

[54] SPUTTERING APPARATUS

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[58] Field of Search **204/298**

[56] **References Cited**

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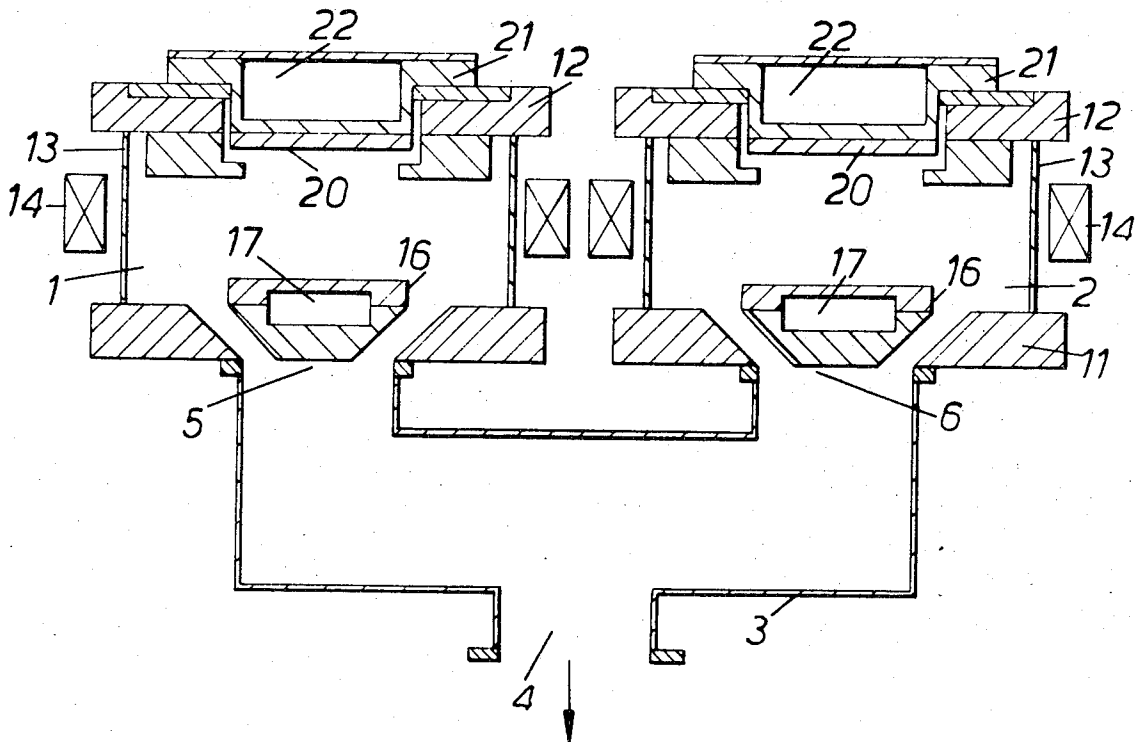
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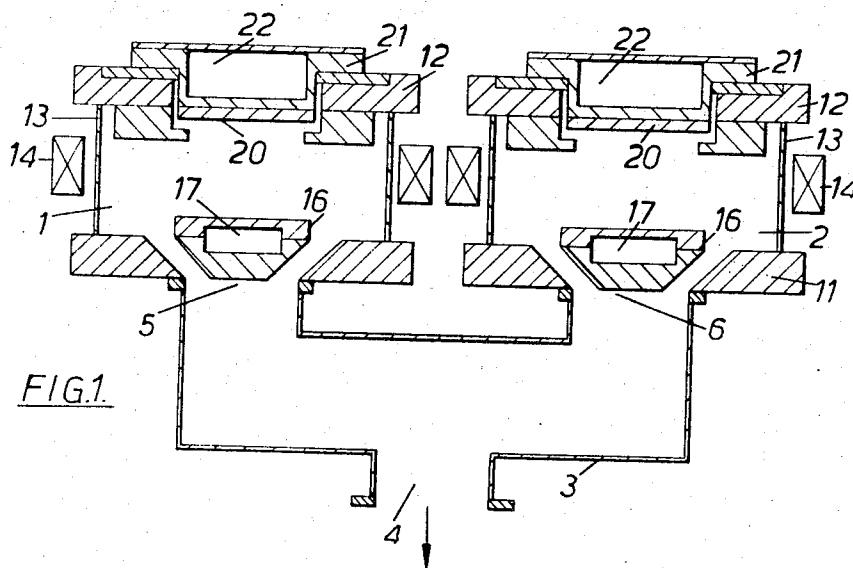
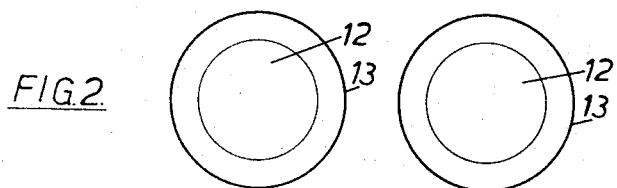
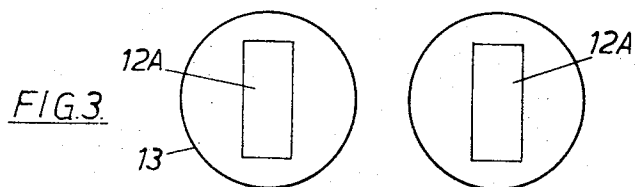
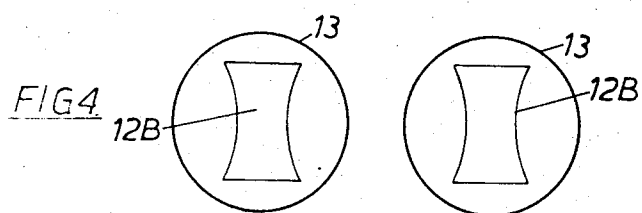
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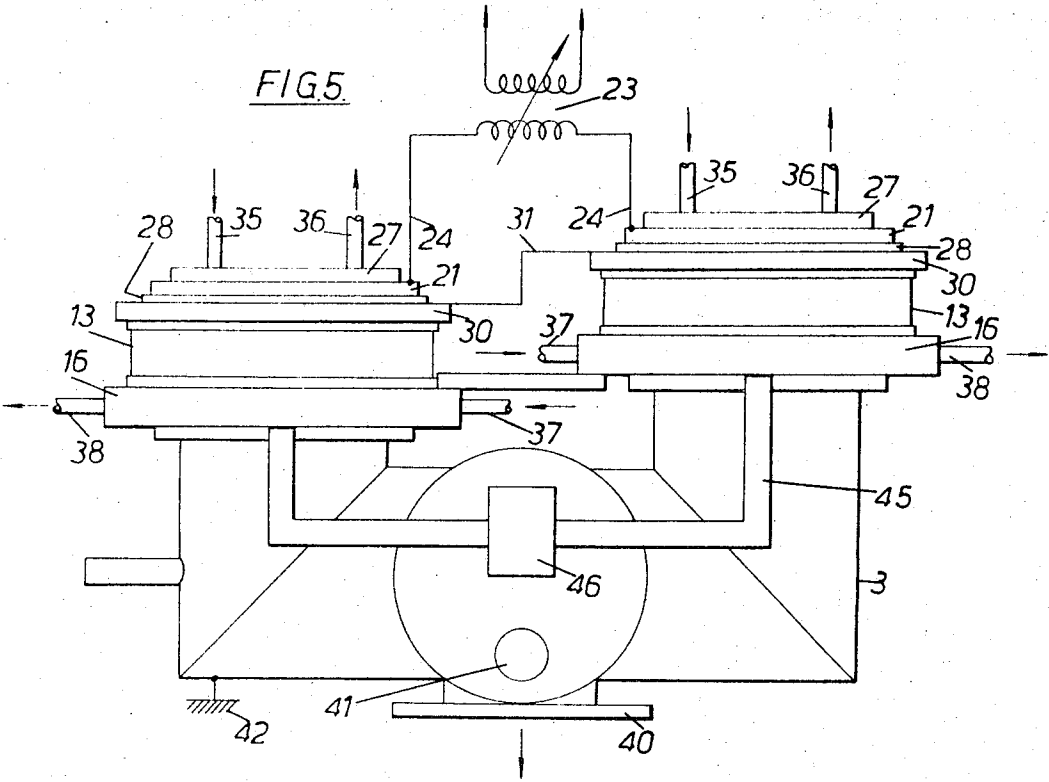
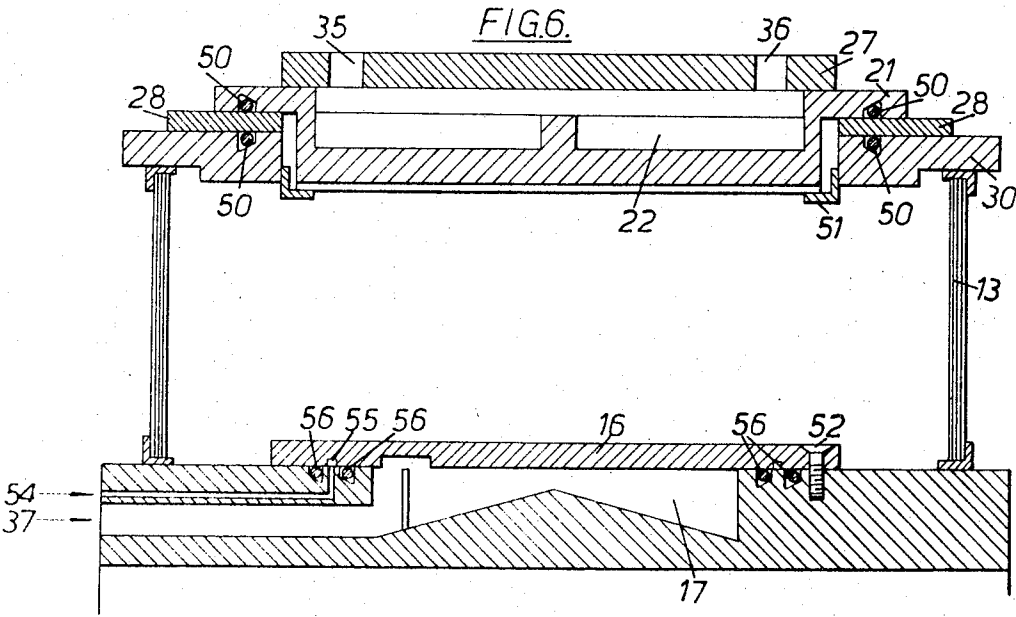
ABSTRACT

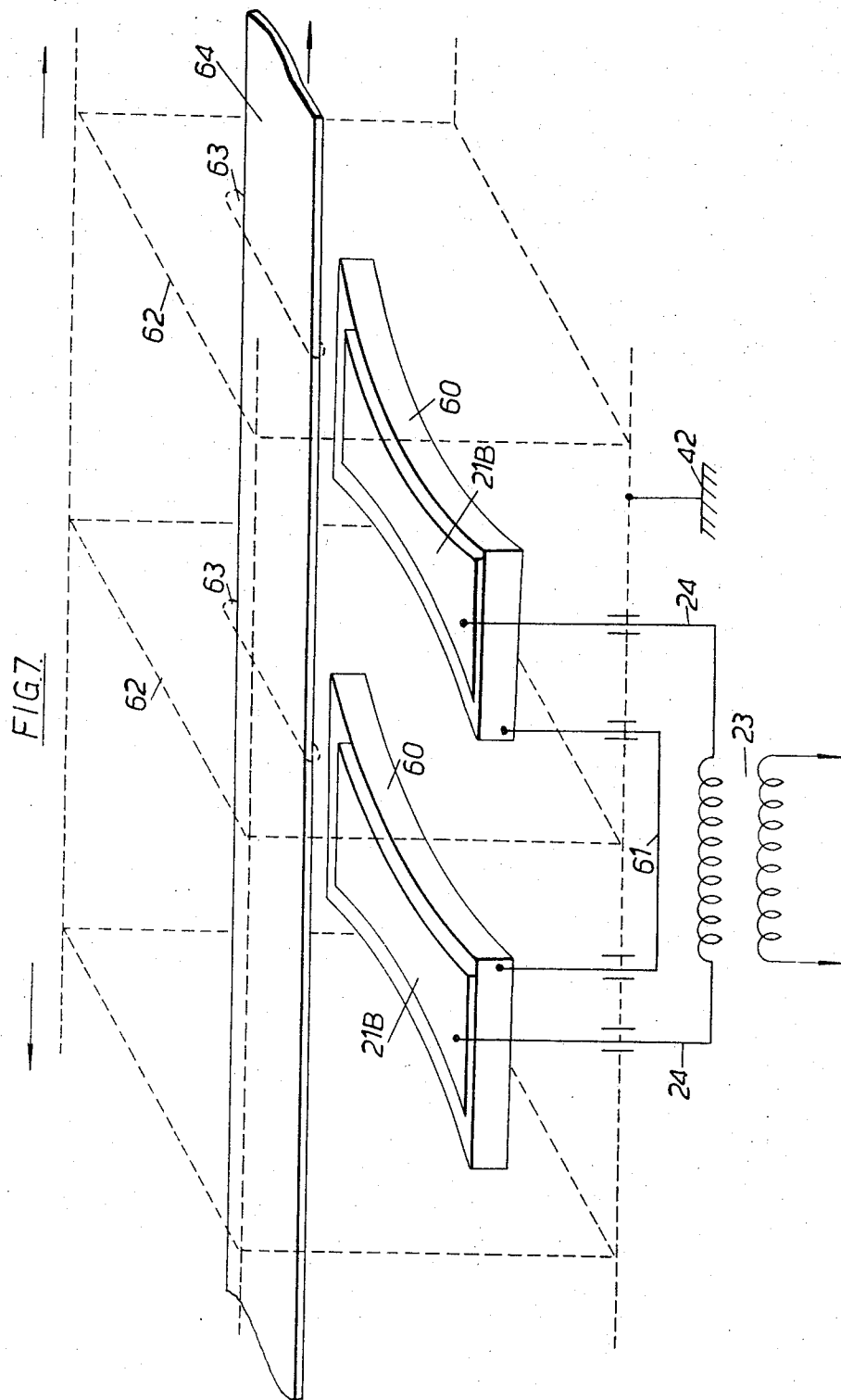
Sputtering apparatus for use with a radio-frequency supply source includes a double electrode arrangement within an evacuable enclosure and in which the individual electrodes are electrically isolated by means of separate walls surrounding each electrode system so as to separate the electric fields associated with the two electrode systems. The walls may define two separately evacuable chambers and these may be interconnected for evacuation by a single pump if required. Separate magnetic field coils may surround each electrode system.

7 Claims, 7 Drawing Figures









SPUTTERING APPARATUS

The use of a radio-frequency supply source for the sputtering of materials is now well established as is also the use of a double electrode system in conjunction with such a source. The preferred type of source is a self-excited radio frequency power generator usually with a non-grounded balanced output which has advantages of cost and ruggedness in use.

Double electrodes previously used have either been of the adjacent type or of the separated type. Examples of this first type are two semi-discs with their diameters placed close to each other or a concentric disc and annulus arrangement while an example of the second type is two separate disc electrodes. With either type of arrangement an associated magnetic field generated by a field coil has generally been employed. The target to be sputtered is placed on the electrodes and it is generally desirable for this to be cooled, one common technique being to bond the target in position and to water-cool the electrode or electrodes.

The bonding of the target is mechanically difficult to achieve with electrodes of the adjacent type unless the target is cut into the shape of the separate electrodes which can be inconvenient. On the other hand the bonding of targets to separate electrodes is much easier. The targets themselves are generally available in the form of discs and for many applications disc electrodes are also preferable in view of the uniformity of deposit thus obtained. Difficulty arises however in providing a suitable magnetic field for both electrodes which will result in the uniformity of etch and deposit from each target disc being symmetrical about the axis of the disc. Even if no magnetic field is used at all the radio-frequency electric fields and plasma associated with the electrodes can interfere with each other and cause non-uniformity of etching and deposit.

According to the present invention the two electrodes of a double electrode arrangement in a sputtering apparatus for use with a radio-frequency supply source are mounted within an evacuable enclosure and are electrically isolated from one another by means of an intervening wall which separates the electric fields associated with the two electrode systems. The separation of the electric fields avoids the interference effects referred to above and thus largely eliminates the resultant non-uniformity of etching and deposit.

Preferably separate magnetic field coils are provided so as to surround each electrode system and the fact that the two systems are isolated from one another means that these two separate coils can be fitted without difficulty. If the two electrodes are mounted within a common chamber the intervening wall needs to extend sufficiently far to divide the chamber into two compartments each of a depth sufficient to contain the plasma generated by the electrode system in that compartment. Preferably two separate walls may be used which thus surround each electrode system and contain the associated plasma and this has the advantage of providing a positive support for the magnetic field coils. Preferably these separate walls are constructed to constitute two separately evacuable chambers rather than separate compartments within a single chamber. This gives rise to the possibility that the two chambers may be atmospherically as well as electrically isolated. In other words different conditions of pressure or gaseous atmosphere may be applied to the two chambers if

required. The two chambers may, however, be interconnected so that they can be evacuated by a single pump when different atmospheric conditions are not required.

A construction in accordance with the invention will now be described in more detail with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic sectional elevation;

FIGS. 2, 3 and 4 illustrate suitable shapes for the double electrodes forming part of the arrangement of FIG. 1;

FIG. 5 shows an example of interconnections between two chambers;

FIG. 6 is a sectional view showing the structure of a chamber in more detail; and

FIG. 7 is a diagrammatic view of an in-line system.

The apparatus shown in FIG. 1 comprises basically two separate chambers 1 and 2 which are interconnected by a conduit 3 so that they can be evacuated by a single pump connected to an opening 4. If different atmospheric conditions are required in the two chambers separate pumps may be fitted to the entrances of the two chambers shown as 5 and 6. The components of each chamber are identical and will thus not be described separately. Each chamber comprises a bottom 11 in which the respective openings 5 and 6 are formed, a top 12 and a generally cylindrical wall 13 extending between the top and the bottom and constituting a support for a magnetic field coil 14.

A worktable 16 for the reception of an object to be coated by sputtering (not shown in the drawings) is cooled by water caused to flow through an internal space 17. The material to be sputtered is constituted by a target 20 which as shown is bonded to an upper electrode 21 which also has an internal space 22 for cooling water. In operation the supply of radio frequency power causes material from the target 20 to be deposited on an object supported by the worktable 16, the chambers 1 and 2 having previously been evacuated as previously described.

During operation the magnetic field coils 14 will normally be supplied with direct current from a source (not shown) thus providing uniform conditions within each chamber resulting in uniformity of etch and deposit. As illustrated in FIG. 1 the electrodes 12 are in the form of discs as illustrated also in FIG. 2 which also illustrates the wall 13 of each chamber. Disc electrodes are usually preferable in view of the uniformity of deposit thus obtained. FIG. 3 shows an alternative shape of electrode shown as 12A which is in the form of a rectangle. This may be used for an in-line system in which substrates or other objects to be coated are passed through successive chambers in which successive stages of the process are carried out.

FIG. 4 illustrates a further shape of electrode 12B also intended for use in an in-line system.

Various of the components in the two chambers 1 and 2 including the work table 16 may be electrically interconnected and FIG. 5 shows an example of such interconnections. In this view, the two chambers are seen in elevation and the electrodes 21 are supplied by a radio frequency supply source 23 by way of conductors 24. Each electrode 21 is fitted with a cover plate 27 and is mounted on an insulator 28. The insulator in its turn is mounted on a member 30 which forms both a top plate and a shield for the electrode 21. The two shields 30 in the two separate chambers are intercon-

ected by a conductor 31, but are not connected to ground. The use of such shielding is standard practice with radio frequency sputtering, its main purpose being to prevent the striking of a discharge between the target-backing electrode 21 and other components which would lead to a loss of power and undesirable erosion. By interconnecting the two shields 30, improved stability of the radio frequency discharge is obtained at high input power levels (i.e., above about 1 watt of radio frequency power per sq. cm. of target).

Alternatively if bias sputtering or controlled reactive sputtering are required the worktable in either or both chambers may be supplied with a D.C. bias with respect to the other components or may be supplied with an alternating voltage with respect to the other components and with the frequency of this voltage not being restricted. A further possibility which can be used in conjunction with those just described is to supply a D.C. voltage to a polarising electrode in either or both chambers.

FIG. 5 also shows various of the external connections to the two chambers. Thus the inlet and outlet connections for cooling water to the electrodes 21 are shown as 35 and 36 respectively, and the corresponding connections to the worktables 16 are shown as 37 and 38. The conduit 3 is shown as formed with a flange 40 for connection to a pump and also includes a pressure gauge 41. The conduit itself is connected to ground at 42. The conduit 3 enables both chambers to be evacuated by a single pump, and a gas inlet pipe 45 fitted with a control valve 46 is connected to both chambers to enable backfilling of the chambers with gas if required.

FIG. 6 shows the internal structure of a single chamber in more detail. As can be seen, the cover plate 27 encloses the water space 22 in the electrode 21. The insulator 28 between the electrode 21 and the shield 30 is fitted with O-rings 50 fitting in corresponding grooves to ensure a good seal at both these points. The combined top plate and shield 30 is provided with an extension 51 to improve its effectiveness as a shield.

The worktable 16 is shown as forming a cover for the space 17 for cooling water, being held in position by screws, one of which is shown as 52 and in addition to the cooling water inlet 37, an inlet 54 for inert gas such as argon at a pressure slightly above that of the water leads to an annular groove 55 in the underside of the worktable. O-rings 56 ensure a good seal on both sides of the groove 55, but even if both these seals fail, the excess gas pressure will prevent the disastrous ingress of water into the chamber.

In the diagrammatic perspective view of FIG. 7, parts already referred to are indicated by the same reference numerals. The electrodes used are of the shape shown in FIG. 4 and are thus denoted as 21B. Each electrode

is provided with shielding 60 which follows the outline of the electrode, the shielding in each chamber being interconnected by a conductor 61 for the reasons already mentioned. As shown, the walls between adjacent chambers, indicated as 62, are formed with openings 63 for the passage of conveyor 64 carrying substrates to be coated (not shown). The conveyor 64 needs to form a close fit with the opening 63 to restrict the passage of gas from one chamber to the next. The substrates are mounted on the conveyor 64 at a spacing such that when one is in one chamber the next is in the adjacent chamber and as the conveyor is moved step by step so each substrate is moved from one chamber to the next. In this way it is possible for successive stages of processing to be obtained in the two chambers. Instead of a conveyor for individual substrates, a substrate in the form of a continuous strip may move continuously through the two chambers.

We claim:

1. Sputtering apparatus for use with a radio frequency supply source, said apparatus including an evacuable enclosure, a double electrode arrangement including two individual electrodes within said enclosure having means affording connection of said electrodes to opposite terminals of a radio frequency source respectively, and wall means arranged to electrically isolate the individual electrodes of said arrangement by separating the electric fields associated with said electrodes when said radio frequency source is energized and defining two electrically separate sputtering areas, and two work supporting table means, one located in each of said areas respectively.

2. Sputtering apparatus according to claim 1, and including separate magnetic field coils surrounding each electrode system.

3. Sputtering apparatus according to claim 1 including separate walls surrounding each electrode system.

4. Sputtering apparatus according to claim 3, in which the walls define two separate chambers, said chambers being adapted for independent evacuation.

5. Sputtering apparatus according to claim 4, including means interconnecting said chambers said means having a connection whereby both chambers may be evacuated by a single pump.

6. Sputtering apparatus according to claim 1 including separate ungrounded shielding associated with each individual electrode and means interconnecting said shielding.

7. Sputtering apparatus according to claim 4, in which said separate chambers are arranged side-by-side said chambers being formed with corresponding openings whereby to permit the continuous passage through them of substrates to be coated.

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