Dielectric Properties of Magnetron Sputtered PTFE Thin Films

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RF magnetron sputtering was involved for synthesis of polytetrafluorethylene thin films. The process was investigated for various RF applied powers and deposition time. The chemical bonds evidence the typical IR absorption bands for PTFE material, with a tendency towards cross linking due to polymerization of volatile fragments sputtered from the polymeric target. The results show the obtainment of smooth films, without cracks, with dielectric constant similar to that of bulk material and very low values of the dielectric losses over a wide frequency range. Such results indicate that the films can be successfully used in electronic devices.

1. Introduction

Fluorinated polymers have found a broad range of applications as thin films, from hydrophobic and super-slippery surfaces to protective coatings or active layer in sensors. In the present contribution, results on magnetron sputtering of polytetrafluorethylene (PTFE) are presented aiming their use for application in electronic devices.

2. Experimental details

Deposition of thin films was performed by RF magnetron sputtering of a PTFE polymeric target at power level in the range 50 – 110 W, on a working pressure of $6x10^{-3}$ mbar, established under an Ar flow of 100 sccm. The magnetron sputtering source is mounted at 45 degrees in respect to the substrate holder plane and positioned at 6 cm distance from it [1]. Deposition uniformity is insured by rotating the substrate holder at a constant speed of 100 rpm.

The deposition rate was obtained by profilometry measurements for samples obtained upon 10 – 30 minutes exposure. The dielectric function of PTFE deposited on Pt/Silicon substrates was determined in two frequency regime: in the low frequency range (1KHz - 5 MHz) by dielectric spectroscopy and in the optical range (UV-VIS-Near IR) by spectroscopic ellipsometry. Surface topography was investigated by means of Atomic Force Microscopy (AFM) on areas of 5x5 μm^2, while the chemical bonds were revealed by Fourier Transformed Infrared Spectroscopy.

3. Results and conclusions

The deposition process is depending on the applied power onto the magnetron sputtering source, with the deposition rate increasing from 1 nm/min at 50W to almost 7 nm/min at 110 W.

The value of dielectric permittivity was calculated in the plane capacitor approximation and was found to be ε_r~2.8, slightly higher than the expected values. A slight decrease of the dielectric constant is encountered on the entire spectral measured range. The electrical losses are small and had values below $7.5*10^{-3}$. In the optical range (300-1700 nm), the refractive index was n~1.44-1.4, with extinction coefficients k below 10^{-4}.

An important characteristic for the utilization of thin films in electronics is a uniform and crack-free surface. The AFM measurements confirm that the obtained deposited films are extremely smooth, regardless the RF power used for deposition, with typical roughness RMS values below 1 nm for film thickness around 200 nm. The investigation of chemical bonding reveal the typical IR absorptions of PTFE, with bands at 978 cm^{-1} associated to CF_3 and those at 1182 cm^{-1} and 1227 cm^{-1} related to CF_2 vibrations. Nevertheless, the band at 1715 cm^{-1} assigned to $C=CF_2$ or $CF=CF_2$ bonds point out toward the crosslinking structure obtained upon target sputtering.

These results are encouraging for utilization of PTFE thin films in various devices, as example as active layers in SAW based sensors.

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4. References

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