Effects of the Wet Air on the Properties of the Lanthanum Oxide and Lanthanum Aluminate Films

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High dielectric-constant materials have attracted much attention since the scaling of semiconductor devices requires a gate dielectric with an equivalent oxide thickness (EOT) of less than 1.5 nm [1]. Some binary metal oxides such as ZrO_2 and HfO_2, and La_2O_3 have been widely studied for use as gate dielectrics [2]. However, it is known that ZrO_2 and the La_2O_3 degraded by the absorption of moisture. From this reason, when the La_2O_3 is used as gate dielectric, only dry cleaning process could be used. In a previous study [3], it is reported that the Al_2O_3 incorporated ZrO_2 showed improved hydration resistance. Accordingly, the study on the Al_2O_3 incorporated La_2O_3 would be worth for use as a gate dielectric with conventional semiconductor process. In addition, since the lanthanum aluminate ($La_xAl_{1-x}O_y$; LAO) is known as one of the most promising materials for use as next generation gate dielectric [2], it is again emphasized the importance of the study on the hydration behavior of the LAO film.

In this work, we deposited both the La_2O_3 and the LAO films by using MOCVD method and stored the films in moisture and dry ambient for days. We will denote them hereafter as H1 (La_2O_3 in wet ambient), H2 (LAO in wet ambient), D1 (La_2O_3 in dry ambient) and D2 (LAO in dry ambient), respectively. The thicknesses of the films were measured by utilizing an ellipsometer. Surface morphologies of the films were studied by using AFM. Also, the MOS (Pt/oxide/Si) structures were fabricated and the electrical properties were investigated.

Figure 1 shows thickness changes of the films as a function of exposure time. The thicknesses of the samples stored in wet ambient increased as storage time increased. Especially the thickness of the H1 film drastically increased after stored for 4 days. The H2 film showed slightly increase in thickness. In case of the D1 and the D2 films, the D1 film showed little change while D2 showed almost no change in thickness.

Figure 2 shows the calculated RMS roughness values of the films as a function of exposure time. The roughness of the H1 film drastically increased after. For the H2 sample, the roughness was not quite different with the as-grown film after exposure for 4 days. However, the roughness also increased after exposure for 10 days. In case of the D1 and the D2 films, there was no distinct change after exposure like the results in Fig. 1.

The ratios of EOT for exposed films to EOT for fresh films are plotted in Fig. 3. The EOT continuously increased for the H1 sample and after exposed for 10 days the EOT of the H1 film increased over one and half times from that of the as-grown La_2O_3 film. In case of the H2 film, although there was almost no change for 4 days exposure, the EOT of the film also considerably increased after exposure for 10 days.

More details will be discussed at the meeting.

[1] P. S. Peercy, Nature, **406**, 1023 (2000).
[2] ITRS Roadmap, 2003 ed., (2003).
[3] N. Biswas et. al., Bull. Mater. Sci., **22**, 37 (1999).

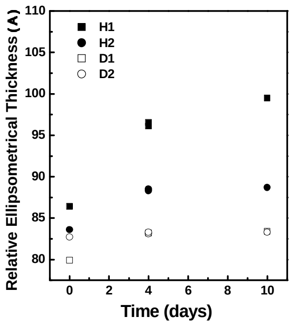

Fig. 1. Changes in ellipsometrical thickness

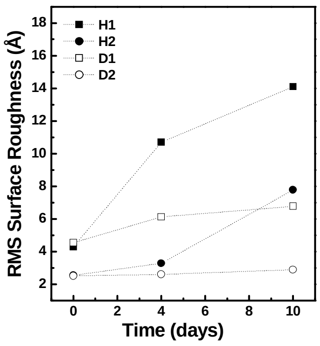

Fig. 2. Changes in RMS roughness values

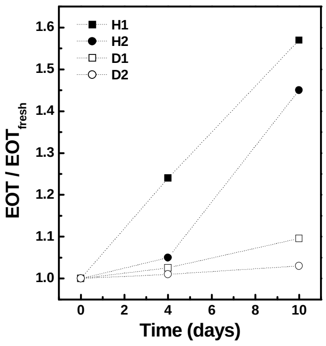

Fig. 3. Ratios of $EOT_{exposed} / EOT_{fresh}$