

DEVICE FOR APPLYING THIN LAYERS TO A SUBSTRATE

The invention pertains to a device for applying thin layers to a substrate by means of the cathode sputtering process in a vacuum chamber, through which the substrate to be coated can be transported, the device including a diaphragm between a cathode to be sputtered and an anode, where the plane of the substrate extends underneath the anode, and where profiles - supported by the walls of the vacuum chamber and provided with conduits - are installed parallel to the cathode plane in the area between the cathode and the anode through the conduits of which a coolant and a process gas are conveyed, the conduits for the process gas being provided with openings, which are transverse to the longitudinal axis of the conduit and which allow the process gas to escape into the vacuum chamber.

A device for applying thin layers to a substrate by means of the cathode sputtering process is known (EP 0 205 028). A mechanical diaphragm is in this case installed between the cathode to be sputtered and the anode to divide the space between the cathode and the substrate to be coated. This device is equipped with several separate cooling pipes and gas pipelines to supply the system with tempering medium and process gas.

This known device suffers from the disadvantage that the tempering medium and the process gas are supplied and returned through separate, multi-component pipelines. The system is thus is highly susceptible to operating breakdowns and is also

complicated to produce and maintain. The pipelines have bends, coils, screw joints, and soldered joints, which are under vacuum during the operation of the system. These conditions, under the additional influence of process-related heat, lead to hairline cracks and leaks in the pipelines. At first, these leaks merely impair the quality of the layers, by reducing, for example, the adhesive strength of the layer being applied to the substrate during the sputtering process. Subsequently, however, they lead inevitably to the total failure of the entire system, which is always associated with considerable labor and enormous cost.

To obtain a significant increase in operational reliability and thus to reduce the down times, to achieve a considerable simplification of the production and maintenance work, and thus to arrive at a significant reduction in the production and operating costs, it has been proposed (DE 40 06 511 A1) that both the tempering medium and the process gas be conducted through conduits, in a one-piece structural component in the form of a hollow profile. Openings transverse to the longitudinal axis of the conduits are provided to allow the process gas to escape. The anodes and diaphragms are screwed directly to the hollow profile.

The present invention is now based on the task of improving the known device in such a way that the replacement of the anodes and diaphragms can be easily accomplished from the top of the process chamber without the need for tools and without eye contact. The service life of the anodes and the thermal load

capacity of the diaphragms are also to be improved.

According to the present invention, this task is accomplished by anodes designed as profiled rails with an L-shaped cross section, the short shank of which extends over, and is supported by, the top surfaces of the hollow profiles. The anodes are held in position by bolts, which extend upward from the tops and fit into holes in the short shanks.

Each approximately plate-shaped diaphragm preferably has two shanks on the section facing the process chamber wall, the end surface of one shank being supported on the process chamber wall, while the other shank is approximately in the shape of a hook. The free end of the hook or a projection provided at this end of the shank extends over a strip or hollow profile attached to the process chamber wall.

Further details and characteristics are more fully described and characterized in the patent claims.

The invention can have a great number of possible embodiments; one of these is schematically shown in greater detail in the attached drawings, wherein:

- Figure 1 shows a section of a cathode station with hollow profiles attached to both walls of the process chamber and with L-shaped anodes and multi-shanked diaphragms suspended from, and screwed to, respectively, the hollow profiles;

- Figure 2 shows a side view of a part of a hollow profile according to Figure 1, in partial longitudinal section; and

- Figure 3 shows a top view of a pair of front diaphragms

for the cathode station according to Figure 1.

As Figure 1 shows, a rectangular vacuum chamber 1 is installed between additional vacuum chambers 1', 1'', the various chambers being connected to each other in a line by transfer locks (not shown in detail) in process chamber walls 2, 3.

In vacuum chamber 1, anodes 4, 5 are installed parallel to each other and crosswise to the substrate transport direction and to the direction in which chambers 1, 1', and 1'' are lined up in such a way that hollow, rectangular profiles 6, 7 and diaphragms 8, 9 extend inward toward the center of the chamber. Coolant feed conduits 6a, 7a and return conduits 6b, 7b are located in the hollow profiles, in which centrally situated gas distributor pipes 6f, 7f are also mounted. In addition, conduits 6d, 7d, for the process gas are provided at the bottom with openings 6e, 6e', ; 7e, 7e', , which recur at certain intervals, to allow the process gas to escape from conduits 6d, 7d into vacuum chamber 1. Substrate 10 can be transported in direction of travel A through vacuum chambers 1, 1', 1'' along substrate plane 11, which extends horizontally underneath anodes 4, 5.

Cathode 12 with its flat target 35 is located above and between diaphragms 8, 9 and is parallel to hollow profiles 6, 7 and thus transverse to direction of travel A of the substrate.

Two Z-shaped sealing/guide plates 13, 14 are arranged in such a way that they, together with sealing hoses 30, 31 of elastic material, seal off the gap remaining between hollow

profiles 6, 7 and process chamber walls 2, 3 of vacuum chamber 1.

Hollow profiles 6, 7 are insulated electrically by means of insulating plates 15, 15' and are rigidly joined by means of screws 16, 17 and spacers 20, 20' to process chamber walls 2, 3, for which purpose screws 16, 17 are in turn surrounded by insulating bushings 18, 19. Anodes 4, 5 are designed as L-shaped profiles, and each rests with its short shank 4a, 5a on the top surface of hollow profile 6, 7, where they are held by means of bolts 21, 21',, anchored in the hollow profiles, and are clamped rigidly in place by means of thumb screws 32, 32', Thumb screws 32, 32',, which are easily accessible through upper opening 28, which can be closed by a cover 23, are for this purpose held in strips 24, 24', which, as can be easily seen in Figure 2, are themselves screwed by way of spacer bushings 25, 25', to hollow profiles 6, 7. The two end walls 29, 29' of each process chamber 1, 1', 1'', are shielded by means of pairs of diaphragms 26, 27, made out of pieces of sheet metal, which are also attached to the top surface of rectangular profiles 6, 7. Each diaphragm 26, 27 consists of a bottom part 26', 27', an end wall part 26'', 27'', a side wall part 26''', 27''', and a collar part 26x, 27x. Strips 24, 24', each of which extends along the top of one of hollow profiles 6, 7, has a plurality of threaded bores for wing nuts 32, 32',, the threaded shafts of which rest on bent-over shanks 4a, 5a of anodes 4, 5 and hold them immovably on hollow profiles 6, 7. Strips 24, 24' are themselves screwed down by means of a row of

screws 33, 33' with spacer bushings 25, 25', to hollow profiles 6, 7. Underneath each hollow profile 6, 7 there is a diaphragm 8, 9, which is formed essentially of a first shank 8', 9', parallel to cathode 12 or its target surface 35, and a hook-like second shank 8", 9", which extends upward from the first shank at an angle of approximately 45°. Whereas the end of first shank 8', 9' facing away from cathode 12 rests against process chamber wall 2, 3 or against a hollow profile 38, 39, extending parallel to hollow profile 6, 7, the upper end of second shank 8", 9" extends with its nose-like projection 37, 37' over the top of hollow profile 38, 39 or over a finger-like, vertical projection 40, 40' extending from the profile. Hollow profile 38, 39 is screwed to process chamber wall 2, 3 and is sealed with respect to the process chamber wall 2, 3 and is sealed with respect to the process chamber wall by means of a sealing hose 41, 42.

As Figure 2 shows, lance or gas distributor pipe 6f, 7f has barrier rings 43, 43', distributed over its length, which can be slid back and forth along the pipe and which can be held by means of clamping pieces 44, 44', at precisely determined points on gas distributor pipe 6f, 7f. As a result, the sections or chambers 6d, 6d', ; 7d, 7d', separated by the barrier rings can be supplied independently with gas, and thus the individual nozzles 6e, 6e', ; 7e, 7e', can be supplied with gas at different flow rates. The combination of gas distributor pipe, barrier rings, and hollow profile therefore

makes it possible for the gas streams emerging from nozzles 6e, 6e', ; 7e, 7e', to be adjusted to the process parameters, and this makes it possible in turn for the layer being deposited on substrate 10 to be distributed uniformly.

In known devices of the type described above, the anodes become coated rather quickly during the sputtering process with an insulating layer, which considerably reduces their service life. The coated anodes must therefore be removed at regular intervals from the process chamber and freed of the insulating layer by sandblasting, for example, which represents a considerable interruption of the production process. Anodes 4, 5 according to the invention can be made of steel, which increases their service life. After thumb screws 32, 32', have been loosened, the anodes can be easily removed from chamber 1, 1' through opening 28, which leads to a reduction in the amount of time required to maintain the system. Known anodes are attached to the walls of the process chamber by means of insulating bushings and Teflon strips, which project into the area of the sputtering zone. After a certain sputtering time, this arrangement leads to functional problems, because these parts are not cooled. As a result, the known anodes can be subjected to only modest thermal loads.



1. Device for applying thin layers to a substrate (10) by means of the cathode sputtering process in a vacuum chamber (1), through which the substrate (10) to be coated can be transported, the device also including a diaphragm (8, 9) installed between a cathode (12) to be sputtered and an anode (4, 5), where the plane (11) of the substrate extends under the anode (4, 5); where hollow profiles (6, 7), which are supported by the walls of the vacuum chamber (1) and are provided with conduits (6a, 6b, 6d, 6f; 7a, 7b, 7f, 7d), are installed parallel to the plane of the cathode in the area between the cathode (12) and the anode (4, 5), through which profiles a coolant and a process gas are conveyed; and where the hollow profiles (6, 7) have openings (6e, 6e', ; 7e, 7e',), trans-verse to the conduits, to allow the process gas to escape into the vacuum chamber (1), characterized by anodes (4, 5), designed as profiled rails with an L-shaped cross section, the short shanks (4a, 5a) of which extend over, and rest on, the tops of the hollow profiles (6, 7), in which position they are held by bolts (21, 21',), screws, or clamps, which extend up from the tops of the hollow profiles (6, 7) and which fit into bores in the short shanks (4a, 5a) of the anodes.

2. Device according to Claim 1, characterized in that the short shanks (4a, 5a) of the anodes (4, 6) are provided with blind holes (36, 36',), which match up with the vertically



- 9 -

oriented bolts (21, 21',), screws, or clamps, which are permanently attached to the top surface of each hollow profile (6, 7).

3. Device according to claim 1, characterized by a permanently attached strip (24, 24') parallel to, and a certain distance away from, the top surface of the hollow profiles (6, 7), the strip having a row of threaded holes for the acceptance of screws (32, 32',), whose downward-extending threaded shafts press the shorter shanks (4a, 5a) of the L-shaped anodes (4, 5) against their contact surface with the hollow profiles (6, 7).

4. Device according to claim 1, characterized in that, between the hollow profile (6, 7) and the process chamber wall (2, 3), there is an electrically insulating plate (15, 15'), which is sealed off with respect to the process chamber wall (2, 3) by a sealing hose (30, 31) of elastic material, and which prevents sputtered particles from being deposited on the process chamber wall (2, 3) in the area of the hollow profile (6, 7).

5. Device for applying thin layers to a substrate (10) by means of the cathode sputtering process in a vacuum chamber (1), through which the substrate (10) to be coated can be transported, the device also including a diaphragm (8, 9) installed between a cathode (12) to be sputtered and an anode (4, 5), where the plane (11) of the substrate extends under the anode (4, 5); where hollow profiles (6, 7), which are supported by the walls of the vacuum chamber (1) and are provided with conduits (6a, 6b, 6d,



- 10 -

6f; 7a, 7b, 7f, 7d), are installed parallel to the plane of the cathode in the area between the cathode (12) and the anode (4, 5), through which profiles a coolant and a process gas are conveyed; and where the hollow profiles (6, 7) have openings (6e, 6e', ; 7e, 7e',), transverse to the conduits, to allow the process gas to escape into the vacuum chamber (1), characterized in that each roughly plate-shaped diaphragm (8, 9) has two shanks (8', 8"; 9', 9") on the section facing the process chamber wall (2, 3), one of these shanks (8', 9') being supported by its end surface on the process chamber wall (2, 3), while the other shank (8", 9") is designed in the approximate form of a hook and extends by its free end or by a nose (37, 38') provided at this end over a strip or hollow profile (38, 39) attached to the process chamber wall.

6. Device according to claim 5, characterized in that the diaphragm (8, 9) is made from an approximately rectangular piece of sheet metal, which, on the top surface facing the cathode (12), is provided with a strip, a tab, or a shank (8", 9") parallel to the longitudinal edge forming the boundary of the opening of the diaphragm, this strip, tab, or shank extending upward at an angle of approximately 45° to the plane of the diaphragm toward the process chamber wall (2, 3), the upper free edge of this shank (8", 9") being provided with one or more noses (37, 37'), which extend vertically downward from the shank and which extend over one or more projections (40, 40',), which are provided on a strip or a hollow profile (38, 39), which



- 11 -

is permanently attached to the process chamber wall (2, 3).

7. Device according to one of the preceding claims, characterized in that the hollow profile (6, 7) has a longitudinal conduit (6d, 7d), through which a lance or pipe (6f, 7f) extends coaxially, on which barrier rings (43, 43',) are mounted in such a way that they can be moved back and forth longitudinally and locked in place, as a result of which the longitudinal conduit (6d, 7d) can be divided into individual sections or chambers (6d, 6d', ; 7d, 7d',) which can be supplied with process gas through the pipe (6f, 7f), the individual chambers communicating via nozzles (6e, 6e', ; 7e, 7e',) with the vacuum chamber (1).



- 12 -

Reference symbol list

1, 1', 1''	Vacuum chamber
2	Process chamber wall
3	Process chamber wall
4, 4a	Anode
5, 5a	Anode
6	Hollow profile
6a	Coolant feed conduit
6b	Coolant return conduit
6c	Coolant connecting conduit
6d	Process gas conduit
6e, 6e', ...	Opening
6f	Gas distributor pipe
6g	Reducing part
6h	Reducing part
6i	Gasket
6k	Opening
6l	Gasket
7a	Coolant feed conduit
7b	Coolant return conduit
7c	Coolant connecting conduit
7d	Process gas conduit
7e, 6e', ...	Opening
7f	Gas distributor pipe
7g	Reducing part
7h	Reducing part



- 13 -

7i	Gasket
7k	Opening
8, 8', 8''	Diaphragm
9, 9', 9''	Diaphragm
10	Substrate
11	Substrate plane
12	Cathode
13	Sealing/Guide Plate
14	Sealing/Guide Plate
15, 15'	Insulating plates
16	Screw
17	Screw
18	Insulating Bushing
19	Insulating Bushing
20, 20'	Spacers
21, 21'	Bolts
22, 22'	Thumb Screws
23	Cover
24, 24'	Strips
25, 25'	Spacer Bushings
26, 26',26 ^x	Diaphragm
27, 27',27 ^x	Diaphragm
28	Opening
29	End wall
30	Sealing hose
31	Sealing hose



- 14 -

32, 32', ...	Thumb screws
33, 33', ...	Screws
35	Target
36, 36' ...	Blind bone
37, 37'	Nose
38	Hollow profile
39	Hollow profile
40, 40'	Projection, nose
41	Sealing hose
42	Sealing hose
43, 43', ...	Barrier rings
44, 44', ...	Clamping pieces

Substrate travel direction