INVESTIGATION OF MULTI-ARC PLASMA PLATING FILM EQUIPMENT BULAT-6 AND ITS TECHNICAL CHARACTERISTICS

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ABSTRACT

In this paper, multi-arc plasma plating film equipment Bulat-6 and its technical characteristics were analyzed in detail. This machine is the first of its kind in China. Influential factors and reducing methods on microdroplets of titanium were investigated. By method of electromagnetic field control and ion beam enhanced deposition, excellent titanium nitride film could be obtained. Microhardness and adhesion were 250Mpa and 6.5 Kg respectively.

1.INTRODUCTION

Multi-arc plasma plating film techniques are widly used to prepare hard films such as TiN and TiC on the surface of tools and dies. The improvements of hard film properties are mainly depedent on the development of coating equipment. The essential function of the equipment and the deveploment is in that ionization probability of evapourated particles from cathode materials increase, and microdroplets from cathode targets decrease. This is because neutral particles and large microdroplets are disadvantageous to adhesion between films and substrate.

There are distinct differences between Bulat-6 and multi-arc machines which commonly used in China. In this paper, some technical characteristics of Bulat-6 are analyzed and methodes of how to reduce microdroplets are explored. Finally, under the optimal conditions, excellent qualities of TiN films can be obtained by Bulat-6.

2. EXPERIMENT

The substrate material: High speed steel was used in this work and its hardness was HRS 61.

Ti and TiN film preparation: Films were prepared by Bulat-6 under different conitions. A series of parameters were studied, including bias voltage, arc-point discharge current(APDC), electromagnetic field intensity, impluse gas delivery, impluse of working cycle, ion beam enchanced deposition with high current, and so on.

Scanning electron microscope(SEM) observation: The microdroplets of Ti and TiN were observed by SEM(AMRAY1000B).

Hardness and adhesion measurements: Microhardness of TiN was measured by a microhardness tester(Akashi MVK-H3) with load of 10gf and loading time of 20 seconds. Adhesion between the films and substrate was measured by a scratch tester(Awatani CSR-01) with a diamond needle of 0.2 milimeters in diameter and loading speed of 10kgf/min..

3.RESULTS AND DISCUSSION

3.1 Components of Bulat-6

The Bulat-6 system is composed of three metal plasma arc sources, one cold cathode ion source, two impulse gas delivery devices, three electromagnetic field coils behind the cathodes, and three electromagnetic field coils between each cathode and workpiece, pumping system, roatation workpiece table. The schematic plot of Bulat-6 is shown in Fig1.

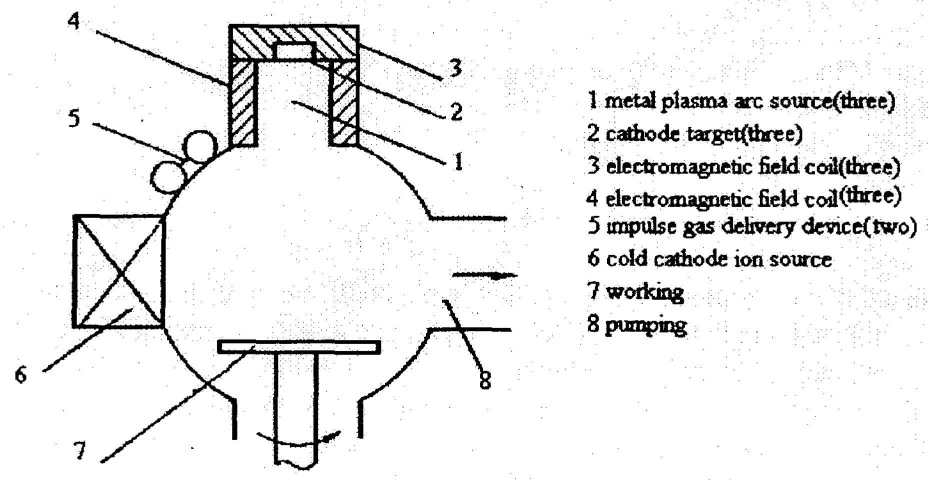
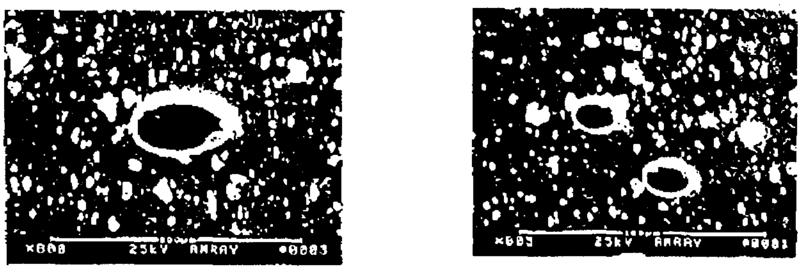


Fig. 1 Schematic plot of Bulat-6

3.2 Impulse Metal Plasma Arc Source and Microdroplets

The metal plasma arc source can be operated continuousely or intermittently. The working or intermittent time can be adjusted within a range of one minute. The APDC of the arc source varies from 70A to 140A.

Generally, the size of microdroplets evaporated by the arc-point ranges from 0.1 micrometers to 100 micrometers [1]. The higher the APDC , the larger and the more frequent microdroplets form. Besides decreasing APDC, the experiments proved that the impulse arc could reduce the size and quantities of microdroplets effectively. When the arc-point continuousely moved only in the center of the target and APDC was 70A, the largest microdroplets of Ti was 41 micrometers, shown in Fig2(a), when done intermittently and was the same, the largest was 20 micrometers , shown in Fig.2(b).



(a)continuous arc deposotion (b) impulse arc deposition

Fig.2 Microdropletsof titanium(APDC70A,focused,deposition time 5min.)

3.3 Arc-Point Movement and Microdroplets

Each of the three electromangnetic field coils surrounds one cathode. The Arc-point can be focused or diverged on the surface of the cathode by adjusting electromaganetic field intensity. When focused, it moves only in the center of cathode surface. In contrast, when diverged , it moves on the whole surface of the cathode, In the latter, the cathode will be homogeneousely evaporated and never heated into a bowl -shape, so that the utilization ratio of the target increase obviously. The cathode evaporated by Bulat-6 and the common multi-arc machine are shown in Fig.3 . In addition, at the same APDC, the microdroplets produced when the arc-point diverged were smaller than produced when the arc-point was focused.

The left: the cathode evaporated by common multi-arc machine

The right: the cathode evaporated by Bulat-6

Fig. 3 Evaporated titanium cathode targets

3.4 Electromangnetic Field between the Cathode and Workpiece and Microdroplets

There is an electromagnetic field coil between each cathode and workpiece, in which the charged particles of plasma jet from the target will circumagitate the magnetic lines of force [2].The greater the distance moved by the charged particles, the more the collision probability between charged particles and neutral particles become. This will result in the increase of ionization probability of vaporated particles from the cathode. At the same time, the large microdroplets can be effectively captured by the electromagnetic field coil wall.

3.5 Cold Cathode Ion Source

The working voltage and current of the cold cathode ion source is 4kv and 300mA respectively.After a polished speciman was bombarded by Ar^+ for 10 mintues, the microstructure of steel could be observed just as etched by Nital .The strong sputtering effect would improve the adhesion between films and substrates[3], especially, when the substrstes are glass ,ceramics and plastics. The ion source also could be used to perform ion beam enchanced dynamic reactive deposition with high nitrgen ion current.

3.6 Impulse Gas Delivery Device

The reactive gas can be delivered intermittently or continuously. The effect of impluse delivery on film properties is currently being explored.

3.7 The Optimal Parameters for TiN Film

A series of technical parameters have been investigated, and the optimal parameters to prepared TiN film in Bulat-6 has been determined as following : bias voltage 150V, APDC 90A, Impulse gas delivery 90times/min., arc-point moving on the whole surface of the Ti cathode , single arc source working for 30 minutes, operating temperature 450℃. Under these conditions the TiN film is 6 micrometers in thickness, 250Mpa in microhardness, and 6.5kg in adhesion.

3. CONCLUSION

The Bluat-6 multi-arc machine from Estonia is equipped with impluse metal plasma arc source ,electromagnetic field coils, cold cathode ion source, and impulse gas delivery devices. Their technical characteristics were discussed.

With the use of electromagnetic field, the movement of the arc-point could be controlled in the center or the whole surface of cathodes.

As a result of utilizing an electromagnetic field control and ion beam enchanceed deposition with current, excellent film properties (microhardness 2500 and adhesion 6.5kg) can be achieved.

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