OPTIMIZATION OF PLASMA ENHANCED CVD FROM STANDPOINT OF OPTICAL PROPERTIES OF PROTECTIVE COATINGS ON POLYCARBONATES

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1. Introduction

Polycarbonates are well-known, commercially available materials. Because of their excellent breakage resistance the polycarbonates (PC) have replaced glass in many products, such as automobile headlamps an the like. However, their low hardness, low scratch resistance and degradation by ultra-violet (UV) radiation limited their full utilisation. To remedy this limitation the methods for producing a hard protective layer are applied. Contemporary development is directed to replace the painting technology dangerous for the environment by more ecological one. For this purpose plasma enhanced chemical vapour deposition (PECVD) is often used [1], [2].

We deposited protective layers on PC at the near room temperature by PECVD based on hexamethyldisiloxane (HMDSO) monomer. Silicon oxide films protected PC against mechanical damages [3], [4]. However, as SiO_2 films are fully transparent in the ultraviolet (UV) they could not protect PC against degradation by the UV radiation. Therefore we dealt with the deposition of organic plasma polymers absorbing in the UV as well.

2. Experimental

We deposited films from HMDSO and HMDSO/O_2 mixtures in a parallel plate reactor. The bottom substrate electrode, 410 mm in diameter, was capacitively coupled to an rf generator working on the frequency of 13.56 MHz. The upper showerhead electrode, 400 mm in diameter and 55 mm distant from the bottom one, was grounded. On the bottom electrode a negative self bias was developed due to the asymmetric coupling. Its value could be increased by an additional dc voltage supply. Rf power P was changed from 100 to 450 W. HMDSO flow rate Q_{HMDSO} was kept at 4.0 sccm. The flow rate of oxygen Q_{O2} was varied from 10 to 80 sccm. Dc negative self bias was maximum -150 V. Films were deposited on polycarbonate Lexan LS2 and silicon substrate put on PC.

Films were characterized by the UVISEL Jobin-Yvon phase modulated ellipsometer. The modulated light intensity, I_0, I_s and I_c were measured in the spectral range 240–830 nm at the incidence angles 55^o–75^o by the step of 5^o. The complex reflection coefficients of a measured

system, $\hat{r}_p$ and $\hat{r}_s$, can be expressed as a functions of $I_{0,s,c}$ [5].

The reflection coefficients $\hat{r}_{p,s}$ for a single thin film between semiinfinite media are given by [6]

$$\hat{r}_{p,s} = \frac{\hat{r}_{1p,s} + \hat{r}_{2p,s}e^{-i\hat{x}}}{1 + \hat{r}_{1p,s}\hat{r}_{2p,s}e^{-i\hat{x}}} \tag{1}$$

The Fresnel coefficients $\hat{r}_{1p,s}$, $\hat{r}_{2p,s}$, and the phase difference $\hat{x}$ are the functions of the film refractive and absorption indices n, k, the film thickness d and optical parameters of the substrate. We used the model of a single homogeneous film to calculate the film optical parameters. In the whole range, they could be described by simple analytical formulae:

$$n = a + b/\lambda^2 + c/\lambda^4, \qquad k = \alpha.e^{-\beta\lambda} \tag{2}$$

where λ is the wavelength.

3. Results and Discussion

We observed the deposition uniformity of two order better than for the gas supply from the center of the bottom electrode. Within the distance of 4 cm any change of the film thickness was not observed. The uniformity in the film refractive index was even better.

Films deposited from pure HMDSO show the pronounced influence of the dc negative bias voltage on their optical properties in the UV-VIS range (see Figure 1). Refractive indices increase with the dc bias in the whole spectral range. Absorption indices steeply increase in the UV range for the higher dc voltages. This effect could be utilized to deposit films protecting PC against the UV radiation. Films deposited from HMDSO/O_2 mixtures are nonabsorbing even for the highest rf power or bias voltage. For smaller ones their refractive indices are below the values tabulated for SiO_2 bulk material probably due to lower film densities. For higher power or dc bias, n achieves or exceeds SiO_2 values.

In contrast to the HMDSO/O_2 feeds, the deposition rate of films from pure HMDSO depends linearly on the rf power (see Figure 2). At lower rf power the deposition rate increases with an increasing oxygen flow rate. We expect that chemical reactions with non-completely dissociated monomer prevaile in the film deposition. On the other hand the deposition rate for 450 W is higher for pure HMDSO feeds and does not depend on the flow rate of added oxygen. In this case the organics parts of monomer are oxidized, pumped out and therefore lost for the deposition.

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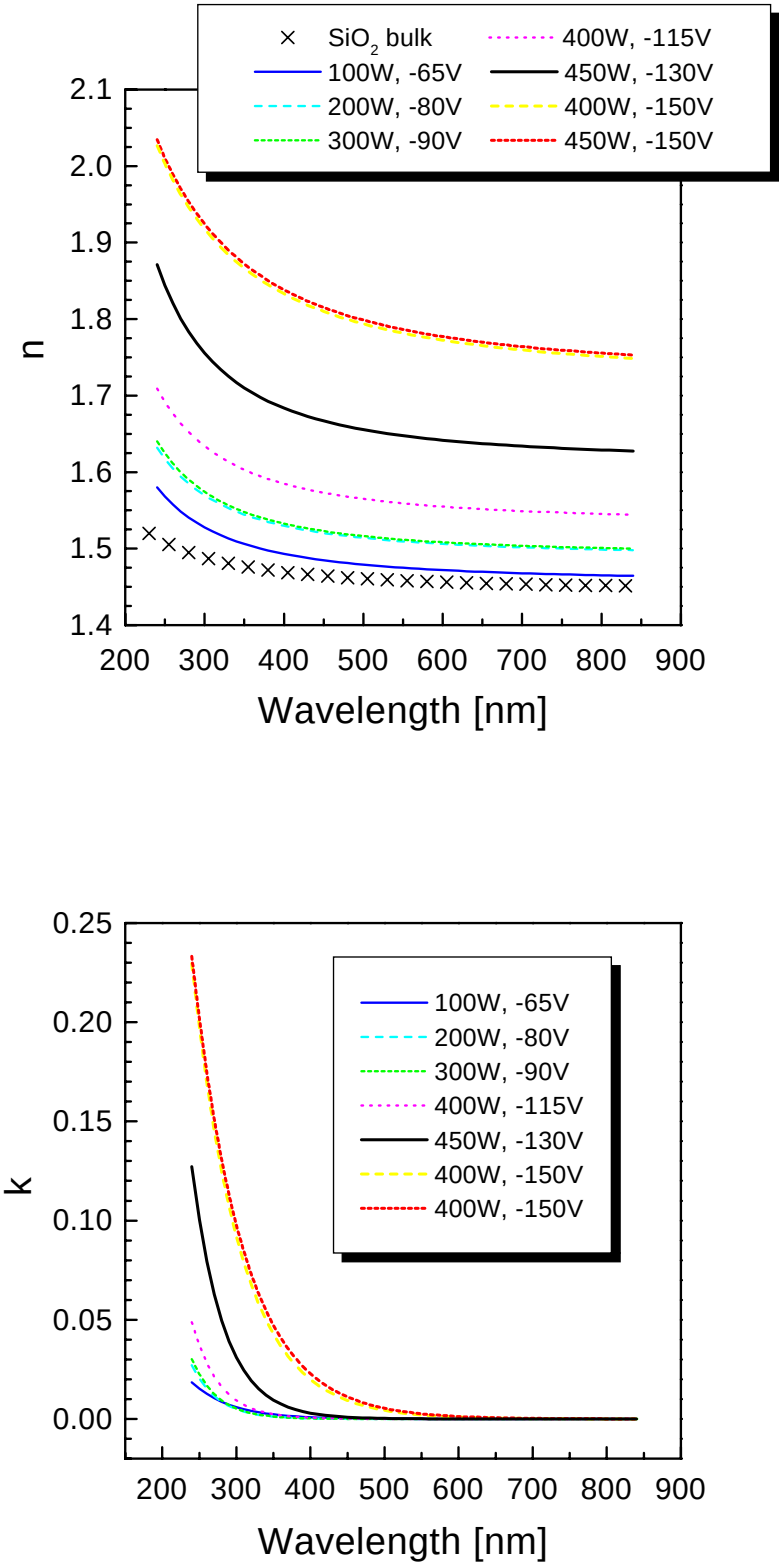

Fig. 1: Dispersion of refractive and absorption indices n and k, respectively of films deposited from pure HMDSO (Q_{HMDSO} = 4.0 sccm, p = 1.2 Pa) as a function of negative bias voltage.

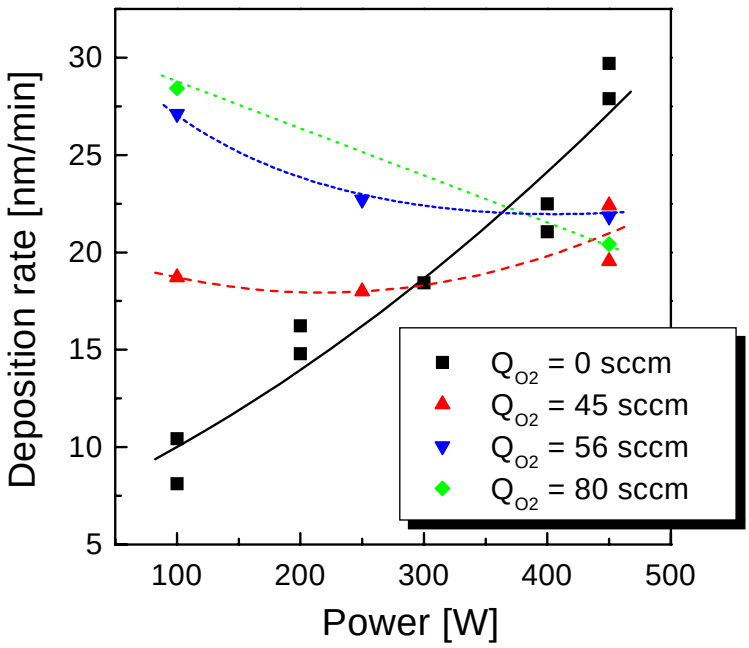

Fig. 2: Influence of rf power on deposition rate of films deposited from HMDSO/O_2 mixtures (Q_{HMDSO} = 4.0 sccm). voltage.

References

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