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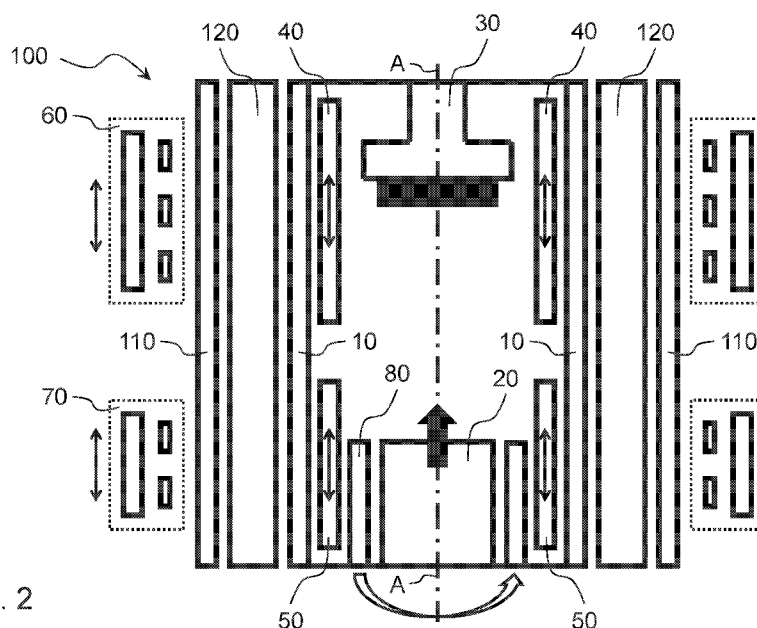


Fig. 2

(57) Abstract: The reaction chamber (100) is designed for a reactor (100) for deposition of layers of semiconductor material on substrates; it comprises a tube (110) and an injector (20) and a holder (30); the tube (110) is made of quartz and has a cylindrical or prismatic shape and surrounds a reaction and deposition zone; the injector (20) is arranged to inject precursor gases into the reaction and deposition zone; the holder (30) is arranged to support a substrate in the reaction and deposition zone during deposition processes; graphite susceptor elements (10, 40, 50) are located inside the tube (110) for heating the reaction and deposition zone and components inside the reaction and deposition zone; an inductor system (60, 70) is located outside the tube (110) for providing energy to the susceptor elements (10, 40, 50) by electromagnetic induction; a rotating element (80) in the form of a cylindrical or prismatic tube is located inside the reaction and deposition zone and surrounds the injector (20).



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REACTION CHAMBER COMPRISING A ROTATING ELEMENT FOR THE DEPOSITION OF A SEMICONDUCTOR MATERIAL

DESCRIPTION

FIELD OF THE INVENTION

5 The present invention relates to a reaction chamber with rotating element and a reactor for deposition of semiconductor material.

STATE OF THE ART

As is known, the reaction chambers of the reactors for deposition of layers of semiconductor material on substrates, sometimes called "seeds", are equipped
10 with a reaction and deposition zone. In particular, (see for example Fig. 1 - similar to Fig. 2 and Fig. 3 of WO2004111316A1 and to Fig. 1 of JP2010280527A) the chamber often (1 in Fig. 1) comprises a tube (2 in Fig. 1), an injector (3 in Fig. 1) and a support (4 in Fig. 1); the tube surrounds a reaction and deposition zone (in Fig. 1; this zone can be considered as the volume associated
15 with the reference 6 or with the entire volume inside the tubular element 5), the injector is arranged to inject precursor gases into the reaction and deposition zone, and the holder is arranged to support a substrate in the reaction and deposition zone during deposition processes.

It is also known that during deposition processes, material can be deposited not
20 only on the substrates, but also elsewhere, in particular on the external surface of the injector (see for example the injector of WO2006125777A1 and JP2010280527A).

To overcome this problem, it is possible to try and design the chamber in such a way as to limit spurious depositions on the external surface of the injector during
25 deposition processes.

However, it is not impossible to completely avoid such spurious depositions; this is particularly true for certain types of reactors.

The Applicant has focused in particular on this problem in the reactors for deposition of layers, for example of silicon carbide on substrates at very high
5 temperature (typically, higher than 2000°C, and which can reach up to 3000°C), more particularly for the "bulk" growth of "ingots/crystals" of silicon carbide on "seeds" of silicon carbide.

In fact, in such reactors, the injector is often located in whole or in large part within the reaction and deposition zone (see, for example, Fig. 1) and therefore
10 the problem of spurious depositions on the external surface of the injector is relevant.

SUMMARY

The general object of the present invention is to provide a reaction chamber which avoids or at least reduces the drawbacks associated with spurious depositions on
15 the external surface of the injector. A first possible drawback is linked to the fact that spurious deposits tend to create particles, for example because they poorly adhere to the surfaces on which they are present. A second possible drawback is linked to the fact that spurious deposits are an (indirect) source of variation in the composition of the material deposited on the substrates; we recall here for
20 example the "autodoping" phenomenon. A third possible drawback is linked to possible mechanical effects due to spurious deposits: difficulty in dismantling the reactor, interferences with moving parts of the reactor.

This general object is reached thanks to what is expressed in the appended claims that form an integral part of the present description.

25 The idea behind the present invention is to use a body which moves suitably

within the reaction and deposition zone and which limits spurious deposits. In particular, these spurious deposits are removed from the body as soon as they tend to exceed a predetermined thickness and/or to leave a predetermined space. This idea is applicable not only to the reactor injector.

5 LIST OF FIGURES

The present invention shall become more readily apparent from the detailed description that follows to be considered together with the accompanying drawings in which:

Fig. 1 shows, very schematically, in side section, a reaction chamber of a reactor
10 for deposition of silicon carbide at a very high temperature according to the prior art,

Fig. 2 shows, schematically, in side section, an example of a reaction chamber of a reactor for deposition of silicon carbide at a very high temperature according to the present invention, and

15 Fig. 3 shows a (partial) detail of the chamber of Fig. 2.

As can be easily understood, there are various ways of practically implementing the present invention which is defined in its main advantageous aspects in the appended claims and is not limited either to the following detailed description or to the appended claims.

20 DETAILED DESCRIPTION

In the reaction chamber 1 of a reactor for deposition of layers of semiconductor material on substrates of Fig. 1, there is an injector 3 represented, for simplicity's sake, as if it were of perfectly cylindrical shape. To understand the solution of Fig. 2 (based on a cylindrical or rotating prismatic tube), the side surface of this
25 cylinder should be mainly taken into consideration, in fact spurious deposition

occurs in particular on this external surface.

In Fig. 2, the injector is associated with the reference 20 and is analogous to the injector 3 of Fig. 1.

In the chamber of Fig. 1, the material continues to slowly deposit on the injector 3
5 during the deposition processes.

In the chamber of Fig. 2, thanks to a mobile element 80 (having a cylindrical or prismatic surface close, for example at a distance of 2-3 mm, to the cylindrical or prismatic surface of the injector 20, but not in contact with this before of the spurious depositions), the thickness of the deposited material is limited, in
10 particular by the distance between the internal surface of the element 80 and the external surface of the injector 20; as soon as these deposits approach the internal surface of the element 80 (for example particularly protruding portions of the deposits such as tips), they are removed from the element itself.

In general, it is advantageous to use a body that moves within the reaction and
15 deposition zone and that has at least one surface that moves close to at least one surface that is subject to spurious depositions, but not in contact therewith (before spurious depositions).

An example of embodiment of the reaction chamber 100 according to the present invention will be described below with the aid of Fig. 2 and Fig. 3.

20 The chamber 100 comprises a tube 110, an injector 20 and a holder 30; the tube 110 is made of quartz and has a cylindrical (or prismatic) shape and surrounds a reaction and deposition zone (which, in particular, corresponds to substantially the entire volume inside the tubular element 10); the injector 20 is arranged to inject precursor gases into the reaction and deposition zone; the holder 30 is arranged to
25 support (at the bottom) a substrate in the reaction and deposition zone during

deposition processes; the black rectangle in the figure corresponds to a substrate on which a considerable thickness of semiconductor material has been deposited. There are graphite susceptor elements 10, 40 and 50 which are located inside the tube 110 for heating the reaction and deposition zone and components inside the reaction and deposition zone; these three elements are cylindrical (or prismatic) tubes; the element 10, which is external and of larger diameter, is used to provide generalized heating, while the elements 40 and 50 are used to provide localized heatings. There is an inductor system, consisting of the assemblies 60 and 70, which is located outside the tube 110 for providing energy to the susceptor elements 10, 40 and 50 by electromagnetic induction. Finally, there is a rotating element 80 in the form of a cylindrical (or prismatic) tube which is located inside the reaction and deposition zone and surrounds the injector 20.

Fig. 2 further shows a cylindrical (or prismatic) tube 120 of thermal insulating material located between the element 110 and the element 10.

It should be noted that, according to this embodiment, the components 10, 20, 30, 40, 50, 60, 70, 80, 110 and 120 have a cylindrical symmetry and their axes coincide (at least substantially) and correspond to the axis AA.

The element 80 is such as to limit deposition of semiconductor material on the external surface of the injector 20 and/or on the internal surface of a bottom susceptor element 50.

Preferably, the element 80 is made of graphite.

The element 80 is located between the injector 20 and the susceptor element 50.

The cylindrical tube of the element 80 can be axially divided into tube sections, i.e. rings, mechanically coupled between each other.

A first cylindrical graphite susceptor element 40 is at a first (upper) end of the

tube 110 and may be moved in a direction parallel to the axis AA (the movement means are not shown in the figures).

A second cylindrical graphite susceptor element 50 is at a first (lower) end of the tube 110 and may be moved in a direction parallel to the axis AA (the movement
5 means are not shown in the figures).

A first inductor assembly 60 is at a first (upper) end of the tube 110 and is associated with the first susceptor element 40; it may be moved in a direction parallel to the axis AA (the movement means are not shown in the figures).

A second inductor assembly 70 is at a second (lower) end of the tube 110 and is
10 associated with the second susceptor element 50; it may be moved in a direction parallel to the axis AA (the movement means are not shown in the figures).

At one of its ends, the element 80 is mechanically coupled to a base device 82, in particular a crown, adapted to receive a rotation motion from a motor (schematically shown in the figure with a block 84) and to transmit the rotation
15 motion to the element 80; preferably, the base device 82 has a plurality of gear teeth at its radial periphery; in Fig. 3, the block 84 is a small toothed pinion (driven by an electric motor) whose teeth mesh with the teeth of the large crown
82.

The cylindrical tube of the element 80 can have an interspace (not shown in the
20 figures) which extends over its length (parallel to the axis AA), and which has an annular-shaped transversal cross-section.

According to a first advantageous possibility, the cylindrical tube of the rotating element 80 has an external surface 80E being rough or rugged and/or an internal surface 80I being rough or rugged; these surfaces which move with respect to the
25 surfaces of the elements 20 and 50 favour an abrasive action on spurious deposits.

According to a second advantageous possibility, wherein the cylindrical tube of the rotating element 80 has an external surface 80E with at least one helical thread and/or an internal surface 80I with at least one helical thread; these moving surfaces that move with respect to the surfaces of the elements 20 and 50 favour
5 gaseous motions and/or the transport of solid material (for example downwards).

It should be noted that the first possibility and the second possibility can be combined.

In Fig. 3, a first interspace is visible between the external cylindrical surface 20E of the injector 20 and the internal cylindrical surface 80I of the element 80, and a
10 second interspace between the external cylindrical surface 80E of the element 80 and the internal cylindrical surface 50I of the susceptor element 50. According to an exemplary embodiment, the thickness of the first interspace (for example 1-10 mm) is smaller than the thickness of the second interspace (for example 1-10 mm); however, in general, the two thicknesses can also be the same.

15 According to the embodiment described, the rotating element has the shape of a cylindrical or prismatic tube; however, first variants may be conceived in which this rotating element has a different shape, for example a truncated cone or a pyramidal trunk or a two-base sphere segment or....

The reaction chamber according to the present invention can advantageously
20 comprise means for removing dust, i.e. the dust generated by the rotating element 80 due to its movement; the previously mentioned helical threads can be considered to be part of these means.

These means can correspond to gas flow inlets and/or gas flow outlets. For example, considering Fig. 3, there is a lower wall 90 of the reaction chamber with
25 a first annular zone 92 and a second annular zone 94 highlighted; in one or both of

these zones a set of holes can be provided adapted to suck up the dust coming from the interspaces.

The reaction chamber according to the present invention can advantageously comprise a cleaning assembly fluidly coupled to the gas flow inlets and/or gas
5 flow outlets. Preferably, this assembly is adapted to be inactive during deposition processes, so as not to create unwanted gas flows during deposition processes.

The reaction chamber according to the present invention advantageously comprises a moving assembly mechanically coupled to the rotating element 80 and adapted to convey a rotation movement to the rotating element 80; the
10 elements 82 and 84 of Fig. 3 can be considered to be part of this assembly.

The moving assembly can be adapted to convey an alternating rotating movement to the element 80.

The moving assembly can be adapted to convey an alternating translational movement to the element 80.

15 A reaction chamber such as the one just described finds use in particular in reactors for deposition of layers, for example of silicon carbide on substrates, in particular in reactors adapted to carry out deposition processes at a very high temperature.

Claims

1. Reaction chamber (100) for a reactor for deposition of layers of semiconductor material on substrates, comprising a tube (110) and an injector (20) and a holder (30), wherein the tube (110) is made of quartz and has a cylindrical or prismatic shape and surrounds a reaction and deposition zone, wherein the injector (20) is arranged to inject precursor gasses into the reaction and deposition zone, wherein the holder (30) is arranged to support a substrate in the reaction and deposition zone during deposition processes, wherein graphite susceptor elements (10, 40, 50) are located inside the tube (110) for heating the reaction and deposition zone and components inside the reaction and deposition zone, wherein an inductor system (60, 70) is located outside the tube (110) for providing energy to the susceptor elements (10, 40, 50) by electromagnetic induction, wherein a rotating element (80) in the form of a cylindrical or prismatic tube is located inside the reaction and deposition zone and surrounds the injector (20).
2. Reaction chamber (100) according to claim 1, wherein the rotating element (80) is arranged so that deposition of semiconductor material on the external surface of the injector (20) and/or on the internal surface of a bottom susceptor element (50) is prevented.
3. Reaction chamber (100) according to claim 1 or 2, wherein a first cylindrical or prismatic graphite susceptor element (40) is at a first end of the tube (110) and may be moved in a direction parallel to the axis (AA) of the tube (110) and a second cylindrical or prismatic graphite susceptor element (50) is at a second end of the tube (110) and may be moved in a direction parallel to the axis (AA) of the tube (110).
4. Reaction chamber (100) according to claim 3, wherein a first inductor

assembly (60) is at a first end of the tube (110) and is associated with the first susceptor element (40) and a second inductor assembly (70) is at a second end of the tube (110) and is associated with the second susceptor element (50).

5 5. Reaction chamber (100) according to any of the preceding claims, wherein the rotating element (80) is made of graphite.

6. Reaction chamber (100) according to any of the preceding claims, wherein the rotating element (80) is located between the injector (20) and a graphite susceptor element (50).

7. Reaction chamber (100) according to any of the preceding claims, wherein
10 the cylindrical or prismatic tube of the rotating element (80) is axially (AA) divided into tube sections mechanically coupled between each other.

8. Reaction chamber (100) according to any of the preceding claims, wherein at an end the rotating element (80) is mechanically coupled to a base device (82) adapted to receive a rotation motion from a motor (84) and to convey the rotation
15 motion to the rotating element (80), wherein preferably said base device (82) has a plurality of gear teeth at its radial periphery.

9. Reaction chamber (100) according to any of the preceding claims, wherein the cylindrical or prismatic tube of the rotating element (80) has a interspace that extends along its length (AA), and that has a annular-shape transversal cross-
20 section.

10. Reaction chamber (100) according to any of the preceding claims, wherein the cylindrical or prismatic tube of the rotating element (80) has an external surface (80E) being rough or rugged and/or an internal surface (80I) being rough or rugged.

25 11. Reaction chamber (100) according to any of the preceding claims, wherein

the cylindrical or prismatic tube of the rotating element (80) has an external surface (80E) with at least one helical thread and/or an internal surface (80I) with at least one helical thread.

12. Reaction chamber (100) according to any of the preceding claims,
5 comprising means for removing dust, said dust being generated possibly by the rotating element (80).

13. Reaction chamber (100) according to claim 12, wherein said means is gas flow inlets and/or gas flow outlets (92, 94).

14. Reaction chamber (100) according to claim 13, wherein said gas flow
10 inlets and/or gas flow outlets (92, 94) are located at the bottom (90) of the reaction chamber.

15. Reaction chamber (100) according to any of the preceding claims,
comprising a cleaning assembly fluidly coupled to said gas flow inlets and/or gas flow outlets (92, 94), and preferably arranged to be inactive during deposition
15 processes.

16. Reaction chamber (100) according to any of the preceding claims,
comprising a moving assembly mechanically coupled to the rotating element (80) and arranged to convey a rotation movement to the rotating element (80).

17. Reaction chamber (100) according to claim 16, wherein said moving
20 assembly is arranged to convey an alternate rotation movement to the rotating element (80).

18. Reaction chamber (100) according to claim 16, wherein said moving
assembly is arranged to convey also an alternate translation movement to the rotating element (80).

25 19. Reactor comprising a reaction chamber (100) according to any of the

preceding claims.

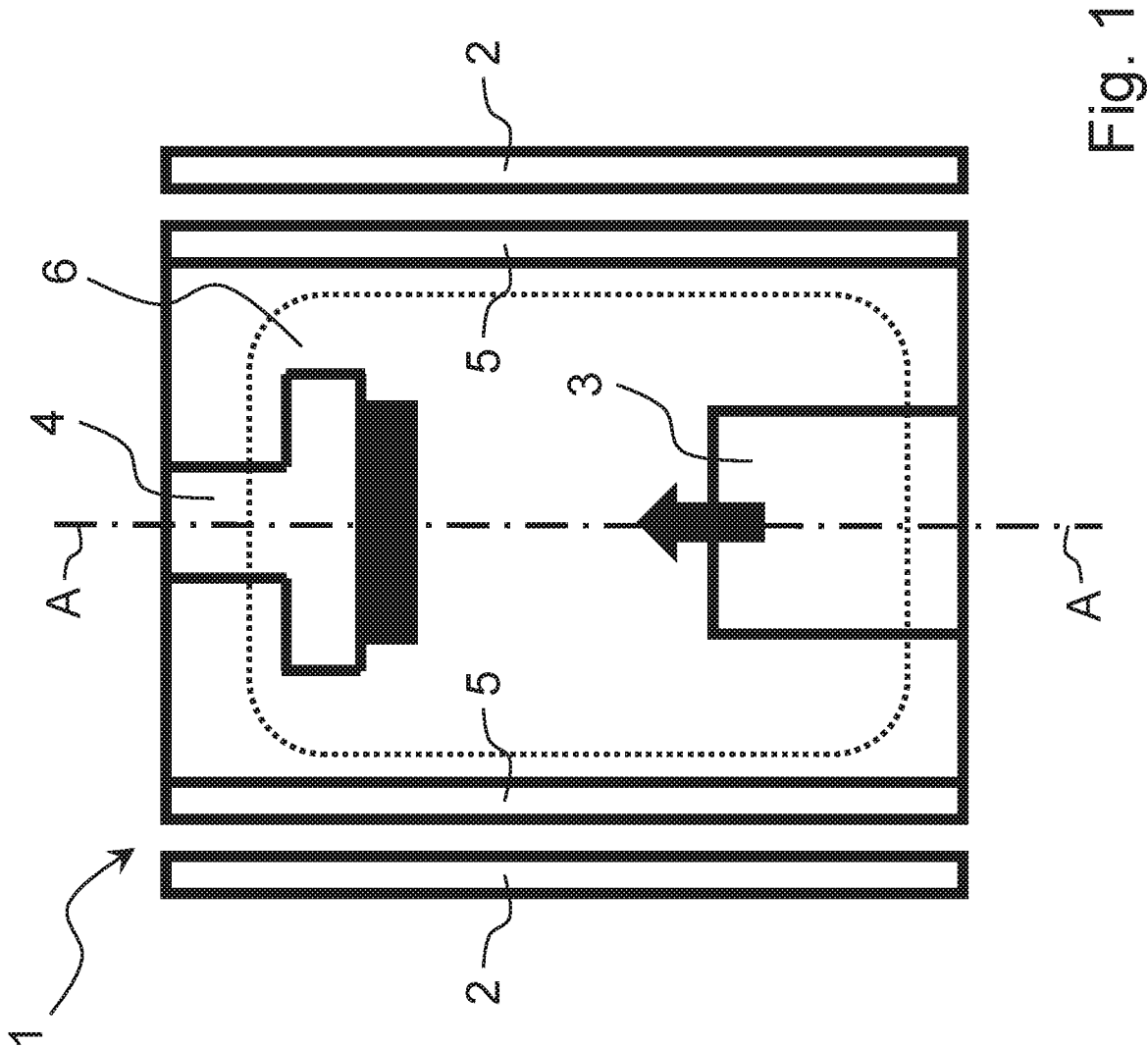
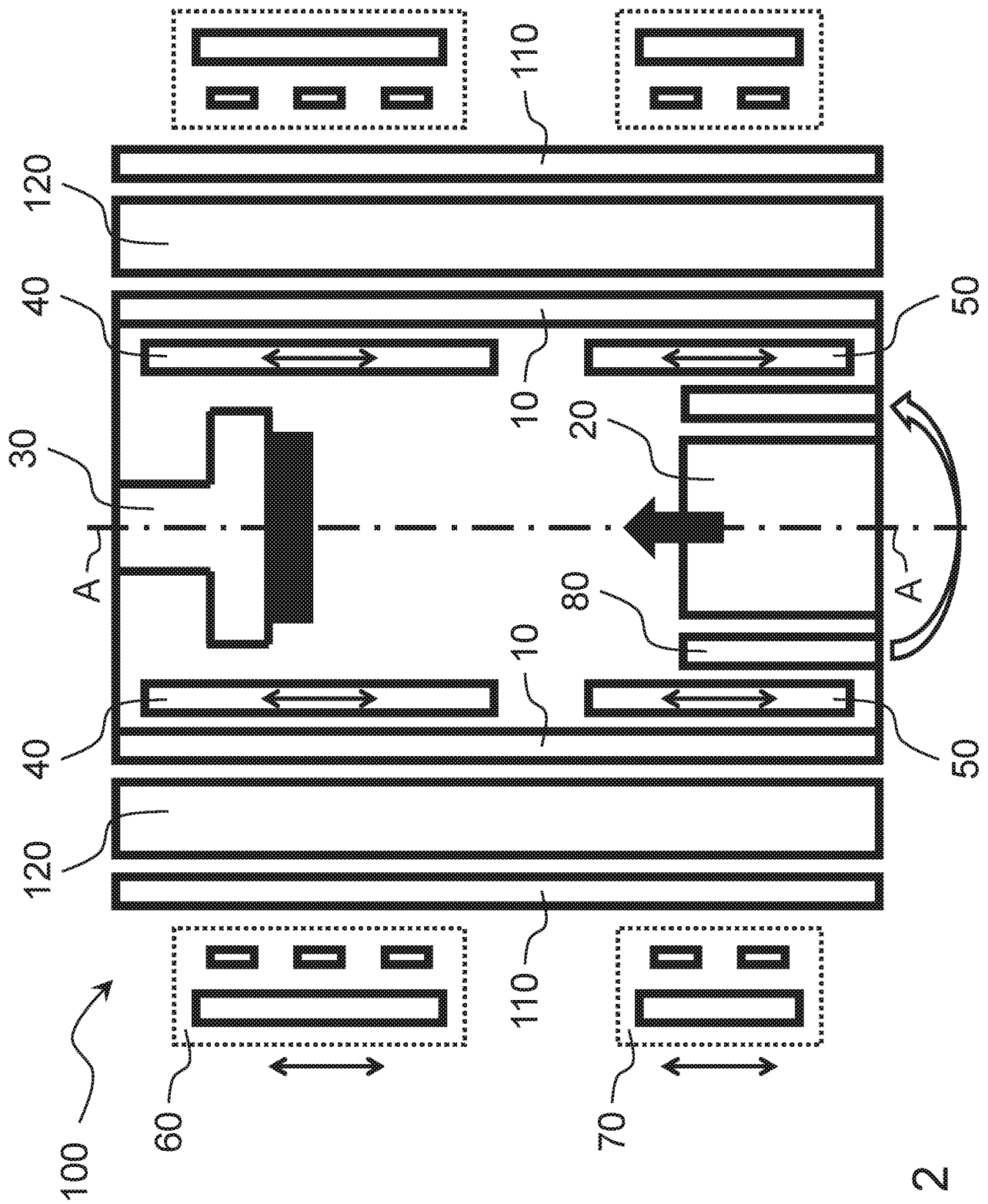
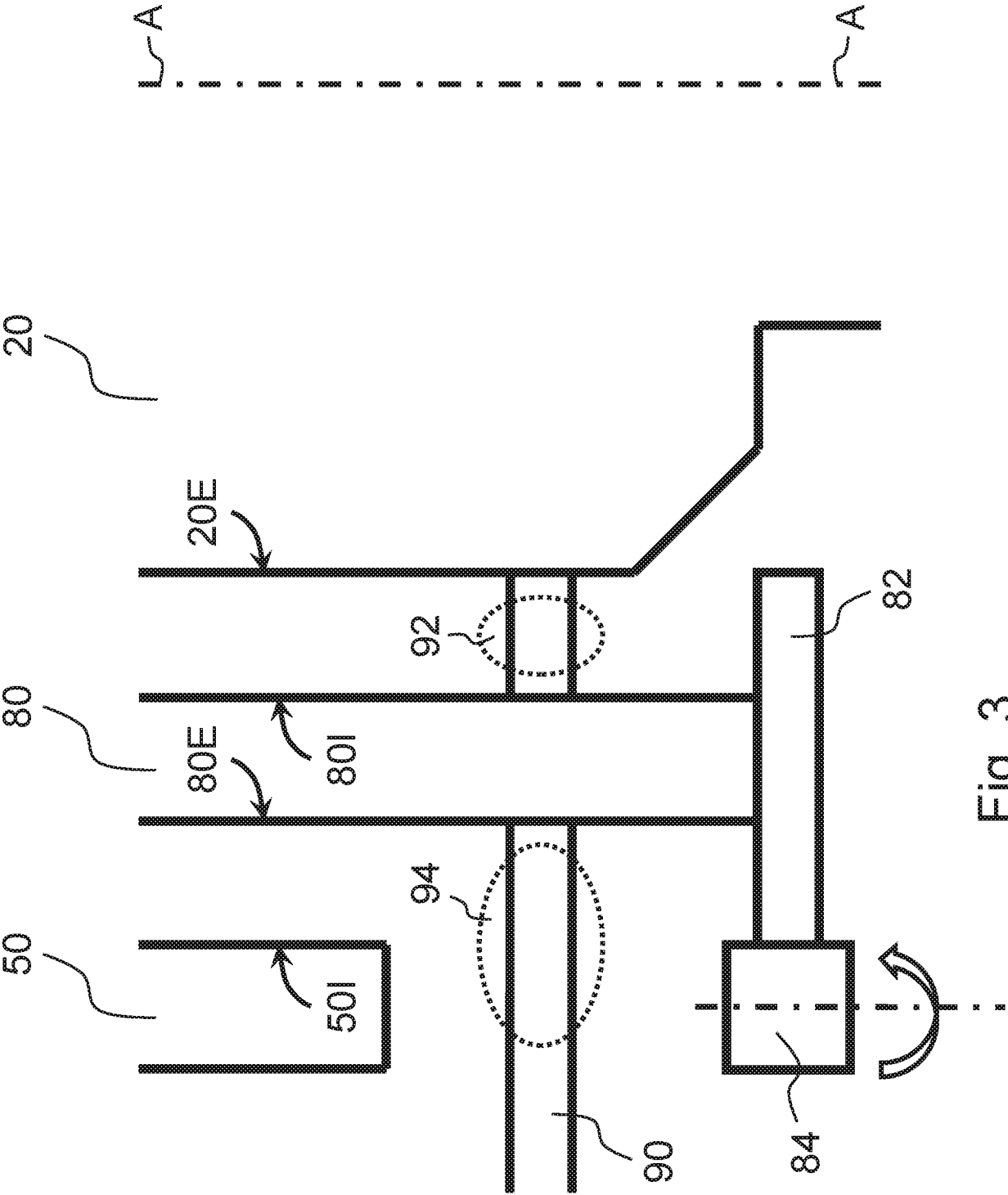


Fig. 1


$$\begin{array}{c} 2 \\ \times \\ 9 \\ \times \\ 4 \end{array}$$



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C C30B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	----- WO 89/04055 A1 (UNIV NORTH CAROLINA STATE [US]) 5 May 1989 (1989-05-05) page 22, line 31 - page 23, line 36; figures 5-6; example 1	1-19
A	----- JP 2013 043805 A (DENSO CORP) 4 March 2013 (2013-03-04) abstract; figures 1-2	1-19
A	----- EP 1 900 856 A2 (DENSO CORP [JP]) 19 March 2008 (2008-03-19) paragraph [0018] - paragraph [0034]; figures 1-6	1-19
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2020/050090

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