OR2006

Stability of plasma polymers produced by opening of ring compounds

Bentsian Elkin, Christian Oehr, Jakob Barz, Michael Haupt

Fraunhofer Institute IGB, Stuttgart, Germany

bentsian.elkin@igb.fraunhofer.de

Opening of ring compounds in plasma is a way to produce plasma polymers possessing chemical functions, which were not present in the parent compound [1]. In this way it is possible to produce plasma polymer with hydroxyl functionality from cyclic ethers, e.g. tetrahydrofuran; with thiol functionality from tetrahydrothiophene; with amine functionality from cyclic secondary amines, e.g. pyrrolidine; and with aldehyde functionality from cyclic ketones, e.g. cyclopentanone. In each case, the desired functional group is produced by ring opening in the vicinity of the functional precursor in the plasma, followed by saturation of the radical generated in this way by a hydrogen atom. We opted for 5-member rings due to the easy availability of the precursor compounds, their suitable vapor pressure, and favorable ratio of the functionalities to "bulk". The plasma polymers were produced by RF plasma at relatively high power density of approx. 0.2 W/cm^2. The deposits were highly adhering and highly stable, with deposition rates of about 25 nm/min. The presence, chemical availability, and concentration of the corresponding functional groups were proved by FTIR spectroscopy, by XPS, and by derivatization. The stability on different substrates was tested by prolonged immersion into a range of solvents as well as water buffers at different pH values.An important factor influencing chemical stability of plasma polymers is presence of radicals produced in the process of deposition. We measured the radical densities and their change over time using ESR. The initial number of radicals after deposition was shown to be approximately proportional to the layer thickness, with relatively low initial spin density of (5..10).10^{17}cm^{-3}. The concentration change with time for all deposits can be well described by formula $C = A_1\exp(-t/\tau_1) + A_2\exp(-t/\tau_2) + C_0$, with τ_1 of around 50 min, and τ_2 of 400..800 min.

[1] B. Elkin, M. Mueller, and C. Oehr. DE 102004057155 B4; WO2006056390 A1 (2006).

Keywords
plasma polymerization
film stability
ESR
ring opening