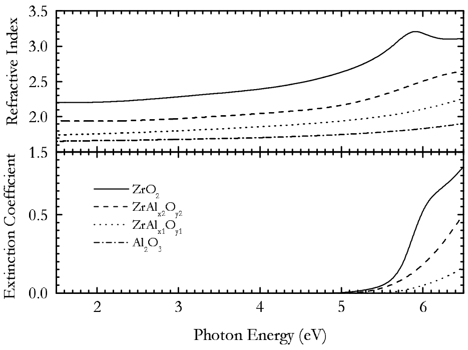

Figure 3: Optical properties of Zr aluminates

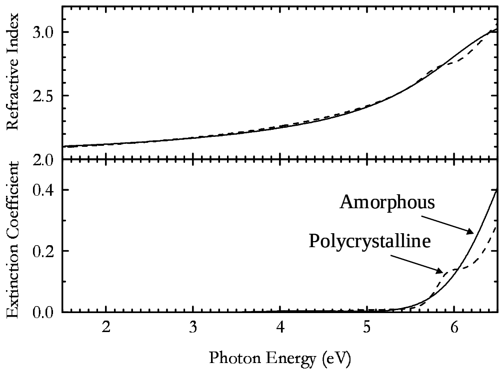

Figure 4: Optical properties of HfO_2

Table 1 Surface roughness: SE Vs AFM

	SE		AFM
	Thick. (Å)	Rough. (Å)	Rough $_{rms}$. (Å)
ZrO_2	494.0	27.2	16.4
	112.9	9.7	4.1
Al_2O_3	139.8	0	1.4