A SMALL UNBALANCED MAGNETRON SPUTTERING SOURCE WITH MULTIPOLE MAGNETIC FIELD ANODE*

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ABSTRACT

A small unbalanced magnetron atom source with multipole cusp magnetic field anode is described. The co-axial magnetron principle is extended to the circular planar magnetron atom source, which raises the efficiency of sputtering target area up to 60%. The multipole magnetic field is put in the anode, which makes the unbalanced magnetron atom source run in a higher discharge current at a lower arc voltage condition. Meanwhile, the sputtering atoms through out the anode can be ionized partially, because the electron reaching the anode have to suffer multiple collisions in order to advance across the multipole magnetic field lines in the anode, which enhances the chemical reactivity of the ejecting atoms in film growth and improve the property of film depositing.

Keywords Magnetron sputtering source, Multipole field anode, Aluminium target

1 INTRODUCTION

The unbalanced magnetron source has shown to be a scientific tool for the study of basic physics in thin film growth, and used for metallurgical coatings and miscellaneous other coatings, because it provides additional bombardment during film growing in the ion mixing of refractory metals.

In the improved small circular planar unbalanced magnetron, the magnetron anode has the multi-pole cusp magnetic field and the co-axial magnetron principle is entended to the circular planar magnetron source, in which the S pole of the magnetic field directs toward the centre of the permanent magnet annulus[1]. Such a construction of magnet arrangement makes the magnetron sputtering target be as small as 34 mm diameter, and the efficiency of the sputtering target area is increased.

2 CONSTRUCTION OF SMALL MAGNETRON SPUTTERING SOURCE

The construction of the small planar circular unbalanced magnetron source with multipole magnetic field anode is shown in Fig.1.

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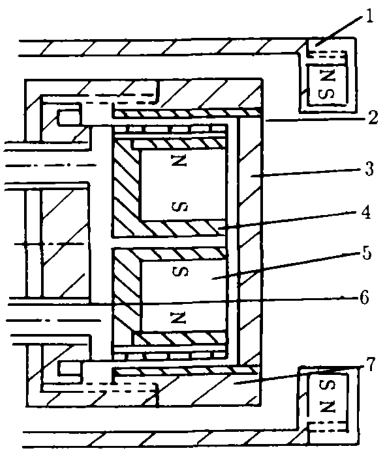

Fig.1 The construction of the small magnetron sputtering source with multipole magnetic field anode

1. Multipole magnetic anode 2. Magnetic field 3. Al target 4. Mild steel 5. Fermanent magnet 6. Copper water return pipe 7. Al body

The cylindrical body of the source is made of aluminium with a 42 mm diameter and the sputtering target with a 34 mm diameter water-cooled magnets. Two copper pipes are used as the water returning and electrical lead-in to the source body. The permanent magnets was cut into 8 segments fitted in a mild steel annulus of 26 mm inside diameter, which provides the tunnel magnetic field at the target surface. Sputtering target is pressed closely onto the surface of the aluminium body by the remnant magnetic field of the mild steel cylinder. The target can be fully water-cooled. The double mild steel cylinder and the aluminium cylinder connected to the magnetron body shield and decrease the unwanted magnetic field strength to 4 mT on the external surface of the aluminium cylinder, 12.5 mT on the unwanted-glow discharge part of planar target surface or below.

It is very important to avoid glow discharge from the unwanted cathode surface of the sputtering target for eliminating contamination.

The multipole magnets are placed in the anode to form multipole cusp magnetic field. The tunnel magnetic field strength of the discharge annulus region is from 45mT to 81mT (5mm from the surface) measured with a Hall probe.

In a crossed electromagnetic field, the motion radius of electrons in sprial is $r = ME/eB^2$. Make the distance D between the cathod and anode be small than $D = 2r$, then $D = 2(M/2e)^{1/2}(-V)^{1/2}/B$, it could eliminate the unnecessary glow discharge. For a Al cathod potential V=-500V, B=12.5mT, we get D= 6mm, the 5mm distance between cathod and anode is selected here.

3 RESULTS AND DISCUSSION

The typical discharge parameters between the voltage and the discharge current in varied Ar pressure for the two kinds of the anode are shown in Fig.2.

The discharge current of the magnetron source is from 150 mA to 500 mA, the applied anode potential is from 350V to 550V, at an Ar pressure of 1.5 Pa to 3.2 Pa for an aluminium target of 3 mm thick. The maximum arc power is 275W (500 mA at 550V). Total input power is 500W (5A at 100V, 1.5 Pa Ar pressure). The discharge voltage does not change at an Ar pressure of 3.2 Pa during the discharge current increases from 250 mA to 600 mA with the input power. The maximum arc power is 180W (600 mA at 300V). the total input power is 278W (3.7A at 75V).

Aluminium deposition film on a sheet of glass becomes a mirror in five minutes. The Al deposition rate is about 40 nm·min^{-1} for an arc input power of 64W (200 mA at 320V), at an Ar pressure of 1.5 Pa with a 5 cm receiver distance.

Some different discharge properties were observed as following compared with the nonmultipole magnetic field[2]. The magnetron sputtering source with multipole field anode can discharge only in high discharge current at a higher applied anode beginning potential, and can run in a lower power input of arc for the same Ar pressure of 1.5 Pa. Especially, as the arc discharge current is increased from 250 mA up to 600mA with the increment of the total power input, the discharge voltage does not change at an Ar pressure of 3.2 Pa.

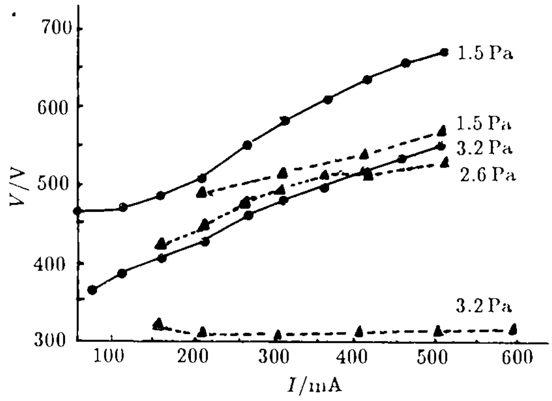

Fig.2 Relation between the discharge current and voltage for the two kinds of anodes

● Planar target ▲ Planar target with multipole field anode

The reason of applying higher beginning anode voltage lies in that electrons cannot reach the anode directly, which is shielded by the multipole magnetic field, they must possess proper energy and suffer multiple collisions in order to advance across the magnetic field lines to reach the anode.

The sputtering annulus on the target is from 14 mm diameter to 30 mm diameter. The deep erosion centre is at 20 mm diameter. The construction of the magnet arrangement can make a small magnetron sputtering be as small as in diameter of 34 mm. The efficiency of the sputtering target area is high up to 60 %.

REFERENCES

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