OPTICAL CHARACTERISATION OF LPCVD SiO_xN_y THIN FILMS

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Dielectric thin films obtained by Chemical Vapour Deposition (CVD) are widely used in microelectronics and optoelectronics industry for passivating coatings and thin gate dielectrics and as well in Micro-Opto-Electro-Mechanical-Systems (MOEMS) as low stress membranes and optical wave-guides. One of the most interesting dielectric materials is certainly silicon oxynitride (SiO_xN_y). Among its properties the ability to control the refractive index (of growing interest for integrated optoelectronic devices), inertness and low mechanical stress should be emphasized. [1,2]

The purpose of this paper is the investigation of the optical and microstructural properties of LPCVD SiO_xN_y thin films and the presentation of the correlation between deposition parameters, material properties and internal structure. Fourier Transform Infrared Spectroscopy - FTIR, Variable Angle Spectroscopic Ellipsometry - VASE (coupled with Bruggeman-EMA [3], Cauchy [4], Sellmeier [4] and Wemple Di Domenico [5] optical models) and photoluminescence spectroscopy - PL were used to characterise the optical and microstructural properties of as-deposited and annealed SiO_xN_y films.

LPCVD SiO_xN_y thin films were deposited on 3-inch silicon wafers using a mixture of $SiCl_2H_2$-NH_3-N_2O.The relation between the LPCVD processing parameters and SiO_xN_y films properties are summarized in Figure 1 (T_d=800-860^{o}C, $d_{SiH2Cl2}$=20sccm and p_d=400mTorr). Films with different stoichiometry have been obtained by varying the relative gas flow ratio, $\rho = Q_{N_2O} / Q_{NH_3}$.

The as-deposited SiO_xN_y films were thermally treated in O_2 and H_2O vapors in an open quartz tube at a temperature of 1050^{0}C for different periods of time from 30 to 120 minutes.

FTIR has been used to identify structural changes in SiO_xN_y produced by both LPCVD conditions and by post growth high temperature annealing.

The Bruggeman EMA model was successfully applied for the LPCVD SiO_xN_y thin films. Cauchy and Sellmeier models can accurately describe the spectral dispersion of the refractive index of the films.

Information about disorder degree and optical bandgap for LPCVD SiO_xN_y thin films has been obtained from the Wemple-Di Domenico model. As the nitrogen content in SiO_xN_y thin films increases, the optical bandgap decreases from 5.93eV to 5.43eV (for Si_3N_4) and the degree of disorder decreases.

A significant change in the LPCVD SiO_xN_y thin films was observed only after 120 min of thermally annealing in O_2 and H_2O vapors at1050^{o}C.

As deposited LPCVD SiO_xN_y thin films show a strong photoluminescence (PL) signal at room temperature (RT) in UV-blue spectral range. In Fig. 2 are presented the PL spectra at RT for as-deposited LPCVD $SiO_{0.71}N_{0.83}$ (n_{632nm}=1.74) sample for different excitation energies.

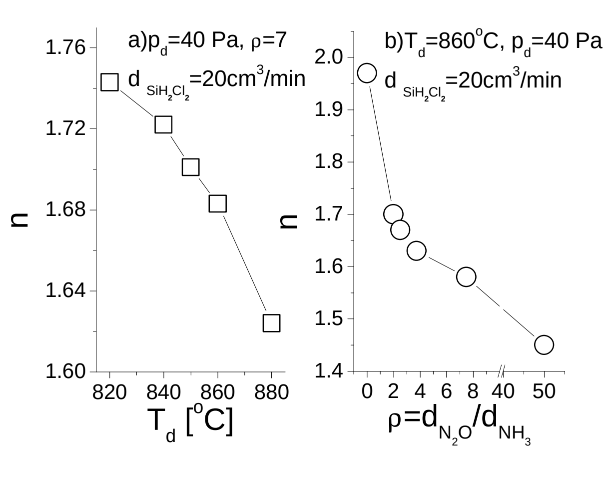

Fig. 1 LPCVD SiO_xN_y thin films refractive index n (at λ=632nm) versus: a) deposition temperature and b) relative gas flow ratio, ρ

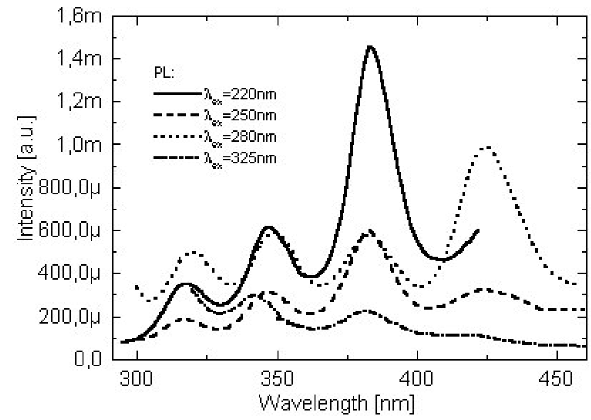

Fig 2. The RT PL spectra, for as-deposited LPCVD $SiO_{0.71}N_{0.83}$ (n_{632nm}=1.74) for different excitation energies

The PL peaks at 380nm and 425nm are resonantly excited with 280nm and 220nm light indicating transition energies of 5.6eV and 4.4eV. The origins of the PL in SiO_xN_y thin films are still under discussion. Different centers ($\equiv Si - Si \equiv ; = Si :$) have been proposed in order to explain the PL results [5].

Several MOEMS applications for LPCVD SiO_xN_y thin films are discussed.

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