United States Patent

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[33] **Great Britain**
[31] **30011/67**

[54] **IN OR RELATING TO VACUUM APPARATUS**
5 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **204/298**
[51] **Int. Cl.** **C23c 15/00**
[50] **Field of Search** 204/298

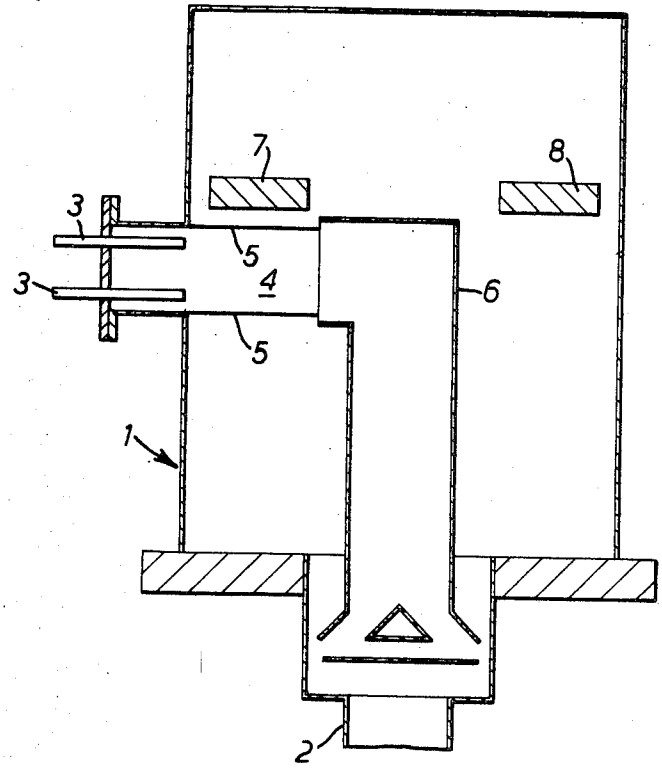
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ABSTRACT: Vacuum apparatus for carrying out a vacuum process within a given region of the chamber, in which gas is introduced to and removed from the region continuously so that the process can be carried out at a selected pressure within the region notwithstanding the fact that the remaining part of the chamber is at a lower pressure.



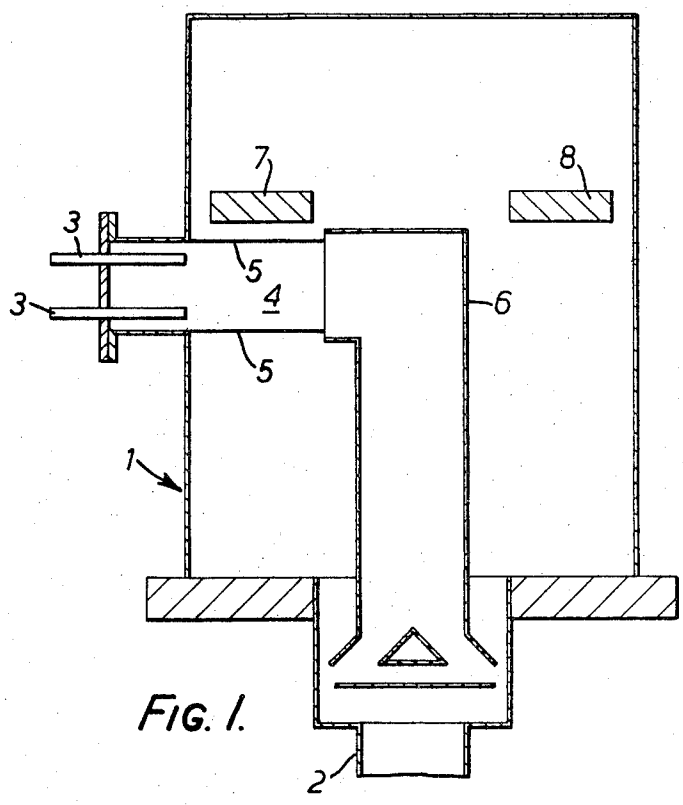


FIG. 1.

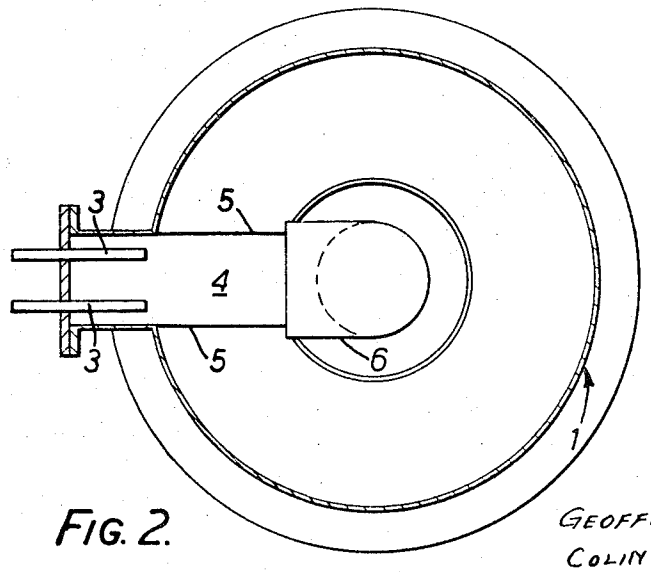


FIG. 2.

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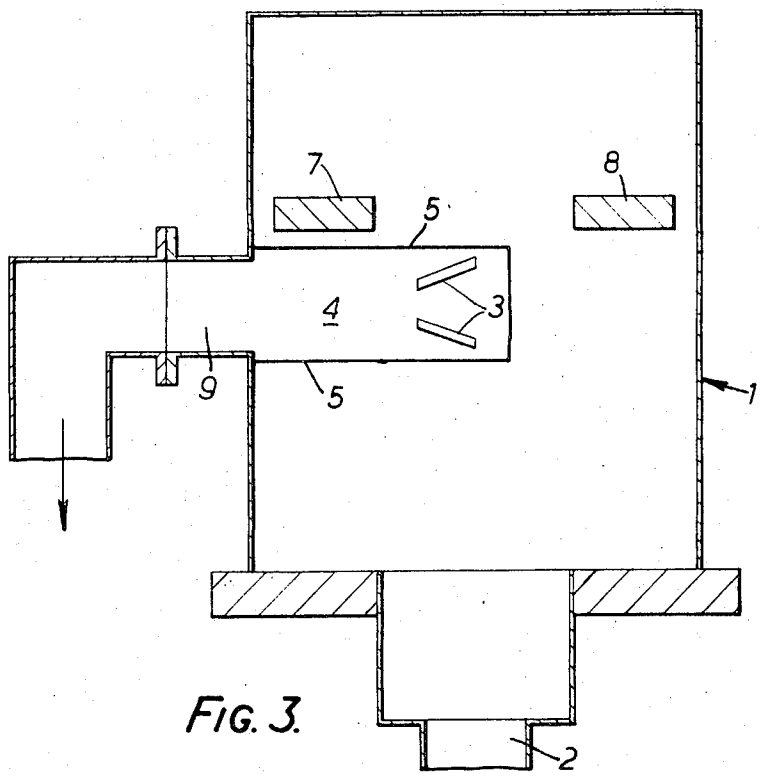


FIG. 3.

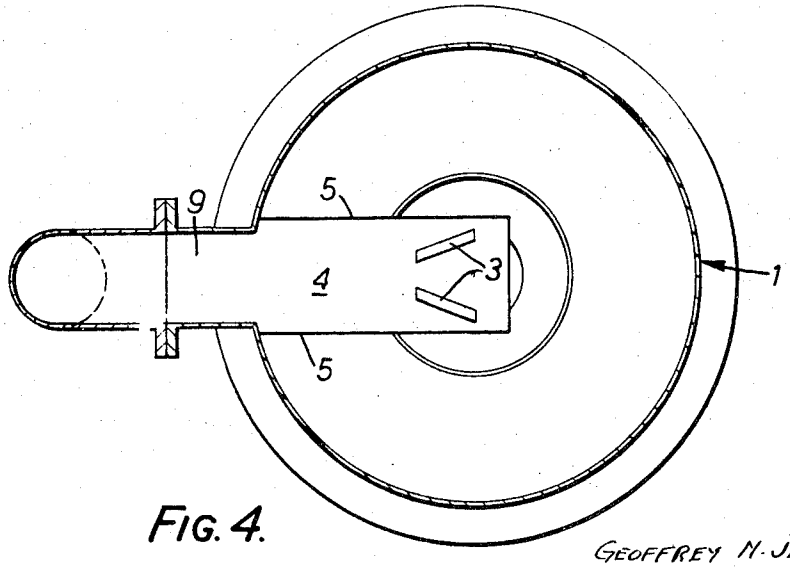


FIG. 4.

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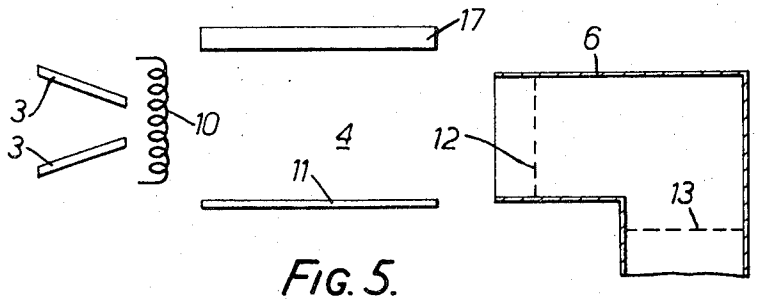


FIG. 5.

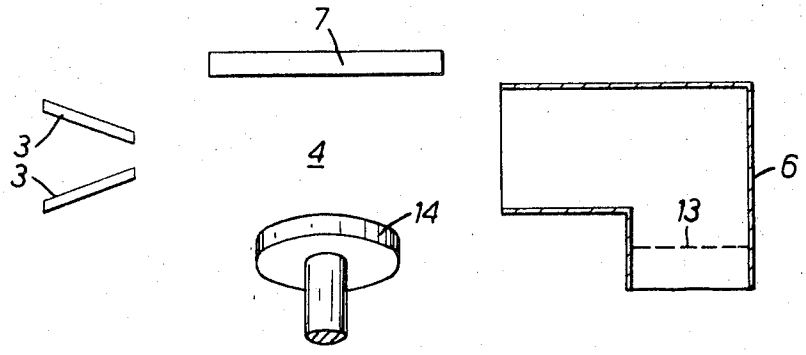


FIG. 6.

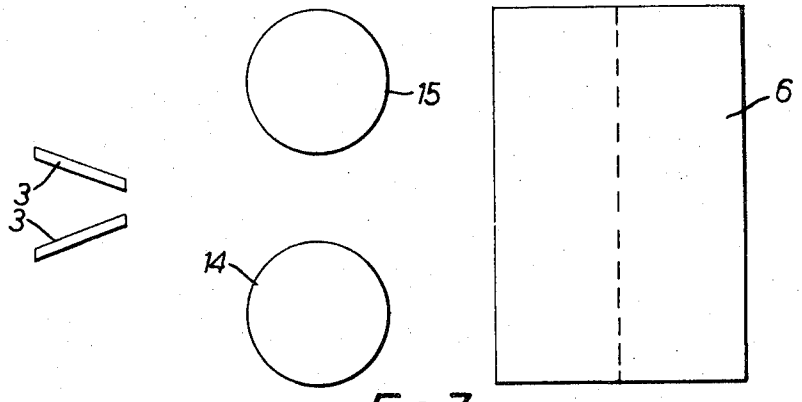


FIG. 7.

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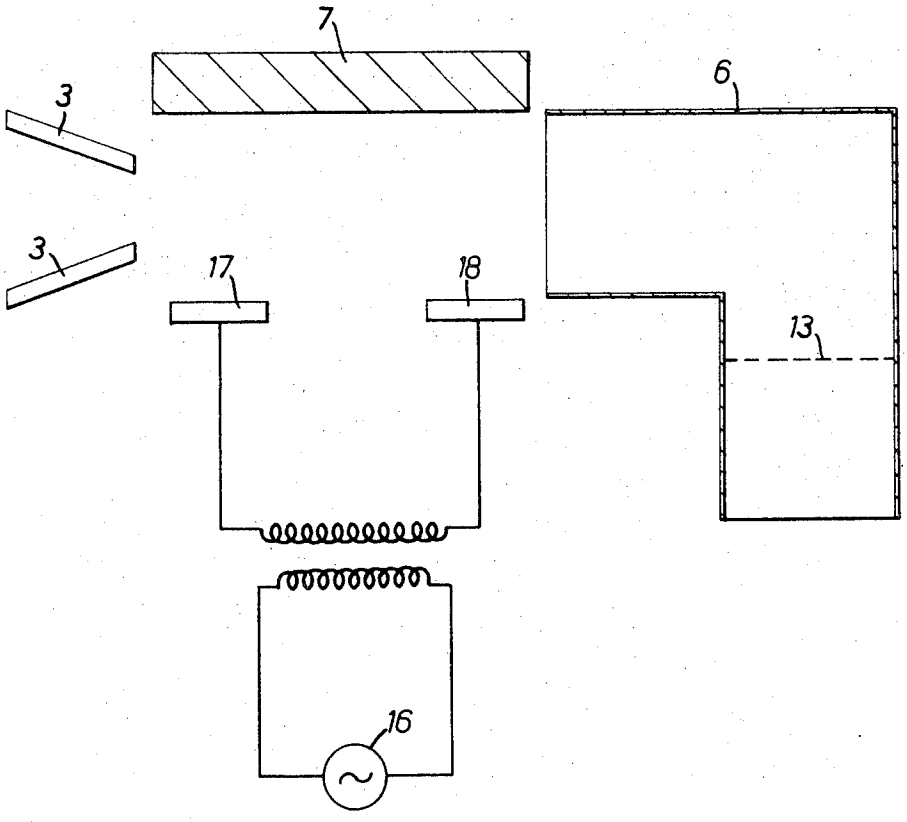


FIG. 8.

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IN OR RELATING TO VACUUM APPARATUS

This invention relates to vacuum apparatus and has particular, although not exclusive, reference to such apparatus for vacuum deposition by sputtering and evaporation techniques.

Sputtering is a process carried out in a vacuum environment in which a target is bombarded with energetic ions or atoms so that it is eroded, the eroded target material being deposited on a suitable substrate. A common technique for generating energetic ions is to create a plasma and to accelerate ions to the target by providing it with a suitable potential bias with respect to the plasma. Three particular forms of the technique are as follows:

a. The plasma can be generated in an anomalous glow discharge with the target as a cathode, the ions from the positive column being accelerated across the cathode dark space towards the cathode. One version of this technique is AC sputtering where each electrode of a number of electrodes becomes a cathode for a period of time in an AC cycle.

b. The plasma can be generated by using a thermionic cathode and an anode supplied with a suitable voltage to generate a glow discharge. The target is biased negatively with respect to the plasma by applying a suitable DC voltage to the target if it is of metal, or by applying a suitable RF voltage to a metal electrode system behind the target if it is of dielectric material. A metal target may be placed over the dielectric for metallic sputtering.

c. The plasma can be generated by a suitable RF electric field in which case the target bias is usually achieved as in (b). The RF voltage used to bias the target can also be used to generate the plasma.

All of these techniques utilizing a "glow discharge" or RF plasma require a vacuum environment in the range 10^{-1} torr to 10^{-4} torr, the pressure depending on the technique used. The gas to be ionized is chosen to suit the process being carried out.

In all these methods the pressure at which sputtering takes place is commonly achieved by baffling the pump and by bleeding in a suitable gas. An equilibrium pressure has therefore to be reached by the successive adjustment of pumping speed and gas influx. However, the pressure creates unsuitable conditions for the simultaneous deposition by evaporation of high-purity films.

According to the present invention vacuum apparatus includes a continuously evacuable chamber, gas introduction means selectively to determine the gas pressure in a predetermined region of the chamber, and a pumping outlet arrangement disposed adjacent the said region so that, in use of the apparatus, the gas may be continuously removed from the said region before its presence substantially affects the pressure in the remaining part of the chamber.

According to a further aspect of the invention vacuum deposition apparatus includes a continuously evacuable chamber housing a sputtering unit for sputtering material from one or more target electrodes onto a workpiece and gas introduction means selectively to determine the gas pressure in the region of the sputtering unit, the apparatus being further provided with a pumping outlet arrangement disposed adjacent the said region so that, in use of the apparatus, the gas may be continuously removed from the said region before its presence substantially affects the pressure in the remaining part of the chamber.

The pumping outlet arrangement may comprise a main pumping outlet from the chamber and a duct directing the gas from the said region to the said outlet. Alternatively, it may comprise a subsidiary pumping outlet situated closely adjacent said region. In either case the gas may be further confined to the said region by a baffle or baffles.

The gas introduction means may most suitably comprise a gas jet or jets.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic sectional elevation of one form of apparatus embodying the invention;

FIG. 2 is a diagrammatic plan view of the apparatus shown in FIG. 1;

FIGS. 3 and 4 corresponding to FIGS. 1 and 2 for a modified form of the apparatus;

FIG. 5 diagrammatically represents the use of triode sputtering in the apparatus illustrated in FIGS. 1 and 2;

FIGS. 6 and 7 diagrammatically represent the use of twin electrode RF sputtering in the apparatus illustrated in FIGS. 1 and 2; and

FIG. 8 diagrammatically represents the use of an AC sputtering technique in the apparatus illustrated in FIGS. 1 and 2.

Referring now to FIGS. 1 and 2 of the drawings, a vacuum chamber 1 is provided with a pumping outlet 2. Gas jets 3 passing through the sidewall of the chamber can introduce gas to the region 4 in which is situated a sputtering arrangement (not shown). The gas is further confined to this region by baffles represented by lines 5 although these are not essential unless a large pressure difference is required. A duct 6 leading to the outlet 2 is provided for continuous removal of the gas. Substrates are shown at 7 and 8, interchange of position being obtained if required by means of a rotary workholder, and it will be seen that substrate 8 is outside the relatively high-pressure region 4 and may be retained at a pressure suitable for further deposition techniques (i.e., evaporation from one or more sources, not shown) which may take place at the same time as deposition by sputtering occurs on substrate 7.

FIGS. 3 and 4 show a modified form of the apparatus described above and it will be seen that the jets 3 are brought into the center of chamber 1 and that a subsidiary pumping outlet 9 is provided for removal of the gas. Lines 5 again represent the use of baffles if a large pressure difference is required.

FIG. 5 shows a triode arrangement employed in the apparatus shown in FIGS. 1 and 2. A cathode filament 10 is placed in front of the gas jets 3 and a perforated or ring type anode 12 is placed at the mouth of duct 6. By applying a DC potential between the anode and the cathode a glow discharge can be obtained in the relatively high-pressure region 4. A target 11 having a negative bias is supported opposite the substrate 7 and sputtering will occur. The gas pumped along duct 6 is prevented from reaching the vacuum pump in an ionized state by means of an earthed or negatively biased grid shield 13. The sputtering rate can be enhanced by providing a magnetic field normal to the plane of the anode 12.

A twin electrode RF sputtering arrangement is illustrated in FIGS. 6 and 7, the second electrode being shown only on FIG. 7. In this case a plasma in region 4 is generated due to the RF voltage applied between the target electrodes 14 and 15, material being sputtered off each of these electrodes onto substrate 7. Again it will be seen that an earthed or suitably biased shield 13 is provided in duct 6. Sputtering of dielectrics can be obtained if the faces of the electrodes 14 and 15 are covered by a dielectric target.

FIG. 8 shows the apparatus employed with an AC sputtering arrangement. An AC supply 16 is connected to the two target electrodes 17 and 18 between which is generated an abnormal glow discharge. The targets will be sputtered alternately and may consist of two different metals in accordance with the coating required on substrate 7.

It will be appreciated that the various sputtering arrangements illustrated in FIGS. 5–8 are by way of illustration only and that any suitable sputtering technique may be employed. The essential feature for operation of apparatus constructed in accordance with the invention is that a region constituted by the major part of the vacuum chamber may be maintained at a lower pressure, say 10^{-6} torr, suitable for many other deposition techniques, while the sputtering region constituted by a minor part of the evacuated chamber may be retained at a low pressure of, say, 10^{-3} torr.

We claim:

1. Vacuum deposition apparatus comprising, in combination:

a. a continuously evacuable chamber,

b. said chamber comprising a major part and a minor part,

c. a sputtering unit including a target electrode situated in said minor part,

d. said minor part constituting a first region to be maintained during operation of the apparatus at a low pressure suitable for sputtering of the target electrode therein, and said major part constituting a second region in said chamber to be maintained at a pressure suitable for other deposition techniques and lower than the pressure to be maintained in said first region,

e. said chamber being provided with a pumping outlet arrangement for continuously evacuating the same, and

f. said apparatus also comprising means for maintaining the difference of pressure between said regions, said last named means being provided in that:

1. said apparatus comprises jet means for delivering gas into said first region, and

2. said pumping outlet arrangement comprises a pumping outlet connection leading directly from said first region,

3. said jet means and pumping outlet connection being relatively positioned so that the gas is continuously projected into and removed from said first region through said jet means and pumping outlet connection for maintaining said low pressure in said first region without substantially affecting the maintenance of said lower pressure in said second region.

2. Apparatus according to claim 1 in which said pumping outlet arrangement comprises a main pumping port leading from said second region of said chamber and a duct directing gas from said first region to said port.

3. Apparatus according to claim 1 in which said first region is constituted by an elongated auxiliary chamber bounded at one end by said jet means and at the other end by said pumping outlet connection, the apparatus also including a baffle which defines a part of said auxiliary chamber.

4. Apparatus according to claim 1 in which said sputtering unit includes an electron-emitting filamentary cathode within said first region adjacent said jet means, and an anode adjacent said pumping outlet connection, with said target electrode situated between said anode and said cathode.

5. Apparatus according to claim 1 in which said sputtering unit comprises a pair of radiofrequency electrodes connected across a radiofrequency voltage supply situated between said jet means and said pumping outlet connection and associated with a material to be sputtered.

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