POLITECHNIKA ŚLĄSKA W GLIWICACH

Wydział Mechaniczny Technologiczny

mgr Rafał Dziwis

PRACA DOKTORSKA

Wykorzystanie metod eksperymentalnych i symulacji komputerowych do wyznaczania wybranych własności mechanicznych powłok uzyskiwanych w procesie PVD na spiekanych materiałach narzędziowych

Promotor:

dr hab. inż. Waldemar Kwaśny prof. PŚ

Gliwice, 2023

ABSTRACT

The thesis presents the results of structure and properties research of oxide tool ceramic Al_2O_3+ZrO_2, Al_2O_3+TiC, Al_2O_3+SiC and also of uncoated and coated tool ceramet in the proces of PVD catodal arc vaporization with single and multi-layer coatings of: TiN, (Ti,Al)N, TiN+(Ti,Al,Si)N, TiN+(Ti,Al,Si)N+(Al,S,Ti)N, TiN+(Ti,Al,Si)N+TiN. Moreover in the thesis coating thickness measurements, roughness, microhardness, assessment of adhesion to the base material, x-ray examinations (phase composition, stress measurement, texture analysis) surface topography observations and also diffraction and spectroscopic researches were processed.

On the basis of the tests processed, it was stated that the coatings applied to the tested substrate materials are characterized by a single, double or multi-layer structure depending on the type of coating used. Moreover, it was found that individual layers tightly adhere to each other and also to the substrate. In thesis it was also stated that the analyzed coatings TiN and Ti(Al,N), are characterized by a columnar structure, while in the case of the coating TiN+(Ti,Al,Si)N, even at the maximum magnifications used, no grain boundaries were revealed, which proves its close-grained structure. Based on the qualitative analysis of the texture, it was stated that it is relatively weak due to the distinguished plane of the coating growth and due to amount of texturing measured by the height of the maxima occurring near the center of the projection of pole figures corresponding to the distinguished plane. In the surface layer of the analyzed coatings, it was observed that there are favorable compressive stresses affecting the hardness and their adhesion to the base material. The highest and lowest compressive stress values of approx -3300MPa and -550MPa, obtained for the coating TiN+(Ti,Al,Si)N which were obtained on a substrate of cermet and oxide tool ceramics Al_2O_3+ZrO_2. Critical load value Lc characterizing the adhesion of coatings to the substrate is between 30 and about 100 N, depending on the type of substrate and coating material used. Furthermore, in the thesis the model was developed using the finite element method for the purpose of computer simulation of microhardness and internal stresses in coatings obtained in PVD processes.

Development of the model requires knowledge of material properties such as: Young's modulus, Poisson ratio, coefficient of thermal expansion, and gives the possibility to

determine stresses in individual layers of coatings which is not always possible experimentally in laboratory conditions.

Developed model of tools covered with coatings in the PVD process was verified by comparing the results of experimental microhardness tests and stress measurements with the results obtained by the finite element method. The verification procedure consisted in assessing the significance of the correlation of the results of the computer simulation and experimental measurements, demonstrating their compliance.