Low temperature plasma enhanced atomic layer deposition of SiO_x films using divalent Si precursor for thin film encapsulation

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Abstract

Silicon dioxide (SiO_2) is a well-known dielectric material, which have been used for semiconductor industries such as gate dielectric, gate spacer and deep shallow trench.

Besides, SiO_2 attract its attention as a promising material for thin film encapsulation (TFE), organic devices such as light emitting diode, photoelectric device need encapsulation layer to prevent degradation of organic materials caused from oxygen and water vapor. Conventionally, SiO_2 films are deposited by chemical vapor deposition (CVD), sputtering and thermal evaporation. The above methods have some problem for TFE such as high growth temperature, poor step coverage, point defect. Plasma enhanced atomic layer deposition (PEALD) method is popular that can achieve high quality SiO_2 without defect at relatively low temperature.

In our study, SiO_x thin film was deposited by PEALD method using N,N'-tert-butyl-1,1-dimethylethylenediamine silylene as a precursor, oxygen plasma as a reactant. PEALD processes show surface limit reaction behavior as increase precursor dose with constant purge time 10s during processes. Also, it exhibited significant process window in the temperature range of 80-200°C with negligible ble carbon, nitrogen impurity concentration. Film thickness, refractive index of SiO_x thin films are investigated using spectroscopic ellipsometry (SE) and films have about 1.45-1.5 refractive index value which is correspond to SiO_2' refractive index although we used divalent precursor. Due to low temperature process, SiO_x thin films are deposited on polymer substrate under 120°C and Water vapor transmission rate (WVTR) is measured by Ca-test method. As a result, we can compare the WVTR properties of SiO_x depending commercial precursor and new divalent precursor.

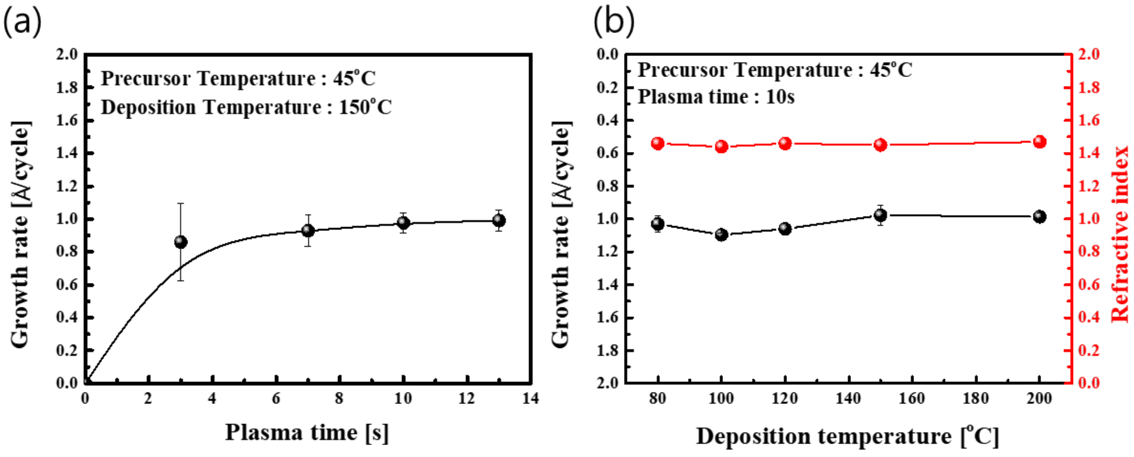

Figure 1. Growth rate of SiOx depend on (a) plasma time, (b) deposition temperature