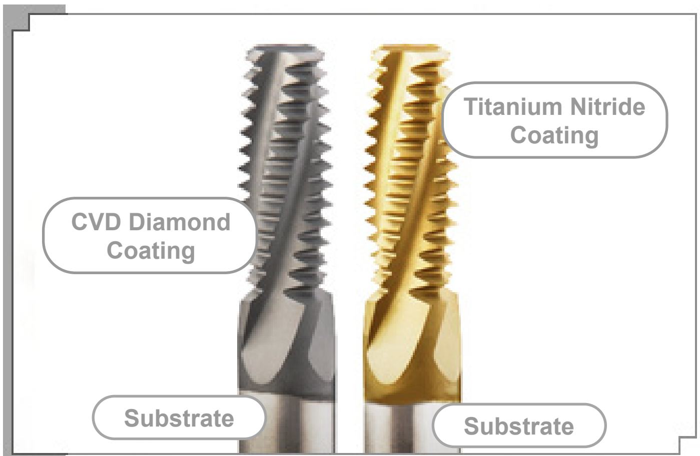
Application Note

PVD/CVD hard coatings for anti-wear tools and components development

MCQ Gas Blender 100 Series CVD-related Application

Introduction

Tools and machinery components are the key instruments of every industrial production. During their working lifetime, tools and components are subjected to intensive degradation due to the combined erosive and abrasive wear and due to the corrosive attack of agents. This degradation shortens the instruments lifetime with a direct impact on process productivity. For an industrial country the costs related to the maintenance/substitution of tools and components can reach 4% of Gross Internal Product (GIP). For all these reasons it is fundamental to enhance instruments lifetime and consequently the productivity. The commonly used solution to enhance tools and components performances is the application of protective hard coatings. The substrate of hard coated tools and components is protected by a thin film (generally few micrometers thick) of hard materials whose main features are high hardness and chemical inertness. Brittle and expensive, these hard protective coatings are usually inappropriate for bulk tool material but turn to be extremely effective for thin films applications. Hard coatings are applied to substrates through Physical Vapor Deposition (PVD) and Chemical Vapor Deposition (CVD). Both these techniques share the need of a highly accurate and controlled gas mixture in order to obtain the desired results. The MCQ solves this need with its Gas Blender 100 Series, a professional instrument for precision gas mixtures preparations and dynamic gas mixtures management.



Appearance of drills with different coatings.

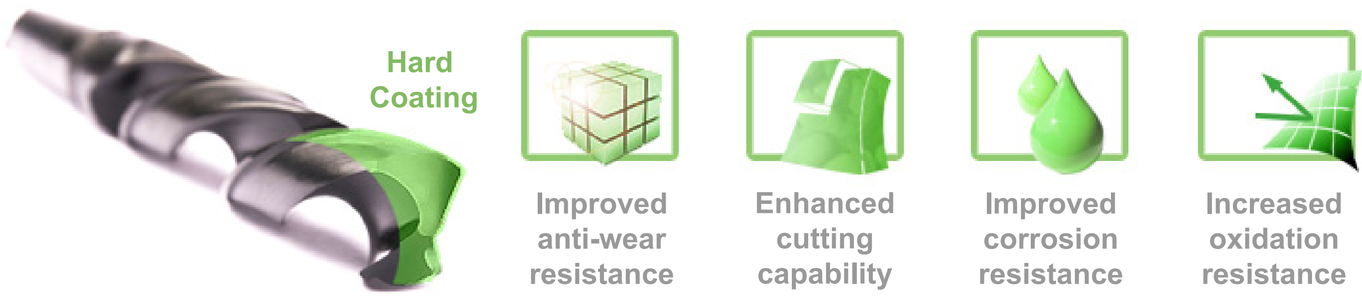
Material choice

All the tools and the machinery components are subjected to wear. Hard protective coatings have been specifically implemented to reduce wear and therefore increasing the instruments lifetime. For each process there are different types of wear mechanisms the tools are subjected to (e.g. abrasion, adhesion, corrosion, high temperature, material sticking etc.). Therefore, in order to choose the most suitable coating material, it is very important to know which mechanism has the highest contribution to wear. Currently there are two material families capable of fulfilling the majority of the industrial process needs: the ceramic materials and the CVD synthetic diamond.

- Ceramic Materials

Ceramic materials is a generic term that refers to a large family of compounds, characterized by high hardness and chemical inertness. The main compounds used for hard coatings applications are nitrides and carbides of transition metals, especially titanium (Ti), chromium (Cr) and zirconium (Zr). These types of hard coatings are not only suitable for anti-wear applications. Each compound has peculiar features that contribute to enhance the material utility. Titanium nitride (TiN) coatings greatly enhance the substrates wear and corrosion resistance but they are also

The main advantages of hard coating deposition for tools and anti-wear components.



used for medical implants applications (due to their non-toxic nature) and for decorative purposes (due to the TiN gold appearance). Titanium carbide (TiC) and chromium nitride (CrN) are especially suitable for corrosion and oxidation protective coatings while zirconium nitride (ZrN) is ofter used for its refractoriness properties.

- CVD Diamond

Tools with natural or synthetic diamond inserts are widely used for industrial applications, especially in processes which no other instrument is capable of providing satisfactory results. These tools are especially suitable for the processing of non ferrous metals, ceramic materials and plastics. Despite their good performances, tools with diamond inserts tend to be expansive, often inadequate for large scale production purposes. During the last two decades, modern science has faced this problem with the development of Chemical Vapour Deposition Diamond (CVD Diamond). Instead of a small diamond inserts, this techniques offers the possibility to produce tools and components that are completely covered by an homogeneous thin film of synthetic diamond. Compared with the fabrication of diamond inserts, the production of diamond coated instruments has many advantages. Costs, since the deposition process is relatively cheap. Versatility, since diamond films can be virtually deposited onto any inorganic substrate with any complex geometry. Efficiency, since diamond chemical and physical properties are transferred onto the substrate, modifying only the instrument surface properties and consequently increasing its wear resistance, cutting capacity, hardness, chemical inertness etc. CVD diamond tools are especially suitable for processing graphite, composite materials (carbon fibers and fiberglasses), green ceramics and copper and aluminium alloys, while CVD diamond coated components are mainly used for anti-wear applications.

A decorative application of Titanium Nitride.

Gas Phase and Deposition Process

Hard coatings depositions are performed through PVD and CVD processes. Cathodic Arc Deposition (Arc-PVD), Sputtering deposition (PVD sputtering) and all the CVD-related techniques require the use of a gas mixture containing the gaseous precursors for the deposition reaction. Scientific community works nowadays to constantly development new and more effective hard coatings, managing and changing the deposition parameters in order to optimized processes and results. Among all the deposition parameters (length, temperature, pressure, etc.), a fundamental role is lead by the gas phase composition. For ceramic material applications, the gas mixture settings can be adjusted in order to modulate the final outcome. Different gas mixture compositions allow to produce ceramic coatings with specific chemical-physical

The MCQ Gas Blender 100 Series

properties [1-3], while a dynamic management of the gas phase can be used to deposit high-performance multilayered coatings [4]. For CVD diamond applications, managing the gas phase is crucial. The gas phase is commonly composed by a hydrogen/methane mixture, with hydrogen as activation gas and methane as carbon source. Concentration of carbon-containing species has significant influence on growth rate, quality and morphology of deposited diamond [5-7]. Small changes in the gas mixture composition can affect the diamond film structure, leading to the formation of micro-, nano- or ultranano-diamond [8]. The use of other gas species has also a strong dependence on the final product. The significant effects of addition of nitrogen [9], oxygen [10] and carbon dioxide [11] on deposited diamond films have been well studied.

• MCQ solution

For all these applications, MCQ suggests the use of its Gas Blender 100 Series, the ideal instrument for precision gas mixtures preparations and dynamic gas mixtures applications. The Gas Blender 100 Series is a professional product specifically engineered to work with three components non-aggressive gas mixtures. MCQ calibrates each channel of the instrument on customer request. The Gas Blender 100 Series main features are a high precision (1% accuracy for each channel), a high repeatability (0,16% of reading value) and the fastest response time for setpoint value changes (50 ms) available on the market. Bundled with the instrument the MCQ provides the Gas Mixer Manager, a software (compatible with any Windows-operating desktop and laptop personal computer) that ensures an easy and intuitive way to manage mixtures dynamically.

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