

**Zeitschrift:** Helvetica Physica Acta  
**Band:** 62 (1989)  
**Heft:** 6-7

**Artikel:** Comparative infrared vibrational spectroscopy of chemical vapour deposition Si<sub>2</sub>O<sub>3</sub> films  
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**DOI:** <https://doi.org/10.5169/seals-116075>

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## COMPARATIVE INFRARED VIBRATIONAL SPECTROSCOPY OF CHEMICAL VAPOUR DEPOSITION SiO<sub>2</sub> FILMS

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**Abstract:** We compare FTIR absorbance spectra due to Si-O stretching, Si-O-Si and O-Si-O bendings in different films of amorphous SiO<sub>2</sub>. We study the effect of thermal annealing on these optical structures.

### 1. Introduction

Amorphous SiO<sub>2</sub> is a very important material in semiconductor devices manufacturing. Nevertheless, in spite of its fundamental importance as dielectric film, very few information about optical, dynamical and structural properties of SiO<sub>2</sub> is at present available. In the present work we apply Fourier transform infrared (FTIR) spectroscopy to the study of vibrational properties of Si-O, Si-O-Si and O-Si-O bonds as function of sample preparation: We compare the cases of thermal oxidation, chemical vapour deposition (CVD) from atmospheric pressure (APCVD) or from low-pressure (LPCVD) and plasma activated SiO<sub>2</sub> films [1].

### 2. Results and discussion

Accordingly to the structural description of SiO<sub>2</sub> [2], three different effective oscillators are identified in the FTIR spectra: They correspond to the Si-O bond stretching vibration and to the Si-O-Si and O-Si-O bond bending oscillations. The bond stretching and bending are described by a central two-body potential and by a three-body non central (Keating-like) potential, respectively. Following the current literature, we attribute to the Si-O stretching a frequency of 1050 cm<sup>-1</sup> and to Si-O-Si and O-Si-O bendings a frequency of 450 cm<sup>-1</sup> and 800 cm<sup>-1</sup>, respectively. In Table I we summarize the peak parameters for as deposited and annealed films. F is the wave number peak position (in cm<sup>-1</sup>); H is the peak height (in 10<sup>-3</sup> absorbance units); FWHM is the full width half medium of the absorbance bands (in cm<sup>-1</sup>). The main conclusions we may drawn are that after annealing the 1050 and 450 cm<sup>-1</sup> peaks are

shifted towards higher frequencies, while the O-Si-O peak is lowered in frequency; the FWHM is strongly reduced in any case and the absorption coefficient is always enhanced. In conclusion, the annealing can be regarded as an ordering process which causes a long-range disorder reduction (*i.e.* a recovering of the crystalline character of the sample); moreover, the statistical distribution of lattice parameters (Si-O bond length and Si-O-Si and O-Si-O bond angle) is also reduced and, consequently, FWHM decreases.

Table I

Film type	450 cm <sup>-1</sup> peak			815 cm <sup>-1</sup> peak			1080 cm <sup>-1</sup> peak		
	<i>F</i>	<i>A</i>	FWHM	<i>F</i>	<i>A</i>	FWHM	<i>F</i>	<i>A</i>	FWHM
dry thermal oxide (1100 °C)	459.0	81	41	806.1	23	69	1080	230	77
APCVD (as deposited) (415 °C)	444.5	33	60	810.0	11	81	1059	128	87
APCVD (annealed) (415 °C)	458.0	60	44	812.0	10	63	1076	182	77
LPCVD (as deposited) (425 °C)	447.5	39	60	815.8	9	65	1057	131	87
LPCVD (annealed) (425 °C)	458.0	70	43	810.0	12	65	1078	206	75
PACVD (as deposited) (380 °C)	447.5	37	59	815.8	9	71	1053	130	93
PACVD (annealed) (380 °C)	458.0	64	43	812.0	11	57	1074	187	75

### 3. References

- [1] A. Borghesi, L. Colombo, S. Rojas and Wing S. Wu, *Il Nuovo Cim.* **10D**, 1487 (1989)
- [2] M.E. Striefler and G.R. Barsch, *Phys. Rev.* **B12**, 4553 (1975)