HPPMS/DC-MSIP (Cr,Al,V)N thin film for high temperature application

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Abstract

Steel forming processes like hot forging and extrusion request excellent mechanical properties and good friction behavior of surfaces. In the temperature range of these processes (600 °C – 800 °C) self-lubricant hard coatings deposited by Physical Vapor Deposition (PVD) suggest a possibility to meet these challenges. In this work the transition metal Vanadium was embedded in a (Cr,Al)N hard matrix. The coating was deposited by a hybrid HPPMS/DC-MSIP PVD technology on 1.2999 (X45MoCrV5-3-1) hot working steel. The transition metal is known to generate friction reducing oxide phases at high temperatures. These so called Magnéli phases offer a wide range of structures with disordering effects. The effects lead to crystallographic shear planes resulting in lower friction at application temperature. The in-situ formation of different oxide phases in the tribocontact zone offer advantages like high wear resistance and low friction.

The deposited coating was analyzed with common thin film characterization methods revealing hardness, Young's modulus and adhesion. Furthermore, room temperature and high temperature Pin-on-Disk (PoD) tribometer measurements (25 °C, 600 °C and 800 °C) and high resolution analysis like SEM, XRD, TEM and EDX were carried out. The phase analysis (XRD) was carried out with specimens, which were annealed for 4 h (25 °C, 600 °C, 800 °C and 1000 °C) in an oxygen containing atmosphere.

The analyses show a reduction of the friction coefficient from 0.60 (25 °C) to 0.20 (600 °C) and 0.05 (800 °C) for the (Cr,Al,V)N coating. Here a formation of VO_2 at the surface can be obtained. Furthermore, TEM and EDX measurements show the formation of an alumina interlayer and a diffusion of the V atoms to the surface.