ARRANGEMENT OF SILICON AND OXYGEN ATOMS IN LOW PRESSURE CHEMICALLY VAPOR DEPOSITED SiO_2 FILMS BY $SiH_4 - O_2$ AND TEOS CHEMISTRIES: COMPARISON WITH THERMALLY GROWN SiO_2 FILMS.

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Dispersion analysis was performed on Fourier Transform Infrared (FTIR) transmission spectra taken on SiO_2 films chemically vapor deposited on Si (100) substrates from $SiH_4 + O_2$ mixtures at 425 ^oC or from the pyrolysis of tetra-ethyl-orthosilicate (TEOS) vapors at various temperatures between 635 and 710 ^oC. It was found that within the range of 900 to 1400 cm^{-1} these spectra were best described by four Lorentz oscillators located near 1060, 1089, 1165 and 1220 cm^{-1}, contrary to what applies for vitreous silica where the former range is described by two oscillators only. The possibilities that some of these oscillators could be due to the existence of oxygen in the Si substrate or to other SiO_2 phases thermodynamically favorable at higher temperatures were excluded.

Figure 1 shows the transmission spectrum of a TEOS deposited SiO_2 film with thickness equal to 103.9 nm, which was grown at 710 ^oC, 300 mTorr. The analysis of the spectrum is presented in the same figure. The main transmission peak can be analyzed into two Lorentz oscillators, denoted T3 and T4 in the figure. The position of these oscillators can be estimated from the two local maxima of the second derivative (presented in light gray line in Fig.1).

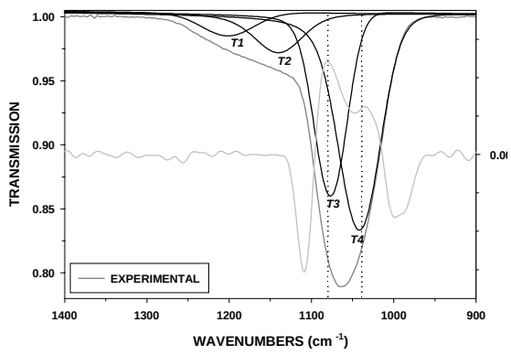

Figure 1: Transmission peak of a TEOS deposited SiO_2 film with thickness equal to 103.9 nm. The peak can be resolved into four Lorentz oscillators named T1, T2, T3 and T4 in the figure. The position of the peaks T3 and T4 can be estimated from the local maxima of the second derivative of transmission (presented in light gray line).

It was found that the Lorentz oscillator located at about 1080 cm^{-1} becomes weaker relative to the oscillator located at about 1060 cm^{-1} as the growth temperature increases or in the case of annealing at higher temperatures. The concentration of the Si – O – Si bridges corresponding to peak T4 over that of the bridges corresponding to peak T3 was found to be equal to about 1.2:1 for the TEOS deposited oxide and increase to 4.35:1 for the thermally grown oxide at 1150 ^oC (figure 2). It was suggested that peak T3 corresponds to Si – O – Si bridges located at the interface with the substrate and the air and also in the case of films with a granular form at the boundaries of the grains.

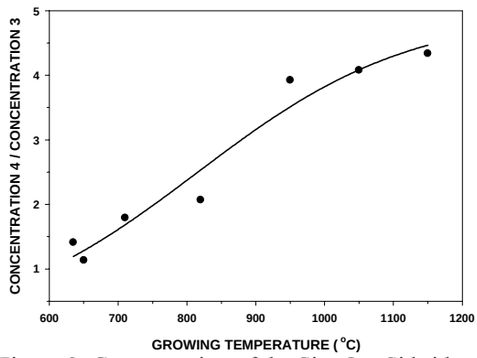

Figure 2: Concentration of the Si – O – Si bridges attributed to peak T4 (concentration 4) over the concentration of the Si – O – Si bridges attributed to peak T3 (concentration 3).

The location of the imaginary part of the dielectric constant (ε_2) was found to be independent of the growth temperature or of the thermal treatment after growth and it depends only on the growth method (figure 3).

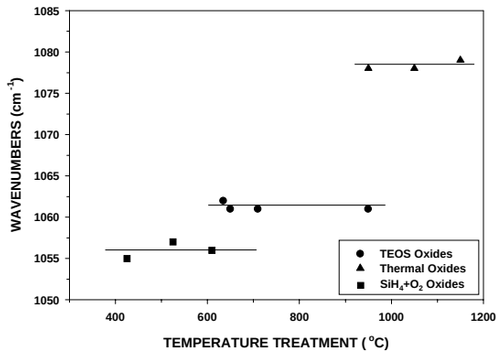

Figure 3: The position of the imaginary part of the dielectric constant (ε_2) in wavenumbers vs. the temperature treatment.