

Plasma Enhanced Chemical Vapor Deposition of Organic Polymers

by

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Abstract

Chemical Vapor Deposition (CVD) with its plasma-enhanced variation (PECVD) is a mighty instrument in the toolbox of surface refinement to cover it with a layer with very even thickness. Remarkable the lateral and vertical conformity which is second to none. Originating from the evaporation of elements, this was soon applied to deposit compound layers by simultaneous evaporation of two or three elemental sources and today, CVD is rather applied for vaporous reactants, whereas the evaporation of solid sources has almost completely shifted to epitaxial processes with even lower deposition rates but growth which is adapted to the crystalline substrate. CVD means first breaking of chemical bonds which is followed by an atomic reorientation. As result, a new compound has been generated. Breaking of bonds requires energy, i.e., heat. Therefore, it was a giant step forward to use plasmas for this rate-limiting step. In most cases, the maximum temperature could be significantly reduced, and eventually, also organic compounds moved into the preparative focus. Even molecules with saturated bonds (CH₄) were subjected to plasmas—and the result was diamond! In this article, some of these strategies are portrayed. One issue is the variety of reaction paths which can happen in a low-pressure plasma. It can act as a source for deposition and etching which turn out to be two sides of the same medal. Therefore, the view is directed to the reasons for this behavior. The advantages and disadvantages of three of the widest-spread types, namely microwave-driven plasmas and the two types of radio frequency-driven plasmas denoted **Capacitively-Coupled Plasmas (CCPs)** and **Inductively-Coupled Plasmas (ICPs)** are described. The view is also directed towards the surface analytics of the deposited layers—a very delicate issue because carbon is the most prominent atom to form multiple bonds and branched polymers which causes multifold reaction paths in almost all cases. Purification of a mixture of volatile compounds is not at all an easy task, but it is impossible for solids. Therefore, the characterization of the film properties is often more orientated towards typical surface properties, e.g., hydrophobicity, or dielectric strength instead of chemical parameters, e.g., certain spectra which characterize the purity (infrared or Raman). Besides diamond and **Carbon Nano Tubes, CNTs**, one of the polymers which exhibit an almost threadlike character is poly-*p*-xylylene, commercially denoted parylene, which has turned out a film with outstanding properties when compared to other synthetics. Therefore, CVD deposition of parylene is making inroads in several technical fields. Even applications demanding tight requirements on coating quality, like gate dielectrics for semiconductor industry and semi-permeable layers for drug eluting implants in medical science, are coming within its purview. Plasma-enhancement of chemical vapor deposition has opened the window for coatings with remarkable surface qualities. In the case of diamond and CNTs, their purity can be proven by spectroscopic methods. In all the other cases, quantitative measurements of other parameters of bulk or surface parameters, resp., are more appropriate to describe and to evaluate the quality of the coatings.

Keywords: plasma enhanced chemical vapor deposition; organic layers; parylene; diamond-like coatings; carbon nanotubes; superhydrophobicity; functionalization of surfaces

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