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Twofold SiOx Films deposited by HFCVD: Its Optical, Compositional and Electrical Properties

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Abstract

Twofold non-stoichiometric silicon oxide (SiOx) films before and after of a thermal annealing are characterized by different techniques. The twofold SiOx films are obtained by hot filament chemical vapor deposition technique in the range of temperatures from 900°C to 1150°C. An important result is the optical energy band gap, which decreases as the growth temperature (Tg) increases from 2.15 to 1.8 eV. The absorption and emission properties are correlated with quantum effects in Si-nc and defects.The twofold SiOx films exhibit compositional changes with the variation of Tg and a restructuration (phase separation) take place with the thermal annealing.

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*Keywords:*Silicon oxide; Photoluminescence; Transmittance; Current-Voltage; HFCVD.

1. Introduction

After discovery of visible light emission at room temperature in the porous silicon by Canham [1] in 1990, many investigators have studied emission properties of materials that contain Si nanoparticles (Si-nps) as the non-stoichiometric silicon oxide (SiOx), because of their technological importance and its interesting optoelectronic properties. In the SiOx films the absorption and emission properties are correlated with quantum effects in silicon nanoparticles, and also associated with defects [2]. From the technological standpoint, the average size of silicon nanoparticle (Si-np) offers band gap widths, which opens the possibility to tune the emission of light using nanostructured thin films in novel optoelectronic devices. Thermals annealing are generally used to enhance the

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luminescent properties of the SiOx films. In this work, a study of the optical, compositional and electrical properties of twofold SiOx films obtained by hot filament chemical vapor deposition (HFCVD) technique, before and after of the thermal annealing is reported. Also the behavior of the material by varying the growth temperature, which opens the possibility for proposed novel optoelectronics applications in a future work.

2. Experiment

Simples SiO_x and twofold SiOx films were deposited on quartz and n-type silicon (100) substrates with 1 to 10 Ω-cm resistivity. These films were obtained by HFCVD technique in the range of temperatures from 900 to 1,150°C using quartz bars and porous silicon as the reactive solid sources. The deposition time was 5 min for the simples SiO_x films and of 10 min for the twofold SiOx films due to that the time for each layer was of 5 min. The relationship between the filament temperature (approximately 2,000°C) and the variation of the source-substrate distance (dss) of 4, 5 and 6 mm provides a change in the growth temperature (Tg) of 1,150°C, 1,020°C and 900°C, respectively. The twofold SiOx were made with two films deposited at two different temperatures, obtaining six possible combinations, 1,150°C/1,020°C, 1,150°C/900°C, 1,020°C/1,150°C, 1,020°C/900°C, 900°C/1,150°C and 900°C/1,020°C. The changes in the dss and Tg, consequently, modify the silicon excess and defects in the non-stoichiometric SiOx films. The thermal annealing was made using a nitrogen atmosphere at 1,100°C for one hour. Several spectroscopic characterization techniques were used. The film thickness was measured using a Dektak 150 profilometer. Room-temperature transmittance was measured using a UV-Vis-NIR Cary 5,000 system. FTIR spectroscopy measurements were done using a Bruker system. PL response was measured at room temperature using a Horiba JobinYvon spectrometer. Current-Voltage (I-V) curves were measured using a 4200-SCS Parameter Analyzer.

3. Results

Figure 1a) shows the UV-Vis transmittance spectra of the twofold SiOx films as-grown deposited on quartz. All the samples exhibited a relatively high transmittance (>70%) between 700 and 1000 nm. The change in the growth temperature produces a shift of the absorption edge towards lower wavelength related to a silicon excess change of the material [3]. Figure shows the absorption coefficient (α) of the twofold SiOx films as-grown obtained of the transmittance spectra and thickness (see table 1). The change in the growth temperature produces an increase of α tending to the silicon. The approximate values of the energy band gap (Eg) were obtained by the relationship known as Tauc plot [4] as shown inset Figure 1.The values of the Eg are shown in the table 1.

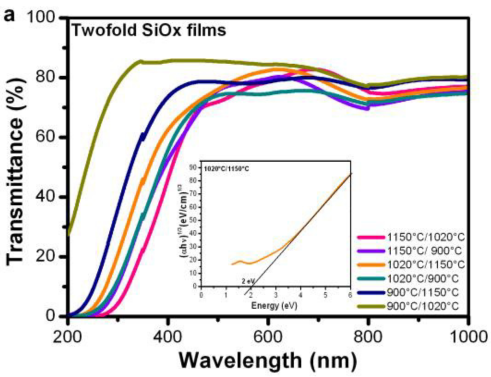

Fig. 1. Absorption coefficient as function of Tg and Eg

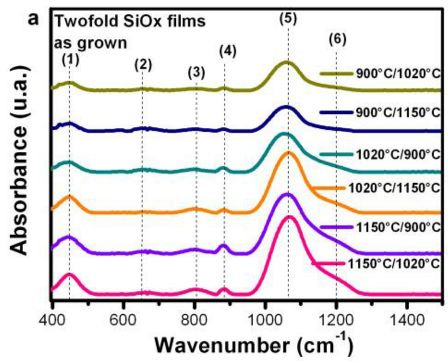

Fig. 2. FTIR spectra from Twofold SiOx films as-grown.