

Small-scale Vacuum System for Deposition of Multilayer Metallic Films “MVU TM – Magna 3M”

V.V. Odinokov, G.Ya. Pavlov, V.V. Panin, V.P. Raschinsky, A.N. Shpakov, A.V. Shubnikov

JSC “Research Institute of Precision Machine Manufacturing” (JSC NIITM),
10, Panfilovsky Pr., 124460 Zelenograd, Moscow, Russia

(Received 19 May 2014; published online 15 July 2014)

A new small-scale vacuum system “MVU TM-Magna 3M” developed at JSC “Research Institute of Precision Machine Manufacturing” is described. Its assembly and working conditions are considered. This system was used for magnetron sputtering multilayer metallic films.

Keywords: Vacuum system, Magnetron sputtering, Thin film deposition, Multilayer metallic coatings.

PACS numbers: 81.15.Cd, 52.77.Dq, 52.50. – b

When designing various semiconductor devices based on thin film technologies for producing high quality multilayer coatings all layers must be deposited on the substrate in one process (vacuum) cycle [1, 2]. Deposition of thin films of various metals on substrates by magnetron sputtering in discharge plasma in one vacuum cycle provides productivity increase and sufficiently high adhesion strength between the substrate and the adhesive layer, and between separate layers of the coating.

This article deals with basic information about the design and technological capabilities of the new small – scale vacuum installation “MVU TM-Magna 3M” [3] designed to:

- processing training;
- scientific research;
- development of technological process;
- low-volume production.

Fig. 1 shows a main view (a) of “MVU TM – Magna 3M” installation and its schematic configuration (b).



Fig. 1 – Main view (a) and schematic configuration (b) of “MVU TM-Magna 3M”. 1 – Working chamber, 2 – Planetary substrate holder, 3 – Ion-beam cleaning electrode, 4 – Throttle shutter, 5 – Valve, 6 – Target, 7 – Magnetron, 8 – Cylindrical shutter

1. CONSTRUCTION OF INSTALLATION

Fig. 2 shows a front view (a) and top view (b) of vacuum - plasma installation “MVU TM-Magna 3M”. It consists of the process module 1 mounted on the frame 2, control and power-supply rack 3 located under the frame, gas cabinet 4 and hydropneumatic panel 6 attached to the frame, on the right and left sides of the control and power-supply rack respectively.

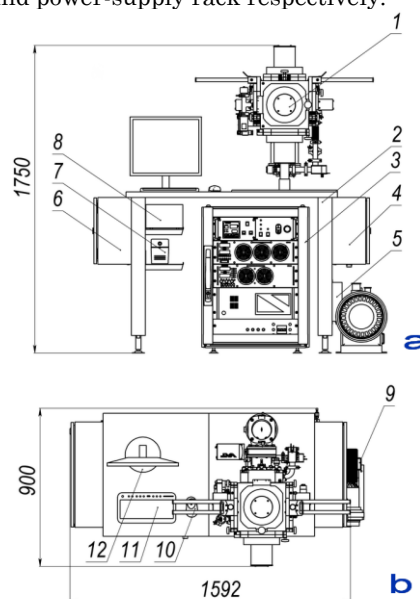


Fig. 2 – Front view (a) and top view (b) of vacuum - plasma installation “MVU TM-Magna 3M”. 1 – Working chamber; 2 – Frame; 3 – Control and power-supply rack; 4 – Gas cabinet, 5 – Commutator; 6 – Hydropneumatic panel; 7 – Uninterruptive power supply; 8 – Turbo-molecular pump controller

The article was reported at the International Conference «The Advanced Technology, Equipment and Analytical Systems for Materials», Kursk, 13-14 May, 2014

Fig. 3 shows a front view (a) and side view (b) of process module. It consists of the vacuum chamber 1 placed on the bracket 9 in the form of a cube with 274 mm edges size. Magnetron spraying devices 10, 13, 16 are located at the bottom, front and top flanges of chamber. Unit of substrate holders 3 is located at the right side of the flange and the shutter (screen) unit 11 – at the left side of the flange. To download the substrates, as well as for convenient operation of the installation, unit of the substrate holder and shutter unit move along the guide 12. Working chamber and technological components are cooled with cold water. Control of the cooling liquid temperature and supply of overpressure to control devices are carried out via hydropneumatic panel. Flow of process gases into the chamber and gas puffing at the end of the spraying process occurs respectively via the electromagnetic valves 19 and 20.

2. OPERATIONAL PRINCIPLE OF THE INSTALLATION

Six pyroceramics plates with dimensions of 48 × 60 mm are fastened in special holders that are attached to the rotary drive via geared transmission. During the

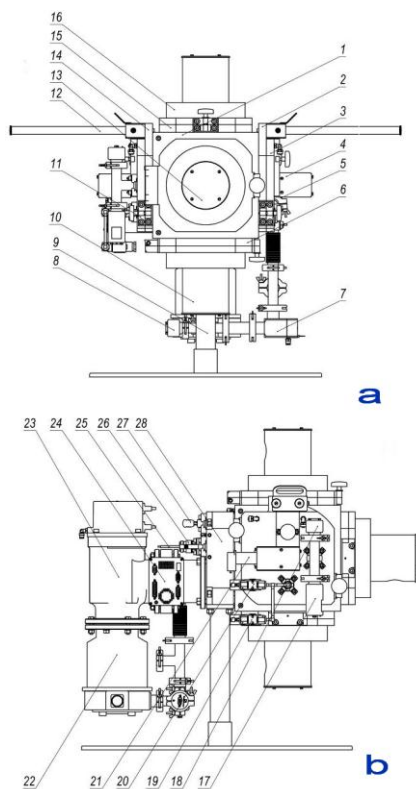


Fig. 3 – Front view (a) and side view (b) of technological module of "MVU TM-Magna 3M". 1 – Working chamber; 2, 6, 14, 15 – Flanges; 3 – Unit of substrate holders; 4 – Rotary drive of carousel; 5, 7 – Vacuum valves; 8, 17, 18 – Vacuum gauge; 9 – Bracket; 10, 13, 16 – Magnetrons; 11 – Shutter (shield) unit; 12 – Guide

REFERENCES

1. V.V. Odínokov, *Proceedings of 16 scientific and technical conference with the participation of foreign specialists «Vacuum science and technology»*, 321 (Moscow: 2009).
2. S.N. Grigoriev, Y.A. Melnik, A.S. Metel, V.V. Panin, *Plasma Phys. Reports* **35**, No 12, 1140 (2009).
3. V.V. Odínokov, Y.P. Panfilov, *Nanoengineering* No 11, 7 (2011).

process they make planetary movements around its axis and about the axis of rotary drive (Fig. 1b) at a frequency in the range from 10 to 50 rev/min. Oil-free vacuum system provides a residual pressure in the chamber at least 5×10^{-4} Pa after 40 minutes of pumping. A couple of halogen lamps with a capacity of 0.5 kW each are used for heating. Heating temperature control is carried out by thermocouple sensor. Ion-plasma cleaning of plates is carried out at an argon pressure of 2 Pa before deposition.

After pretreatment one of the three magnetron sputtering systems is turned on and target cleaning is carried out within 60 seconds. To generate the deposited flux of matter planar magnetron sputtering systems with disk targets of 100 mm in diameter and 6 mm in thickness are used. They are retained against the copper base cooled by water. The anode is a grounded housing. Commutator 5 is used for switching power between magnetrons (Fig. 2). Processes are carried out at an operating pressure of argon of 0.1-1.0 Pa, and sputtering power of each target in a range of 1.5-3 kW.

3. RESULTS

Multilayer coatings with alternating layers of chromium or vanadium and copper or aluminum are obtained in one technological cycle by magnetron sputtering onto pyroceramics plates with dimensions of 60 × 48 mm and thickness of 0.25-2 mm by using "MVU TM-Magna 3M". Moreover, experiments on deposition of single coatings of these metals were held. Control of the deposition process was carried out with respect to processing time.

4. CONCLUSION

The described installation allows realizing processes by magnetron sputtering of various metal coatings in one technological cycle. In such a case, high-quality multilayer films are formed; they have good adhesion strength between the base and the adhesive layer, and also between separate layers. Automated control system of the installation controls all process parameters and supports their stability according to the set values, providing good reproducibility of the deposited coatings properties. Planetary rotation of the substrates provides uniformity of treatment at all stages of the process. Autonomous cooling system of units provides effective heat removal from the heating elements and the absence of condensation in the channels. Working chamber made from one-piece plate of duralumin alloy excludes leaks due to lack of welds. The unit has a small size and low power consumption, which ensures its effective use in processing training, scientific research, development of technological process and test or low-volume production.