INTERACTION BETWEEN ACTIVE PLASMA AND GROWING Co-C-O – LAYER DURING PACVD

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Transport and chemical rate phenomena are analysed for Co-C-O-layers generated on steel C35 from cobalt(II) acetylacetonate by PACVD. The investigations are carried out in a parallel plate reactor, under the high frequency (13.56 MHz) plasma, with low ionization (ionization degree 10^{-7}-10^{-6}, electron temperature 5 eV, electron density 0.6 10^{15} to 1.8 10^{15} m^{-3}) and at the pressure of 100 – 400 Pa, see Figure 1.

Deposition rate phenomena are esimated according to the semi-theoretical concept based on laminar boundary layer theory. On the other side, in active plasma, the concept of steady state diffusion with concentration source/sink is used to substitute the net deviation of characteristic concentration flow in plasma above the substrate.

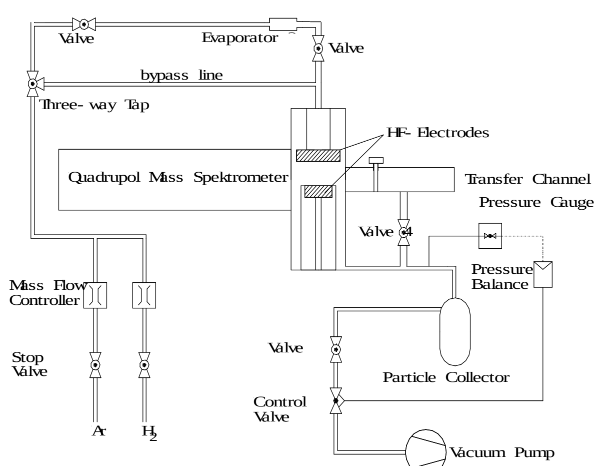

Fig. 1. PACVD equipment

Table 1 Calculated values

	523 K	623 K	723 K
Re	1.89	1.67	1.50
Sc	1.12	1.16	1.18
Sh	1.42	1.36	1.29
δ_v, (mm)	35.6	37.9	40.0
δ_c, (mm)	34.3	36.0	38.0
D_{100Pa} (m^2/s)	6.73 10^{-2}	8.86 10^{-2}	11.1 10^{-2}
D_{200Pa} (m^2/s)	3.36 10^{-2}	4.43 10^{-2}	5.55 10^{-2}
D_{400Pa} (m^2/s)	1.68 10^{-2}	2.21 10^{-2}	2.77 10^{-2}
$D_{10^5 Pa}$ (m^2/s)	6.73 10^{-5}	8.86 10^{-5}	11.1 10^{-5}
β_{100Pa} (m/s)	1.27	1.60	1.90
β_{200Pa} (m/s)	0.63	0.80	0.95
β_{400Pa} (m/s)	0.31	0.40	0.47
$\beta_{10^5 Pa}$ (m^2/s)	1.27 10^{-3}	1.60 10^{-3}	1.90 10^{-3}

In the system Co-C-O the deposition is strongly influenced by a particle formation in the gas phase. Inspite of the vacuum sealed equipment the layers always contain oxygen. Therefore the oxygen comes from the precursor compounds. The deposition temperature is rather low, the maximum temperature is 750 K. Because of these reasons, the PACVD deposition of Co- C-O layers is discussed in the light of transport and chemical rate phenomena at low preassures with plasma activated chemical reactions in gas phase.

MODELING About the semi-theoretical approach based on laminar boundary layer theory see (8-10). According to balance equation, referent situation, simplified analysis of Frank-Kameneskii (13) and the model of mass transfer coefficient (β), Table 1, one can obtained deposition rate r (Table 2.)

$$\mathbf{j = \beta\theta^{III}\Delta C / [1 + (z\Phi)^{-1}] = (\rho/M) d\delta_f/dt} \quad \text{or}$$

$$\mathbf{r = d\delta_f/dt = (M/\rho)\beta\theta^{III}\Delta C / [1 + (z\Phi)^{-1}]}$$

where: $\Phi = [1 - (\pm f(m)_\upsilon \pm f(m)_D \pm FG_H)/N_\upsilon]$, numerical value of real conditions, $z = k(s)/\beta$, ρ: the density of Co, M: the mass of Co per molecule and θ^{III} : normalized deviation, derivated from the concept of steady state diffusion with concentration source/sink in surrounding plasma (14).

Table 2. Values for ΔC and (r)

mol/m^3 ($mol/m^2 s$)	523 K	623 K	723 K
ΔC_{100Pa} 10^{-6} (r 10^{-6})	3.1 (≈4.0)	4.3 (≈7.0)	4.7 (≈9.0)
ΔC_{200Pa} 10^{-6} (r 10^{-6})	12.7 (≈8.0)	11.2 (≈9.0)	12.7 (≈12.0)
ΔC_{400Pa} 10^{-6} (r 10^{-6})	11.1 (≈3.5)	13.7 (≈5.5)	21.0 (≈10.0)

The presented procedure is imagined as a flexible iterative system for the following experimental data. This model can be used as a tool in computer-aided process optimization, too.

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