Absorption spectroscopy measurements of atomic and molecular carbon population densities in an expanding thermal arc plasma

ABSORPTION SPECTROSCOPY MEASUREMENTS OF ATOMIC AND MOLECULAR CARBON POPULATION DENSITIES IN AN EXPANDING THERMAL ARC PLASMA

D.K. Otorbaev, A.J.M. Buuron, J.W.A.M. Gielen, M.C.M. van de Sanden,

and D.C. Schram

Department of Physics, Eindhoven University of Technology,

P.O. Box 513, 5600 MB Eindhoven, The Netherlands

Absolute population densities of argon and atomic and molecular carbon are determined using the method of reabsorption in the expanding thermal arc plasma during the deposition of a-C:H coatings. The reactor conditions under which the experiments have been performed were the following: background pressure 20 - 200 Pa, argon flow rate 58 - 116 scc/s, arc current 45 A, arc voltage 70 - 80 V, hydrocarbons (CH_4 or C_2H_2) with a flow rate of 3 - 6 scc/s were injected either into the nozzle of the arc, or directly into the vessel.

Depending on the gas mixture argon - methane/acetylene, and the hydrocarbon injection (downstream or in the nozzle), the stationary positive or negative absorption between the quantum states of $Ar(3p^5 4p \rightarrow 3p^5 4s)(\lambda = 696.5$ nm), $C(2p^2 3s \rightarrow 2p^2 1s)(\lambda = 247.9$ nm) and $C_2(d^3\Pi_g, v' = 0 \rightarrow a^3\Pi_u, v'' = 0)$ (band head at $\lambda = 516.5$ nm) are determined. From this absorption the absolute population densities of the radicals in the plasmas are obtained. Depending on the plasma conditions the density of the argon first excited state $Ar(3p^5 4s, {}^3P_2)$ was $\simeq 10^{16} - 10^{17}$ m^{-3}, whereas the atomic and molecular carbon densities were of the order of $10^{18} - 10^{19}$ m^{-3}. Possible implications for the deposition of a-C:H coatings and the role of C_2 in the deposition mechanism are discussed.