Properties and benefits of combining chemical, electrochemical and physical deposition methods

Prof. dr. Bojan Podgornik[1] and Dr. Orlaw Massler[2]

[1]Institute of Metalls and Technology, SI-1000 Ljubljana (bojan.podgornik@imt.si)
[2]De Martin AG Surface Technology, CH-9545 Wängi (o.massler@demartin.com)

Abstract

Designers and engineers of modern machines and components are under extreme pressure to meet the legislative demands for producing environmentally friendly lightweight solutions, which are cost effective, safe and satisfy all customer demands. This is the most evident in the automotive and aerospace industry. The factors for the development of modern cars, trucks and airplanes involve environmental protection, resource utilization, economy, customer satisfaction, etc. These challenges are directly related to the improvement of durability and fuel economy that principally depend on the reduction of friction losses, improved wear and corrosion resistance and components weight reduction. These can be achieved by the utilization of wear resistant low friction surfaces as well as by the use of low-weight materials.

In the last decades, a tremendous progress has been made in the field of hard coatings and surface treatments. However, the majority of research work refers to thin hard coatings, which in most cases are deposited on "hard" substrates, i.e. ceramics and tool steels, and used in cutting tool applications. On the other hand, requirements for machine components are quite different from those for tools. In addition to a hard, wear resistant surface with good frictional characteristics, a tough, lightweight, and corrosion and fatigue resistant bulk is necessary. Weight reduction is most commonly achieved by introducing machine elements made of light metals. However, the light metal alloys display low hardness and elastic modulus, and besides having a high tendency to stick to the counter-surface in sliding contact they show low load carrying capacity. In terms of corrosion and wear resistance, the most conventional way of improving wear and corrosion resistance of machine components made from light metal alloys and low alloy steels is by galvanic coating (i.e. electro-less nickel, hard chrome, etc.). Nevertheless, besides not being the most environmentally friendly, galvanic coatings also lack diversity in terms of composition as well as range of available properties. On the other hand, physical vapor deposition (PVD) and plasma-assisted chemical vapor deposition (PACVD) techniques can provide not only metallic, but also alloyed, ceramic and diamond like carbon (DLC) coatings with a virtually unlimited range of chemical composition and properties. However, in the case of PVD and PACVD coatings we are faced with limitations in terms of coating adhesion and coating thickness. Typical PVD and PACVD coatings are only few µm thick and very brittle, thus not suitable for highly loaded components where large base material deformations will lead to coating cracking.

The obvious solution although not being very effectively executed is by combining different coating technologies and substrate pretreatments in a system, with emphasized benefits and eliminated deficiencies. The most effective is to divide bulk and surface requirements of a tool or component and implement the surface functionality already in the design phase, with the bulk properties achieved through proper heat or thermo-mechanical treatment, load-carrying capacity and corrosion resistance through intermediate galvanic coating deposition and final wear and low friction performance by thin hard PVD or PACVD top coating. In the talk, benefits and limitations of each individual technique will be presented, and possibilities for their effective combination including synergistic effects when preparing hybrid coatings explained on practical examples.