NANO-Textured Functional Layers for Sustainable Products

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Abstract: The versatile role of nano-textured layers and their advanced performances have been elucidated in selected R&D projects. The aim was to overcome the limitation of conventional thin films due to micro defects like pinholes and scratches by nano-texturing the functional layers. Our concept allows the development of highly effective diffusion barrier layers for reactive gases in order to prevent their loss to the environment during storage. A second application describes the nanoactive corrosion protection for metallic products due to the combination of a passive physical barrier consisting of a highly cross-linked hydrocarbon layer and the adjustment of the electro-chemical potential by incorporating metallic clusters. Tiny amounts of added metals like zinc substitute toxic metals used for conventional corrosion protection so far which enables a management of sustainable materials.

Keywords: Corrosion protection · Diffusion barrier layers · Hydrogen storage · Nanotechnology

1. Introduction

Thin films that provide the underlying material with specific mechanical, physical, and optical properties, such as wear-resistant coatings for tools and light-reflecting metallic surfaces can be used in a wide range of applications. In general, the properties of the thin films meet the product specifications and their inherent defects do not affect the performances in these protective or decorative application fields. However, tiny holes or scratches in the thin films can lead to a complete breakdown of the layer protection if a chemical reaction takes place at the interface.

If the substrate needs to be entirely protected by a layer, the coverage of the thin films has to be provided under perfect conditions, such as avoiding the generation of dust in a ‘clean room’. Another way is to inactivate the layer defects by a functional property of the layer itself.

In general, the aim of our research field is to combine the specific properties of a particular coating with the physical or chemical potential of a second material in order to enhance the properties and durability of the thin films. As a result, multifunctional coatings are obtained in which at least one function is adjusted to compensate the destructive impact of the micro defects in the coating. A positive side effect of the development of highly effective plasma-polymerized layers is the consequent development of sustainable products by the selection of an environmentally harmless basic material followed by surface treatment in well-defined closed systems. Several patent applications have been submitted to protect the production of the functional layer systems described in this article [1].

Hitherto, incorporated particles in conventional polymeric materials were, for example, widely used as scavengers for oxygen gas in packaging. On the other hand, plasma-polymerized thin films are of increasing importance in the field of transparent packaging. In particular, plasma-polymerized amorphous hydrocarbon coatings (a-C:H) proved to exhibit excellent diffusion barrier properties for gases and water vapor [2]. The incorporation of particles into hydrocarbon layers has been adapted for the high pressure CNG (compressed natural gas) vessel project [3] together with the concept of highly effective diffusion barrier systems which provide long-term storage for hydrogen gas. The non-linear relationship of a dense and elastic barrier layer forces the generation of multilayers containing varying amounts of metallic species to adsorb hydrogen gas at higher pressures. In that way, the functional layers ‘blow up’ and build up an intrinsic pressure that is able to withstand the high pressure inside the vessel to a certain extent. In particular, the creation of nano-textured functional layers enables their performance to be tailored to the desired product specification.

Another promising application is the development of active corrosion protective coatings based on metal-doped amorphous hydrocarbon thin films (Me-a-C:H). The basis for the nanoactive concept is provid-