PECVD and characterisation of Si-C film systems for wear-resistant applications

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1. Motivation

Today many applications in the range of wear-protection demand high toughness and durability of the utilized components. In this context thin films play an important role, because such coatings are able to supplement the properties of a material on the surface and so broaden the range of uses decisively. Among other things this is highly interesting in the medical sector, where the quality requirements are exceedingly challenging.

Since diamond-like carbon (DLC) is characterised by high hardness and low friction, it is the material of choice to improve wear-sensitive surfaces. Moreover it possesses good abrasion- and corrosion-resistance as well as chemical inertness. Due to the biocompatibility it is promising to use it in medical applications like the coating of implants or medical tools.

A difficulty is the lack of adhesion of DLC on most metallic surfaces. This is due to poor chemical binding between a-C:H and metals or high internal stresses inside the DLC film itself. This easily leads to flankings in the film and therefore to the loss of the films' qualities.

We will present a new technique to conquer these limitations by changing the composition of our film systems, to reduce stresses and enhance the bonding-qualities of the DLC coating.

2. Experiment

One promising technique to overcome the problems is the deposition of a very thin interface layer between the metal and the DLC film. Such an interface can replace weak coating/substrate bonds with strong substrate/interface-layer and interface-layer/coating bonds. Another positive effect of the interface layer can be the reduction of internal stresses in the interface.

In the present work hydrogenated amorphous silicon (a-Si:H) was used for this intermediate layer. The silicon forms stable silicide-bonds with the metal surface on the one hand, and binds also the DLC coating by the formation of strong covalent bonds between silicon and carbon on the other hand.

To deposit these films the plasma enhanced chemical vapor deposition (PECVD) process was chosen. The film deposition with plasma supported methods like PECVD offers a wide range of variables to variegate the structural and mechanical properties as well as the possibility to influence the interface-profile of the intermediate layer.

The described film systems are optimised for the use on nickel-titanium alloys to gain new solutions for the surface-treatment e.g. of medical implants.

One current focus of interest for example is the shape of the interface between the intermediate layer and the functional DLC coating. By introducing a gradual transition from a-Si:H to a-C:H e.g. it was possible to further enhance the adhesion and relax internal stresses in the interface.

3. Diagnostics

All films have been analyzed by a variety of diagnostics to examine their properties in dependence of the deposition conditions. Fundamental techniques for the characterization of the investigated films are diagnostics like ellipsometry, RBS and measurements of the intrinsic stresses as well as methods to investigate the wear resistance of the film systems. Important for us are primarily scratch tests, cavitation erosion and measurements of the films ductility.

4. References