Optical properties of organic material produced in a dusty plasma

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Thin films of organic material produced in a dusty plasma in N_2–CH_4 mixtures are deposited on silicon substrates. The real (n) and imaginary (k) parts of the complex refractive index are determined using the spectroscopic ellipsometry technique in the 370-1000 nm wavelength range. The optical index depend strongly on the methane concentrations: k values decreases with initial CH_4 concentration, while the real optical index (n) increases. Thanks to Mid-infrared spectra recorded for thin films, the larger absorption in the visible range is explained by an increase of the secondary and primary amines signatures.

1- Introduction

Titan the biggest Saturn's satellite, presents a dense atmosphere mainly constituted of N_2 and CH_4. The energetic particles coming from Saturn's magnetosphere and the solar UV radiation dissociate both N_2 and CH_4, allowing a complex chemistry leading to the formation of solid aerosols as a permanent haze around the satellite. These aerosols play an important role in the climate, the composition and the properties of Titan's atmosphere. Models developed to explain the optical properties of Titan's atmosphere require knowledge of optical indices of Titan's haze. As no return sample is planned from Titan's atmosphere at short term, the use of laboratory experiments is of primary importance to produce analogues of Titan's aerosols. In the present work we report optical properties of Titan's aerosols analogues (tholins) produced in CCP RF dusty plasma.

2- Experiment

The CCP RF discharge is described in details in [1]. The plasma is produced between a shower shape electrode and a grounded confining cylindrical metallic grid. Gas mixture from 0 to 10% of CH_4 in N_2 is injected through the polarized electrode. Si substrates (0.5 mm thick and 13mm diameter) are deposited on the grounded electrode. Discharge is running at a pressure of 0.9 mbar during 2 hours in order to obtain a less than 1µm thin film. After tholins film deposition, samples are studied by spectroscopic ellipsometry at atmospheric pressure in order to determine n and k, the real and imaginary parts of their refractive in the 370 - 1000 nm wavelengths range. Spectroscopic Ellipsometry (SE) is an optical technique based on the measurement of the change in polarized light upon light reflection on a sample [2-3]. The ES measured parameters are fitted using the Complete EASE™ Woollam software in order to determine: the thickness d, the non-uniformity, the roughness and the complex refractive index of the organic thin film.

3- Results

Figure 1 shows the values of n and k obtained for films produced at different percentages of injected methane. We observe that k values decrease of one order of magnitude when the concentration of CH_4 increases from 1% to 10%., in agreement with the anti-correlated evolution of the n values.

To strenghthen our discussion on the relationship between the composition of tholins and its optical constants, Mid-infrared spectra were recorded on the DESIRS (Spectroscopy and Microscopy in the Infrared using Synchrotron) beam line of SOLEIL synchrotron radiation facility (France) using a NicPlan microscope coupled to a Nicolet Magna System 560 Fourier Transformed Infra-Red (FTIR) spectrometer with a spectral resolution of 4 cm^{-1} (Fig.2).

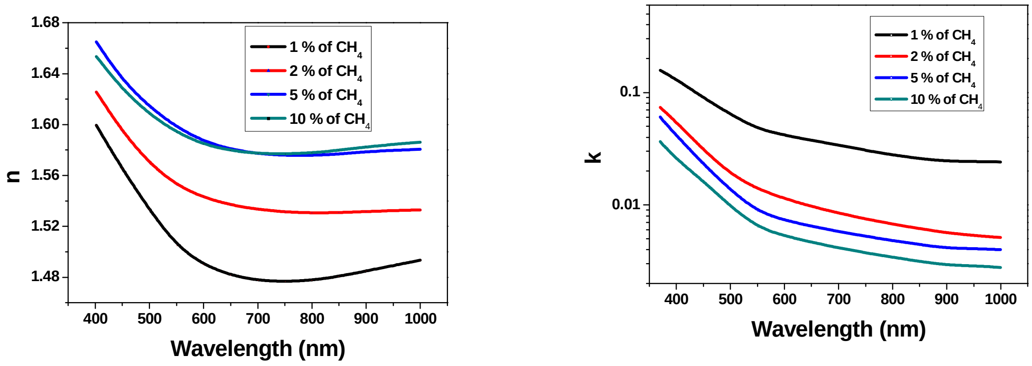

Figure. 1: real (left) and imaginary (right) index of the tholins thin films refractive indices produced with different initial methane concentration.

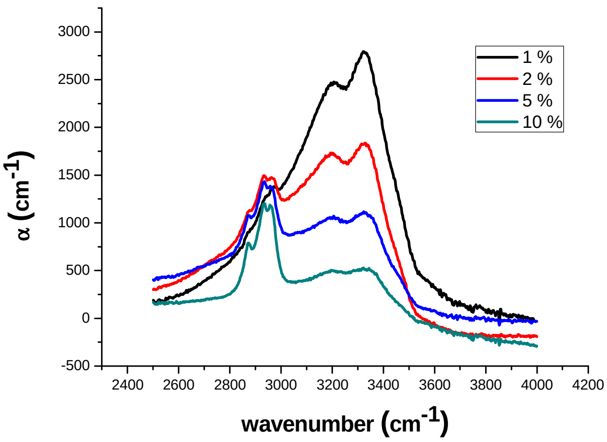

Figure 2: Absorption spectra of organic thin film in the Mid-Infrared for different CH_4 concentrations

Figure 2 shows in all spectra a broad doublet centered at 3205 and 3325 cm^{-1} respectively [4]. These bands are attributed to primary and secondary amines increase. The increase of amount of amines in the organic film when the CH_4 percentage decreases, could explain theobserved increase of k values [5].

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