Proceedings of the 3rd World Congress on New Technologies (NewTech'17)
Rome, Italy – June 6 – 8, 2017
Paper No. ICNFA 131
ISSN: 2369-8128
DOI: 10.11159/icnfa17.131

Structure and Properties of Monolithic and Multilayer M-AlSiN Superhard Films

Dimitrios Chaliampalias, Evangelia Tarani, Dimitrios Karfaridis, Nikolaos Pliatsikas, Aikaterini Kamou, George Vourlias, Efstathios Polychroniadis
Physics Department, Aristotle University of Thessaloniki
Thessaloniki, GR 54124, Greece
dimchal@auth.gr; etarani@physics.auth.gr; dkarfari@physics.auth.gr; nipliats@auth.gr; akamou@physics.auth.gr; gvourlia@auth.gr; polychr@auth.gr

Extended Abstract

The surface hardening of steels has been subjected to intensive investigation by the researchers for decades, which was focused on the deposition of hard films consisting of transition metal nitrides. These films can be monolayer ternary or quaternary phases and multilayer. In this work the deposition of nanocomposite TiAlSiN, CrAlSiN and multilayer CrAlSiN/AlSiN films on stainless steel is examined focusing on the structural identification and thermal stability.

All films were deposited on stainless steel substrates by cathodic arc deposition using a a Platit π80+ unit equipped with a Lateral Arc Rotating Cathode (LARC) system. The morphology and the chemical composition of the samples were determined using a 20 kV JEOL 840A SEM and a 200 kV Jeol 2010 HRTEM. The phase identification was performed using a 2-cycles Rigaku Ultima+ diffractometer (40 KV, 30 mA, CuKα radiation) while near-surface chemical composition was studied by means of core level XPS using a KRATOS Axis Ultra DLD system. The thermal stability of the samples was investigated by non-isothermal heating using a TG-DTA Setaram Setsys 16/18 system.

For TiAlSiN films it was revealed that near the interface the bonding gradient Ti-N film grows epitaxially and forms collumnary grains. However, the film over this layer has a multilayer like morphology attributed to the compositional modulation. The grain size in this case was measured 10 nm.

CrAlSiN films investigation revealed the formation of two different layers corresponding firstly to the buffer CrN adhesion layer which is homogeneous and shows no apparent morphological features. The above layer consists of compositionally gradient CrAlSiN exhibiting columnar morphology. Identification of the samples showed the formation of a CrxAl1-xN ternary compound and the crystallite size was estimated to be 14 nm. Silicon nitride was only detected in the Si 2p XPS spectra because of its amorphous nature and seems not to be incorporated in the lattice due to its low solubility in CrN.

The multilayer CrAlSiN/AlSiN films have seven distinct layers. From XRD and XPS examination it was found that on the surface the CrxAl1-xN solid solution is the predominant phase. The outmost CrAlSiN layer has a characteristic columnary structure including distinguishing nanolayers with 4nm average thickness. Their existence is, most probably, due to the resputtering effect of the light elements in combination with the substrate rotation during deposition. Their presence create considerably much more interfaces which impede the ion diffusion and crack propagation. The AlSiN layers have nanoctystalline structure and contain an hex-AlN. Also the diffused indiscernible ring that appears in the TEM ED pattern can be attributed to the Si-N amorphous phase.

Thermal stability measurements revealed that CrAlSiN films have the best performance as up to 1000oC no mass gain was recorded. TiAlSiN films began to oxidize from 730oC while multilayer films have similar stability with CrAlSiN monolayer films since the surface layer is the same. However the film stability of CrAlSiN films, Fe and Cr diffusion from the substrate was detected from 900oC.