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PRECISION PROCESSING OF MICROTOOLS WITH BEAMS OF FAST ATOMS OBTAINED IN PLASMA BY ACCELERATING ITS IONS AND THEIR CHARGE EXCHANGE COLLISIONS*

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The wear-resistant coatings can appreciably improve efficiency of cutting tools. However, the cutting edge radii of micro cutters can grow by 2–2.5 times after the coating deposition, and it does not allow a stable cutting process. Micro cutters are small and have a lower ability to resist bending. Therefore, it is impossible to increase the thickness of the cut chips, because bending can result in destruction of the tool.

To solve the problem a layer should be removed from the tool surface its thickness exceeding the thickness of the wear-resistant coating deposited afterwards. The surface layer removal was carried out using a grid immersed in the glow discharge plasma filling a vacuum chamber (Fig. 1). The grid is fastened to a feedthrough and can be negatively biased to 5 kV. There is inside the chamber a rotating holder for micro end mills by Cerin (IT) with the working part diameter amounting to 3 mm and length of 12 mm.

At an argon pressure in the chamber $p \sim 0.3$ Pa, an increase in the voltage between the anode and the chamber to several hundred volts results in a glow discharge with a current in the anode circuit I_a up to 4 A and a discharge voltage of U_d = 400–500 V [1]. The transparency of 20-cm-diameter concave grid with a surface curvature radius of 20 cm amounts to ~ 80%. Under negative voltage of 5 kV, it is surrounded by a space charge sheath. The ions accelerated from the plasma pass through the grid holes. Due to collisions in the sheath with gas molecules, they turns into fast neutral atoms sputtering the rotating end mill.

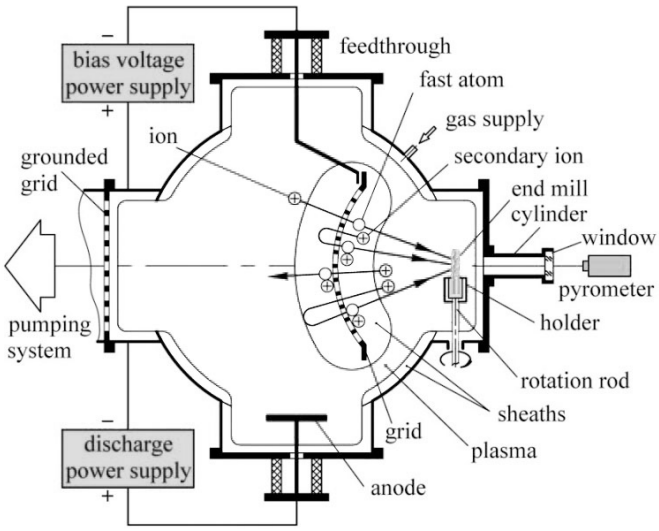

Fig.1. Scheme of a concentrated beam generation by a grid immersed in plasma

Measurements of the cutting edge radius R using an optical measuring system MikroCAD premium+ manufactured by GFMesstechnik GmbH showed that during a three-hour-long processing it diminished from the initial R ~ 11 μm to R ~ 4 μm. After the end mill processing, a 3-μm-thick wear-resistant coating was deposited on its surface using a Platit π 311 system manufactured by Platit (Switzerland). The deposited diamond-like coating (DLC) was a two-layer composition: an adhesive sublayer based on a complex nitride (CrAlSi)N and a wear-resistant DLC layer. The cutting edge radius of coated end mill amounted to 7 μm. Hence, the sharpening of micro tools with a fast atom beam makes it possible to avoid blunting of their cutting edges caused by an increase in their radii after the coating deposition.

REFERENCES

[1] A.S. Metel, S.N. Grigoriev, Y.A. Melnik, V.V. Panin, "Filling the vacuum chamber of a technological system with homogeneous plasma using a stationary glow discharge", Plasma Phys. Rep., vol. 35, no. 12. pp. 1058–1067, 2009.

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