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Structure evolution in TiAlCN/VCN nanoscale multilayer coatings deposited by reactive High Power Impulse Magnetron Sputtering technology

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High Power Impulse Magnetron Sputtering (HIPIMS) is a novel technology, which utilises highly ionised metal plasmas. Despite the many similarities with Arc plasmas extensively studied for several decades there are clearly new effects taking place in HIPIMS, especially in reactive HIPIMS processes, which influence structure evolution of thin films and need careful consideration.
2.5 μm thick TiAlCN/VCN coatings were deposited by reactive a HIPIMS process carried out in a mixed Ar, N_2, CH_4 atmosphere utilising two opposing TiAl and V targets. Cross section Transmission Electron Microscopy (XTEM) showed a gradual evolution of the structure of the coating with thickness. The initial structure is nanoscale multilayer with sharp interlayer interfaces. This transforms to nanocomposite of TiAlCN and VCN nanocrystalline grains surrounded by C-rich tissue phase and finally changes to an amorphous carbon rich Me-C phase. In contrast, deposition in similar conditions using standard magnetron sputtering produces a well defined nanoscale multilayer structure independent from the coating thickness. Depth profiling by Auger Electron Spectrometry (AES) showed that the carbon content in the HIPIMS coating gradually increased from 27% at the coating substrate interface to 35% at the top thus supporting the TEM observations.
Energy-resolved mass spectrometry revealed that HIPIMS plasma is a factor of 10 richer in C^{1+} ions, and therefore more reactive, as compared to the plasma generated by standard magnetron discharge at the same conditions. The structure evolution in the HIPIMS case is believed to be due to the synergy between two effects. It can be speculated that a progressive target poisoning takes place, which leads to a gradual increase of the free carbon in the plasma and therefore in the coating with time. Secondly due to intensive ion bombardment during coating growth continuous outward diffusion of carbon is expected to take place driven by the temperature gradient between the condensation surface and the bulk of the coating a process previously observed in non-reactively deposited Cr-C films.

Keywords
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