

Nanoscale Multilayer PVD Coatings Deposited by the HIPIMS/UBM Technology Dedicated to Aerospace, Automotive and Biomedical applications.

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The paper discusses advanced nanoscale multilayer PVD coatings dedicated to serve applications in aerospace automotive and medical industries. In all these sectors the demand for coatings for protection of special grades of automotive or aerospace alloys against environmental attack as well as the demand for dry high speed machining of both very hard or very soft often called "sticky" materials is ever growing.

CrAlYN/CrN coatings utilising a nanoscale multilayer structure with a typical bi-layer thickness of 4.2nm have been developed to protect light-weight Ti-45Al-8Nb alloys known as γ -TiAl against wear and aggressive environmental attack at high temperatures. Thermo gravimetric quasi-isothermal oxidation tests carried out in air at 850°C revealed that after 1000 hours exposure CrAlYN/CrN coated γ -TiAl alloys showed four times smaller weight gain compared to the uncoated material. In sulphidation tests after 1000 hours exposure to aggressive H₂/H₂S/H₂O atmosphere the CrAlYN/CrN protected γ -TiAl alloys showed reduced weigh gain by factor of four as compared to the uncoated substrate. High temperature pin-on-disc tests revealed that the friction coefficient is temperature dependent. However, unlike most of the nitride PVD coatings, which tend to increase their friction coefficient with temperature, CrAlYN/CrN reduces its friction coefficient from 0.56 at room temperature to 0.4 at 650°C, which demonstrates the excellent high temperature tribological behaviour of the coating.

Aluminium, titanium and nickel based alloys are widely used in aerospace, automotive and medical applications. These materials are relatively soft compared to hardened steels for example but metallurgically very reactive, which leads to fast build-up edge (BUE) formation during cutting and therefore short tool life and poor surface finish. Recently both aerospace and automotive industries are attempting lower costs by lower fuel consumption achieved by the introduction of a new generation of lightweight materials such as the metal matrix composites (MMC), combining light-metal matrix and reinforcement, (Si, SiC and B₄C particles or Al₂O₃ and C- fibres). Here the cutting tool is challenged not only by the reactivity of the soft metal matrix (Al, Mg or Ti-alloys) but also by the aggressiveness of the highly abrasive reinforcement, therefore the wear resistance of the coating defines ultimately the tool life time.

A new VMeCN based PVD coatings combining high hardness, low friction coefficient and chemical inertness have been developed to address these demanding applications. Excellent performance was achieved due to the synergy between V and C and the nanoscale multilayer structure of the coating. Vanadium provides for low coefficient of friction due to the formation highly lubricious V₂O₅ during sliding. Introduction of Carbon increases the chemical inertness between cutting tool and workpiece material and reduces build up edge formation. The coating combines low friction, ($\mu = 0.42$ against Al₂O₃) with high hardness ($H_V = 2900 \text{ kgmm}^{-2}$) and unique wear mechanism. HRTEM and Electron Energy Loss Spectroscopy revealed that in TiAlCN/VCN, Carbon is segregated laterally between the individual layers of the laminated coating producing low shear strength interfaces. Provision of low shear strength interfaces results in a well defined nanometer scale layer by layer wear mechanism, which is the key for prevention of tribofilm and consequently thick build up layer formation.

In dry milling of Al 7010-T 7651 alloy, TiAlCN/VCN nanoscale multilayer PVD coating outperformed state of the art Diamond Like Carbon (DLC, Cr/WC/a-CH) coated and uncoated end mills by factor of 4 and 8 respectively. In turning of Ti-alloys the TiAlCN/VCN coated cemented carbide inserts produced 2-3 times more components (orthopaedic implants), as compared to uncoated tools.

CrAlYN/CrN and TiAlCN/VCN have been deposited by a combined technology bringing together the novel High Power Impulse Magnetron Sputtering and the conventional Unbalanced Magnetron sputtering technology using a HIPIMS enabled Hauzer HTC 1000-4 PVD system.