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MEVVA Ion Source And Filtered Thin-Film Deposition System

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Abstract

Metal-vapor-vacuum-arc ion source is an ideal source for both high current metal ion implanter and high current plasma thin-film deposition systems. It uses the direct evaporation of metal from surface of cathode by vacuum arc to produce a very high flux of ion plasmas. The MEVVA ion source, the high-current metal-ion implanter and high-current magnetic-field-filtered plasma thin-film deposition systems developed in Beijing Normal University are introduced in this paper.

1. Mevva Ion Source and Ion Implanter

Metal-vapor-vacuum-arc (MEVVA) ion source was originally developed in 1985 by Brown at University California at Berkeley [1]. It works in pulsed mode using vacuum arc to melt and evaporate surface materials of a metal cathode to produce a very high flux of ion plasma. The MEVVA ion source is an ideal tool for high-current metal-ion implantation with the following advantages: capable to produce almost all the metal-ion species; very high-beam current; producing pure ion beams; high metal-ion charge states; and providing a large area of beam irradiation etc.

The ion implanter employing the MEVVA source is the best candidate for the surface modification at the industrial level with simple structure, easy operation and relatively low cost. The ISM - Cutting Edge Products, Inc. [2], based in San Diego of California is a main manufacture of the MEVVA ion implanter worldwide.

Table 1 Specifications of MEVVA 50.

Average ion beam	50 mA (max. 83 mA)
Extraction voltage	50 kV
Beam spot size	50 cm in diameter
Pulse length	2.4 ms
Repetition rate	0 - 25 pps
Lifetime of cathode	> 8 h
Trigger voltage	Up to 10 kV
Arc current	80 - 200 A

Since 1987, the MEVVA ion source and ion implanter have also been developed in Beijing Normal University (BNU) [3] under a contract with The National High Technology Research and Development Program of China. In these years, more than twenty MEVVA ion implanters and thin-film deposition systems with different specifications have been produced in BNU and deployed to research laboratories and industrial workshops around mainland, Hong Kong, and Taiwan. Among them, the largest-MEVVA 50 implanter is now operated in Advanced Material Center in Shenzhen of southern China. The photo of this machine is shown in Fig. 1

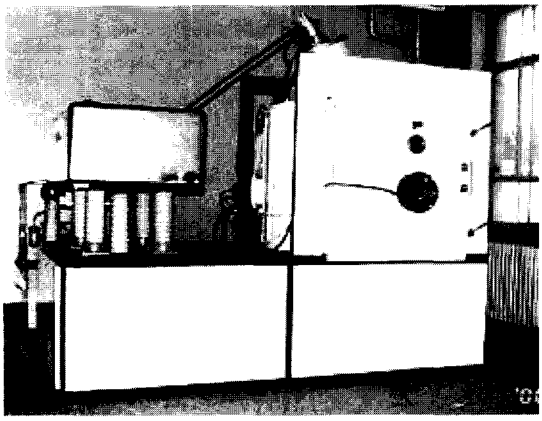

Fig. 1. The MEVVA 50 ion implanter

and the specifications can be found in Table 1. An even larger machine is currently under construction in BNU, whose ion current is expected to reach 100 mA. The diameter of the vacuum chamber is 2 m that provides a total processing area of 2 m^2 with a single loading. It will become the world largest metal implanter for industrial surface processing. With this large capacity of processing, the average cost for each cm^2 with $2x10^{17}$ implanted ions will be lowed down to few cents. This will make a breakthrough for industrialized metal-ion implantation.

2. The Magnetic Filtered Thin-Film Deposition System

The MEVVA ion source can also be used for thin-film deposition. The thin-film deposition systems with the MEVVA ion source and the dc vacuum arc source are developed in BNU during recent years. With low bias voltage and in pulsed mode, the MEVVA ion source can deposit thin films at a thickness of a few atom layers level. This will be ideal for a nm multilayer thin-film deposition. In order to eliminate the μm sized neutral particles which will destroy the structure of nm layer, an magnetic filter, consisting of a 90-degree duct and a dc coil is applied. A schematic diagram of this duct is shown in Fig. 2. The duct guides the plasma to the deposition site with high efficiency and removes almost all the neutral particles. Photographs of the plasma deposition system with the magnetic filter are shown in Figs. 3-5. With the dc vacuum arc ion source, thin films with a thickness up to a few μm can be deposited. The specifications of MEVVA thin-film deposition system is given in Table 2.

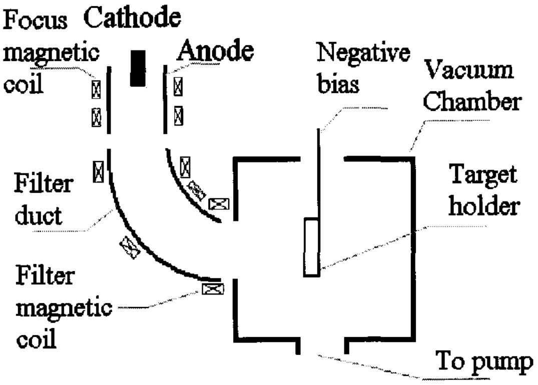

Fig. 2. Schematic diagram of magnetic filter.

The systems shown in Figs. 3-5 are allowed to install multiple-ion sources around a single vacuum chamber. The significance of this arrangement is the flexibility to combine ion implantation with plasma thin-film deposition, and the possibility of co-implantation and deposition. Several works in these categories have been carried out in BNU and valuable results were reported [4,5].

Table 2 Specifications of MEVVA thin-film deposition system.

Pulse width	2.5 ms
Repetition rate	1 - 25 pps
Pulsed current	5 - 200 A
Deposition rate	0 - 0.3 nm/s
Deposition voltage	0 - 300 V
Deposition area	5 - 15 cm in diameter
Implantation voltage	0 - 30 kV
Vacuum chamber	sphere (50 cm in diameter)
Vacuum	4×10^{-4} Pa

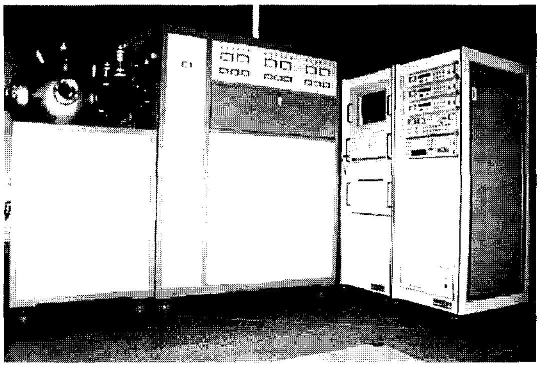

Fig. 3. Three filtered-cathode arc deposition system in CUHK (Hong Kong).

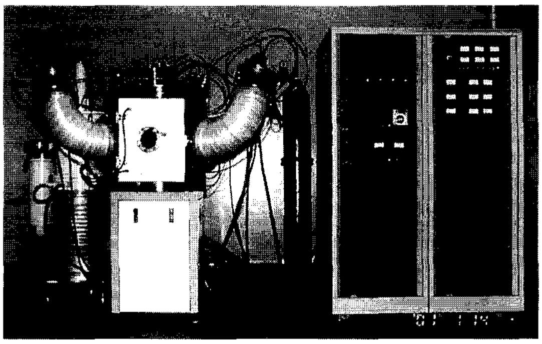

Fig. 4. Co-implantation and Film-deposition system in Tsinghua University (Taiwan).

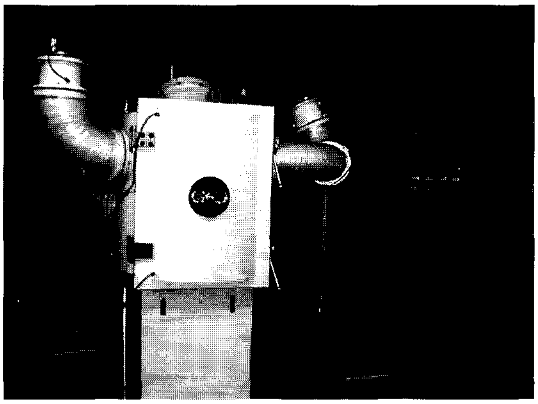

Fig. 5. Multi-head filtered-cathode arc deposition system in BNU.

Acknowledgements

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