A New Apparatus for Cathodic Sputtering

THE cathodic sputtering process has been almost completely replaced in recent years by the vacuum evaporation technique for the production of thin solid films. However, renewed interest in the sputtering technique has been created by the discovery that films of metal oxide can be deposited by sputtering from a metal cathode in a glow discharge containing oxygen. Such films are usually required in combination with metal and other dielectric films for interferometry, etc. It is a simple procedure to deposit multi-layer coatings by vacuum evaporation, whereas their preparation is tedious when using the conventional form of sputtering apparatus. This is because it is necessary to break the vacuum and insert a new disk cathode of the required metal for each fresh layer. I have recently developed apparatus for the deposition during one coating cycle, on to plane receivers, of several sputtered films in sequence or for laminating sputtered deposits with vacuum-evaporated films. It is also possible to dispense with the need for rectification of the high-tension output without loss in the sputtering efficiency.

The new sputtering apparatus is shown in Fig. 1 (subject of a patent specification). The glow-discharge electrodes consist of two *V*-shaped elements made of the material to be sputtered and connected to the output of a high-voltage transformer. The leakage current from the supply to earth must be a minimum, otherwise sputtering can occur from earthed metal fittings in the chamber. Each of the *V*-electrodes operates as a cathode electrode on alternate cycles and deposits material on the plane receiver, which is rotated to ensure uniform deposition. The *V*-electrodes are mounted on earthed *V*-shaped shields with a gap of smaller dimension than the depth of the cathode dark space, so that a glow discharge cannot be sustained on the electrode side remote from the receiver surface. A *V*-shaped electrode operated from a d.c. supply has been used in Germany for glow-discharge cleaning prior to vacuum evaporation[1]; but it has not to my knowledge been used in the a.c. form described above for sputtering.

Experiments have shown that *V*-electrodes with arcs subtending an angle from 10° to 180° at the centre of the work plane produce very uniform deposits on a 12-in. diameter receiver when connected to a 3 kV. 500 m.amp. a.c. supply. By shaping the electrodes, it is possible to increase or decrease the thickness of the deposit at the centre of the receiver. The angular gap between electrodes must be such that one electrode does not penetrate the cathode dark space of the other and thereby interfere with the current density distribution over the cathode surface. This can be avoided by mounting the pair of *V*-electrodes diametrically opposite as in Fig. 1. Several such pairs of electrodes can be mounted above a rotary receiver for deposition of films in sequence.

To obtain uniform evaporated films on plane receivers, it is desirable to rotate the receiver and mount the vapour source in an offset position as shown in Fig. 1[2]. Sputtering electrodes can then be arranged with vapour sources for deposition of multi-layers. The vacuum pump used on this latter apparatus must be capable of obtaining low gas pressures for evaporation (0·1 micron mercury) and operate at high pressures (0·1 mm. mercury) with a controlled gas leak into the chamber during sputtering.

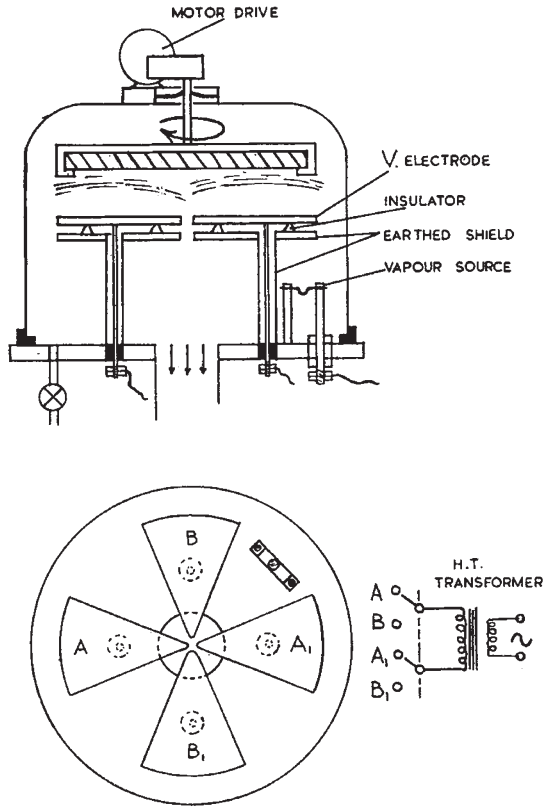

Fig. 1. Sputtering apparatus with *V*-electrodes

Suitable pumps, commonly known as booster-diffusion pumps, are commercially available for this purpose.

The new sputtering apparatus is being used in my laboratory for: (i) preparing durable multi-layer interference filters consisting of sputtered metal oxide films laminated with vacuum-evaporated magnesium fluoride films (titanium oxide films prepared in the laboratory by sputtering in pure oxygen have been found to have a refractive index of about 2·5 and are highly tenacious to glass); (ii) the sputtering of transparent conducting gold films on sputtered bismuth oxide base layers; the properties of this film combination have been described by Gillham and Preston[3] and others[4].

It should also be possible to prepare coatings of alloys and mixtures by sputtering from two *V*-electrodes of dissimilar metals operated from an a.c. supply.

A full account of the new sputtering technique and its uses will be published shortly. Acknowledgments are made to Mr. G. Siddall for his assistance in the construction of a prototype apparatus, and to Mr. A. S. D. Barrett, technical director, for permission to publish this communication.

L. HOLLAND

Research Laboratory,
Edwards High Vacuum, Ltd.,
Crawley, Sussex.
Feb. 9.

[1] Koenig, H., and Heisinger, L., *Festschrift Heraeus Platinschmelze* (Hanau, 1947).
[2] Holland, L., and Steckelmacher, W., *Vacuum*, **2**, 346 (1952).
[3] Gillham, E. J., and Preston, J. S., *Proc. Phys. Soc.*, **65B**, 649 (1952).
[4] Libbey–Owens–Ford Glass Co., Brit. Pat. 682,264. Holland, L., and Siddall, G., *Vacuum*, **3**, 375 (1953).