Structure and mechanical properties of gradient metal-carbon films

E.A. Kulesh[1], A. V. Rogachev[1,2,*], D.G.Piliptsou[1,2], A.S Rudenkov[1,2] and J.X. Hong[2]
International Chinese-Belarusian scientific laboratory on vacuum-plasma technology:
[1]Francisk Skorina Gomel State University, Belarus
[2]Nanjing University of Science and Technology, China
[*]rogachevav@mail.ru

Amorphous carbon (a-C) films are widely used as wear-resistant protective films for friction units and tools However, a sudden change the mechanical parameters from substrate to film has many inherent disadvantages, such as the mismatch in properties at the interface between the film and type of substrate can cause stress concentrations to develop during deposition or while in service cause delamination of the film and result in a deterioration of a tool's life, especially in the friction conditions [1]. One way to resolve this problem is to apply gradient metal-carbon films with the improved functional characteristics [2].
Gradient films were obtained as a result of deposition from the combined titanium plasma fluxes of a DC arc discharge and the flow of carbon ions formed by sputtering a graphite target with an impulse arc discharge. The ratio of titanium and carbon atoms in the films was ruled by a change in the frequency of the pulsed arc discharge. To obtain nitride layers (TiN or CN), nitrogen was introduced into the chamber with a pressure of 10^{-1} Pa.
Structure and surface morphology of the Ti/a-C (5…20Hz) and TiN/a-CN(5…20 Hz) films were analyzed by Raman spectroscopy, X-ray photoelectron spectroscopy, atomic force microscopy, and scanning electron microscopy equipped with energy dispersive X-ray spectroscopy. Friction parameters of the films have been studied under the condition of dry sliding using a "sphere-plane" method. The microhardness of the films were studied by the AFFRI DM8 test machine with a Knoop style diamond tip. The microhardness was determined for various burdens on the indenter, which allowed to establish the distribution of hardness along the thickness of the film. The dependence between the carbon concentration in the depth of the studied films and their microhardness has been found out. Raman spectroscopy showed that films with high contents of the sp^3 phase are formed, the presence of titanium atoms leads to a decrease the size of the carbon sp^2 cluster, nitrogen conducts to an increase in the degree of disordering of sp^2 carbon clusters. The N-doping of uplayer of the gradient films leads to a decrease in the friction coefficient and substantial changes in both the phase compositions and surface morphology, which, in turn, reduce the counterbody wear rate and noticeably increase microhardness of these films, due to the formation nitride layers in the volume of film.

Keywords: Carbon films, gradient films, Raman spectroscopy, microhardness, friction and wear.

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