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NASA TECH BRIEF

NASA Pasadena Office

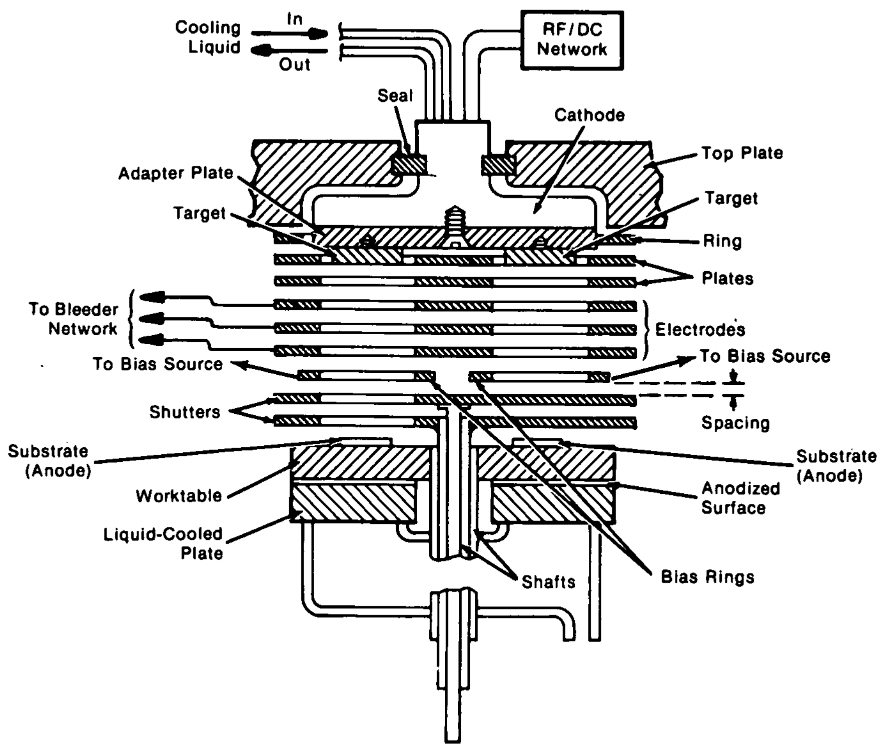
Improved Multiple-Target Sputtering Equipment

The problem:

Sputtering is widely used for depositing thin films in the fabrication of microelectronic components. Normally a thin film layer is deposited in an evacuated chamber filled with an inert gas (e.g., argon, xenon, nitrogen, or helium) at 0.1 to 10 μm Hg. Inside, the chamber has a cathode, called a target, which is the material to be deposited. The substrate located opposite the cathode serves as an anode. As the electrons leave the cathode, they collide with the gas molecules, generating positive ions. These ions bombard the cathode, causing it to eject atomic-size neutral particles which move at random velocities and deposit themselves on the substrate. The input-power sputtering yield of the material and the duration of the sputtering determine the deposited-film thickness.

When several different materials are to be deposited onto the substrate sequentially, the process becomes more involved. If only one chamber is used, the cathode material must be changed, and the chamber must be reevacuated and refilled with neutral gas. The process is repeated for each film layer. Alternatively, a number of chambers can be used, one for each film layer. In both cases much time is lost in evacuating and refilling the chambers.

Whenever the deposited film is exposed to air, an unknown contaminating layer (usually oxides) forms on the surface. The subsequent metal layer will be desposited upon this interface.



Multiple-Target Sputtering Equipment

(continued overleaf)

The solution:

Fast and economical sputtering equipment has been developed in which a multiple target is used in one chamber. A number of film layers can be deposited without repeated evacuation and refilling with gas. This eliminates contamination due to air exposure.

How it's done:

The newly developed equipment is shown in the illustration. It includes the cathode which is supported by a top plate and which is electrically isolated from it by seals. A coolant source and an RF/dc tuning network are connected to the cathode.

Individual targets are supported on an adapter plate which is screwed into the cathode. Each target is about 3 in. (7.6 cm) in diameter and about 1/4 in. (6 mm) thick. The targets are fabricated from the different materials which are to be deposited except when rare or expensive materials are involved. In those instances, the target is made of stainless steel, and thin sheets of these materials are welded to it.

The grounded plasma shields in this arrangement consist of a ring surrounding an adapter plate and plates or shields which are provided with a series of apertures corresponding to the number of targets with which they are alined. The ring and shields are spaced apart approximately 1/4 in. (6 mm). These elements confine the plasma to prevent spreading and cross-contamination. They are designed so that during operation each individual target cannot "see" either of the adjacent substrates. Since these shields are at the same positive potential as the anode, they can remove some of the electrons from the plasma stream.

In order to sustain the plasma, additional energy is imparted to the stream by a set of electrodes between the shields and the anode. The electrodes have the same aperture configuration, target alinement, and element spacing as the shields. They are electrostatically charged from a voltage divider connected across the high-voltage supply.

Further plasma control is provided by biasing rings. Each ring surrounds the path extending from one target to the substrate. The rings are individually biased by a negative dc voltage ranging from 0 to -3 kV, as required for the particular deposition being produced. Variation of this bias controls the deposition rate.

Two shutters are provided for different purposes. The bottom shutter, used as the conventional shutter, provides a barrier when the target surface is being cleansed before deposition on the substrate is begun. The top shutter selects the particular target from which material is to be drawn. Both shutters have a single aperture. The top shutter is always alined with one of the corresponding apertures in the shields and the electrodes. A spacing between the top shutter and the biasing rings is adjustable and is varied to suit the gas pressure in the chamber and the applied high voltage.

The substrates are mounted on a rotatable worktable which is cooled by a liquid-cooled plate underneath. Each shutter is supported by a hollow shaft; the shafts are arranged in coaxial relationship for the rotation of the worktable.

Using this equipment, films can be deposited in two ways. If the rotating table is moved rapidly between one material and another, the resulting deposition would indicate a definite demarcation between the materials. If the worktable is moved slowly, a mixture would result with a gradual transition between the materials. For compatible materials, this latter mode of operation produces the best adhesion and is extremely useful in fabricating certain types of multilayer depositions.

Note:

Requests for further information may be directed to:

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Reference: TSP75-10178

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,864,239). Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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Categories: 01 (Electronics - Components and Circuitry)
04 (Materials)
08 (Fabrication Technology)