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(54) Title: RADIO FREQUENCY (RF) - SPUTTER DEPOSITION SOURCE, CONNECTOR FOR RETROFITTING A SPUTTER DEPOSITION SOURCE, APPARATUS AND METHOD OF OPERATING THEREOF

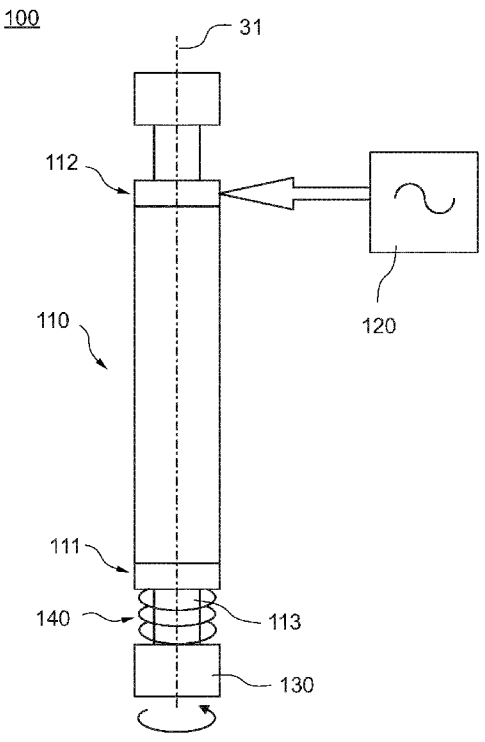


FIG. 1

(57) Abstract: A deposition source for sputter deposition and a method of operating a deposition source for sputter deposition is provided. The deposition source (100) includes a rotatable cathode (110) having a first end (111) and a second end (112). Further, the deposition source includes an RF power supply (120) for providing the rotatable cathode with RF energy. The first end (112) of the rotatable cathode (110) is connected to a drive (130) for rotating the rotatable cathode (110) via a connecting portion (113), wherein a coil (140) is arranged around the connecting portion (113) for shielding the drive (130) from the RF energy. The method (300) includes feeding (310) a rotatable cathode with RF energy, and shielding (320) a drive (130) for rotating the rotatable cathode (110) from the RF energy.

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RADIO FREQUENCY (RF) – SPUTTER DEPOSITION SOURCE, CONNECTOR FOR RETROFITTING A SPUTTER DEPOSITION SOURCE, APPARATUS AND METHOD OF OPERATING THEREOF

TECHNICAL FIELD

[0001] The present disclosure relates to a deposition source for sputter deposition, a connector for a deposition source, a sputtering apparatus, and a method of operating thereof. In particular the present disclosure relates to a sputter deposition source for radio frequency (RF) sputtering utilizing a rotatable cathode, a connector for retrofitting a sputter deposition source, an RF sputtering apparatus for sputter deposition in a vacuum chamber, and a method of operating an RF deposition source for sputter deposition.

BACKGROUND

[0002] PVD processes, particularly sputtering processes, gain increasing attention in some technical fields, e.g. display manufacturing. A good deposition rate can be obtained with sufficient layer characteristics by various sputtering techniques. Sputtering, particularly magnetron sputtering, is a technique for coating substrates such as glass or plastic substrates with metallic or non-metallic layers. Accordingly, a stream of coating material is generated by sputtering a target using a plasma. Material is released from the target surface as a result of collisions with high-energy particles from the plasma, wherein plasma parameters such as pressure, power, gas, magnetic field etc. are controlled. The material released from the target travels from the target toward one or more substrates to be coated and adheres thereto. A wide variety of materials, including metals, semiconductors and dielectric materials can be sputtered to desired specifications. Magnetron sputtering has found acceptance in a variety of applications including semiconductor processing, optical coatings, food packaging, magnetic recording, and protective wear coatings.

[0003] Known sputtering devices include a power arrangement with a power supply for generating and supplying electric energy, a power delivery assembly for depositing said

energy in a gas for igniting and maintaining the plasma, magnetic elements for controlling the motion of the plasma ions, and at least one cathode including a target for providing the coating material through sputtering by the plasma. Sputtering is accomplished with a wide variety of devices having differing electrical, magnetic, and mechanical configurations. The known configurations include power arrangements providing direct current (DC) or alternating current (AC) for producing the plasma, wherein AC electromagnetic fields that are applied to a gas regularly provide for higher plasma rates than DC electromagnetic fields. In a radio frequency (RF) sputtering apparatus, the plasma is striked and maintained by applying an RF electric field. Accordingly, also non-conductive materials may be sputtered.

[0004] Sputtering devices with both static targets such as flat plate targets and rotating targets such as rotating cylindrical targets are known in the art. Regularly, sputtering devices with rotating targets are adapted for operation with direct current or low- to medium frequency alternating current only, but do not operate using RF emissions. As a result, such devices are only suitable for the deposition of conductive layers. In recent years, efforts have been made to combine the advantages of rotatable targets and RF sputtering. However, it is difficult to reliably apply RF power to rotating targets and at the same time avoid undesired inductive and magnetic effects. The present disclosure addresses these problems and is meant for providing sputtering devices for RF sputtering utilizing rotatable targets.

SUMMARY

[0005] In light of the above, a deposition source for sputter deposition, an connector for a sputter deposition source, a method of operating a deposition source, and a sputtering apparatus according to the independent claims are provided. Further advantages, features, aspects and details are apparent from the dependent claims, the description, and the accompanying drawings.

[0006] According to one aspect of the present disclosure, a deposition source for sputter deposition is provided. The deposition source includes a rotatable cathode having a first end and a second end. Further, the deposition source includes a RF power supply for

providing the rotatable cathode with RF energy. The first end of the a rotatable cathode is connected to a drive for rotating the rotatable cathode via a connecting portion, wherein a coil is arranged around the connecting portion for shielding the drive from the RF energy.

[0007] According to another aspect of the present disclosure, a connector for shielding a drive for a rotatable cathode of a deposition source from RF energy provided to the rotatable cathode is provided. The connector includes a first coupling portion adapted for coupling the connector with the drive of the rotatable cathode at a first end of the connector. Further, the connector includes a second coupling portion adapted for coupling the connector with the rotatable cathode at a second end of the connector. Further, an insulator is arranged between the first end of the connector and the second end of the connector, and a coil is mounted on the insulator.

[0008] According to one aspect of the present disclosure, an existing deposition source including a rotatable cathode may be retrofitted with a connector according to embodiments described herein for shielding a drive for the rotatable cathode from RF energy. Accordingly, a method for retrofitting a deposition source including a rotatable cathode is disclosed, wherein the method for retrofitting a deposition source includes providing the deposition source with the connector according to embodiments described herein.

[0009] According to a further aspect of the present disclosure, a method of operating a deposition source for sputter deposition is provided. The method includes feeding a rotatable cathode with RF energy, and shielding a drive for rotating the rotatable cathode from the RF energy.

[0010] According to a further aspect of the present disclosure, a sputtering apparatus is provided. The sputtering apparatus includes a vacuum chamber and a deposition source according to embodiments described herein. Alternatively, the sputtering apparatus includes a vacuum chamber and a rotatable cathode connected to a drive for rotating the rotatable cathode, wherein the rotatable cathode is connected to the drive via a connector according to embodiments described herein.

[0011] The disclosure is also directed to an apparatus for carrying out the disclosed methods and including apparatus parts for performing the methods. The method may be performed by way of hardware components, a computer programmed by appropriate software, by any combination of the two or in any other manner. Furthermore, the disclosure is also directed to operating methods of the described apparatus. It includes a method for carrying out every function of the apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] So that the manner in which the above recited features of the disclosure described herein can be understood in detail, a more particular description, briefly summarized above, may be had by reference to embodiments. The accompanying drawings relate to embodiments of the disclosure and are described in the following:

FIG. 1 shows a schematic side view of a deposition source for sputter deposition according to embodiments described herein;

FIG. 2A shows a schematic side view of a section of a deposition source for sputter deposition according to embodiments described herein;

FIG. 2B shows a schematic top view of the section A-A of Fig. 2A of the deposition source for sputter deposition according to embodiments described herein;

FIG. 2C shows a schematic side view of a section of a deposition source for sputter deposition according to embodiments described herein;

FIG. 2D shows a schematic top view of the section E-E of Fig. 2C of the deposition source for sputter deposition according to embodiments described herein;

FIG. 3 shows a schematic side view of a deposition source for sputter deposition according to embodiments described herein;

FIG. 4A shows a schematic side view of a section of a deposition source for sputter deposition according to embodiments described herein;

FIG. 4B shows a schematic top view of the section B-B of Fig. 4A of the deposition source for sputter deposition according to embodiments described herein;

FIG. 5 shows a schematic side view of a deposition source for sputter deposition according to embodiments described herein;

FIG. 6A shows a schematic side view of a connector according to embodiments described herein for shielding a drive for a rotatable cathode of a deposition source from RF energy provided to the rotatable cathode.

FIG. 6B shows a schematic sectional view along section C-C of a connector according to embodiments described herein as shown in FIG. 6A.

FIG. 7A shows a schematic side view of a connector according to further embodiments described herein for shielding a drive for a rotatable cathode of a deposition source from RF energy provided to the rotatable cathode.

FIG. 7B shows a schematic sectional view along section D-D of a connector according to embodiments described herein as shown in FIG. 7A.

FIG. 8 shows a block diagram illustrating a method of operating a deposition source for sputter deposition according to embodiments described herein; and

FIG. 9 shows a schematic view of a sputtering apparatus according to embodiments described herein.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0013] Reference will now be made in detail to the various embodiments of the disclosure, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. In the following, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the disclosure and is not meant as a limitation of the disclosure. Further, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a

further embodiment. It is intended that the description includes such modifications and variations.

[0014] In the present disclosure, a "deposition source" may be understood as a deposition source for sputter deposition including a rotatable cathode having a target made of the material to be deposited on the substrate. For example, the target material can be selected from the group consisting of: aluminum, silicon, tantalum, molybdenum, niobium, titanium, indium, gallium, zinc, tin, silver and copper. Particularly, the target material can be selected from the group consisting of indium, gallium and zinc.

[0015] In the present disclosure, a "rotatable cathode" may be understood as a cylindrical cathode having an axial rotation axis. In particular, a "rotatable cathode" may be understood as a cathode which rotates around the axial rotation axis of the cathode during sputtering. For example, a "rotatable cathode" may be driven by a drive during sputter deposition of target material on a substrate. In the present disclosure, a "rotatable cathode" may extend along a longitudinal axis from a first end of the rotatable cathode to a second end of the rotatable cathode, e.g. along a longitudinal rotation axis around which the rotatable cathode may be rotatable. The first end of the rotatable cathode may be opposed to the second end of the rotatable cathode. In particular, the longitudinal extension of a "rotatable cathode" as described herein may be defined by the portion of the "rotatable cathode" which includes a target material. The portion of the rotatable cathode including the target material may extend from the first end of the rotatable cathode to the second end of the rotatable cathode.

[0016] In the present disclosure, a "RF power supply" may be understood as a power supply which is adapted for supplying alternating current that oscillates at radio frequencies. In particular, the term "RF power" as used herein refers to currents oscillating at an oscillation rate in a frequency range between 1 MHz to 300 GHz, particularly in a range between 2 MHz to 1 GHz, and particularly to alternating current (AC) power having a frequency of 13.56 MHz, particularly 27.12 MHz or another multiple of 13.56 MHz.

[0017] In the present disclosure, a "coil" may be understood as an electromagnetic coil. In particular, a "coil" may be understood as an electrical conductor such as a wire in the shape of a coil, spiral or helix.

[0018] In the present disclosure, the expression "shielding from the RF energy" may be understood in that RF energy is subjected to a low-pass filter, such that only frequencies lower than a certain cutoff frequency may pass, and frequencies higher than the cutoff frequency may be attenuated. In particular, the cutoff frequency may be selected such that RF frequencies as described herein are attenuated or even blocked.

[0019] FIG. 1 shows a deposition source 100 for sputter deposition, including a rotatable cathode 110 having a first end 111 and a second end 112. Further, the deposition source includes a RF power supply 120 for providing the rotatable cathode with RF energy. As exemplarily shown in FIG. 1, the first end 111 may be connected to a drive 130 for rotating the rotatable cathode 110 via a connecting portion 113, wherein a coil 140 is arranged around the connecting portion 113 for shielding the drive 130 from the RF energy. Particularly, the coil 140 may be arranged around the connecting portion 113 between the drive 130 and the rotatable cathode 110. According to embodiments which can be combined with other embodiments described herein, the drive 130 may be connected to the first end 111 of the rotatable cathode 110 or to the second end 112 of the rotatable cathode 110. Alternatively, a first drive may be connected to the first end 111 of the rotatable cathode 110 and a second drive may be connected to the second end 112 of the rotatable cathode 110. Accordingly, the coil arranged around the connecting portion may function as a low pass filter for the RF energy provided to the rotatable cathode, such that the RF energy may not be transmitted into the drive, the bearings and sliding contacts of the rotatable cathode. Accordingly, negative effects of the RF energy on the drive and the bearings, such as heating and material stress caused by RF energy can be reduced or even eliminated. Accordingly, embodiments of the deposition source as described herein provide for improved RF sputtering utilizing rotatable targets. In particular, embodiments of the deposition source as described herein provide for a prolonged product-lifecycle compared to conventional RF deposition sources having rotatable cathodes.

[0020] As exemplarily shown in FIG. 1, according to some embodiments of the deposition source which can be combined with other embodiments described herein, the RF power supply 120 for providing the rotatable cathode with RF energy may be connected to the rotatable cathode 110 at the second end 112 of the rotatable cathode 110. Additionally or alternatively the RF power supply 120 for providing the rotatable cathode

with RF energy may be connected to the rotatable cathode 110 at the first end 111 of the rotatable cathode 110.

[0021] According to embodiments which can be combined with other embodiments described herein, the rotatable cathode 110, as exemplarily shown in FIG. 1, may have a cylindrical form and may be rotatable around a rotation axis 31. According to embodiments described herein, the first end 111 of the rotatable cathode 110 is a first axial end of the rotatable cathode 110, and the second end 112 of the rotatable cathode 110 is a second axial end of the rotatable cathode opposing the first end 111 of the rotatable cathode 110. The rotatable cathode 110 may include a target of metallic and/or non-metallic material to be released from the target by sputtering and to be deposited on a substrate to be coated.

[0022] As compared to a stationary planar target, a rotatable target provides the advantage that the target material may be reliably utilized around the whole circumference of the target during sputtering. Further, the occurrence of less sputtering on the edge portions of the target surface, in a lateral direction of the target, can be avoided. Accordingly, by utilizing rotatable cathodes, material costs can be reduced and the target can be used for a longer time period, before a target exchange becomes necessary.

[0023] According to embodiments which can be combined with other embodiments described herein, the coil may include a conductive material, in particular a metallic material. For example, the coil may include at least one material selected from the group consisting of: silver (Ag); copper (Cu); gold (Au); and aluminium (Al). According to embodiments which can be combined with other embodiments described herein, the coil may include a conductive alloy, for example an alloy including at least one material selected from the group consisting of: silver (Ag); copper (Cu); gold (Au); and aluminium (Al).

[0024] According to embodiments which can be combined with other embodiments described herein, the coil may include at least one winding. For example, the coil can include one winding, i.e. the coil may be a ring. In particular, the number of windings, the material of the coil, the diameter of the coil, and the diameter of the wire forming the coil

may be selected according to the desired electromagnetic properties of the coil employed for shielding the drive from the RF energy.

[0025] With exemplary reference to FIGS. 2A and 2B, according to embodiments which can be combined with other embodiments described herein, the connecting portion 113 may include an insulator 114. Accordingly, the connecting portion 113 may be protected from RF-energy. The insulator may include at least one material selected from the group consisting of: plastic, particularly polyethylen, polyvinyl chloride, kapton, teflon, silicon, ethylene tetrafluoroethylene; tetrafluoroethylene (PTFE); polyether ether ketone (PEEK); glass; ceramic; and porcelain, particularly Frialit (Al_2O_3).

[0026] According to embodiments which can be combined with other embodiments described herein, the insulator 114 may be coupled to the drive 130, as exemplarily shown in FIG. 2A. In particular, the insulator may be coupled to the drive such that a turning moment can be transmitted from the drive to the insulator. Accordingly, the insulator 114 may be rotatable and driven by the drive 130. According to embodiments in which the coil 140 is mounted on the insulator 114, the coil 140 may rotate with the insulator 114 when the insulator is driven by the drive 130. For example, the coil may be wound onto the insulator. Accordingly, the insulator 114 and the coil 140 mounted on the insulator may be rotatable with the rotatable cathode 110. In particular, the angular velocity of the insulator and the coil may be equal to the angular velocity of the rotatable cathode, when the insulator and the rotatable cathode are driven by the drive.

[0027] According to embodiments which can be combined with other embodiments described herein, the coil may be a tubular coil for providing a cooling liquid into the interior of the tubular coil. The tubular coil may include an inlet for providing the cooling liquid into the tubular coil and an outlet for cooling liquid discharge.

[0028] As exemplarily shown in FIG. 2B, according to embodiments which can be combined with other embodiments described herein, the insulator may be protected by at least one protecting element 115. The protecting element 115 may be at least one element selected from the group consisting of: a meander shield, a glass shield, and a ceramic shield. Accordingly, an improved protection of the connecting portion 113 from RF-energy may be provided. According to embodiments which can be combined with other

embodiments described herein, the insulator may be protected from sputter material released from the target during sputtering. For example, the insulator may be protected from sputter material by providing a protection casing which is arranged around the insulator. For example, the protection casing may include a first tube fitted into a second tube, particularly without contact of the first tube with the second tube. Alternatively, the protection casing may be arranged around the coil and the insulator. Accordingly, the first tube and the second tube of the protection casing may have a larger diameter than the coil. According to embodiments which can be combined with other embodiments described herein, the first tube of the protection casing may be connected to the target and the second tube of the protection casing may be connected to the housing of drive. Accordingly, the first tube of the protection casing may rotate with the target and the second tube of the protection casing may remain static. According to embodiments which can be combined with other embodiments described herein, the coil and the insulator may rotate with a driving flange of the drive. Accordingly, it is to be understood that in embodiments as described herein in which the coil is arranged inside a casing 150 which can be filled with an inert gas, vacuum or air, the casing 150 may be protected by a protection casing as described herein. Accordingly, the protection casing ensures the insulation performance of the insulator and the power supplied to the target may only be transmitted via the coil.

[0029] According to embodiments which can be combined with other embodiments described herein, at least one coil may be arranged at a lateral position of the connecting portion 113, as exemplarily shown in FIG. 2C. For example, two or more coils may be arranged at a lateral position of the connecting portion 113 as exemplarily shown in FIGS. 2C and 2D. In particular, multiple coils may be arranged such that the connecting portion of 113 may be surrounded by the multiple coils. According to embodiments which can be combined with other embodiments described herein, the at least one coil arranged at a lateral position of the connecting portion may be connected to the target of rotatable cathode.

[0030] With exemplary reference to FIG. 3, according to embodiments which can be combined with other embodiments described herein, the first end 111 of the rotatable cathode 110 may be connected to a DC power supply 125 for providing the rotatable cathode with DC energy. Accordingly, the rotatable cathode 110 can be simultaneously

supplied with RF energy and DC energy. For example, the rotatable cathode 110 may be provided with DC energy at the first end of the rotatable cathode and with RF energy at the second end of the rotatable cathode, as exemplarily shown in FIG. 3. Accordingly, the coil 140 arranged around the connecting portion 113 at the first end 111 of the rotatable cathode may function as a low-pass filter for the RF energy but allow the DC-power to be transmitted to the rotatable cathode. Accordingly, by providing a deposition source which is provided with RF energy and DC energy, the sputtering deposition rate of the deposition source can be increased. Further, an improved and symmetrical utilization of the target material, particularly in the regions of the outer edges of the target may be achieved, e.g. at the first end of the rotatable cathode and at the second end of the rotatable cathode.

[0031] According to embodiments which can be combined with other embodiments described herein, the first end 111 of the rotatable cathode 110 may be connected to the DC power supply via the coil 140 for providing the rotatable cathode with DC energy. For example, the coil may contact the target of the rotatable cathode. In particular, a first end of the coil may contact the target of the rotatable cathode and a second end of the coil opposing the first end of the coil may contact a flange of the drive. Accordingly, the coil may be used as a conductor to transmit the DC energy to the rotatable cathode, which may allow for a more compact construction.

[0032] As exemplarily shown in FIGS. 4A and 4B, according to embodiments which can be combined with other embodiments described herein, the coil may be arranged inside a casing 150. The casing may include an insulating material. For example, the insulating material may be at least one material selected from the group consisting of: plastic, particularly polyethylen, polyvinyl chloride, kapton, teflon, silicon, ethylene tetrafluoroethylene; tetrafluoroethylene (PTFE); polyether ether ketone (PEEK); glass; ceramic, and porcelain, particularly Frialit (Al_2O_3). Accordingly, the connecting portion including the coil may be electromagnetically isolated.

[0033] According to embodiments which can be combined with other embodiments described herein, the casing 150 may be filled with an inert gas, vacuum or air. Accordingly, the dielectric strength of the assembly including the connecting portion, the coil and the casing may be increased. For example, the inert gas may be selected from the

group consisting of helium, neon, argon, krypton, xenon or radon. In particular the inert gas may be argon (Ar).

[0034] As exemplarily shown in FIG. 5, the deposition source 100 according to embodiments described herein, may be used as a part of a sputtering apparatus according to embodiments described herein. The sputtering apparatus may include a vacuum chamber for performing sputtering within the vacuum chamber. In FIG. 5, a wall portion 151 of the vacuum chamber is shown. According to embodiments, as exemplarily shown in FIG. 5, the RF power supply 120 and the DC power supply 125 may be arranged outside the vacuum chamber and the rotatable cathode 110 may be arranged inside the vacuum chamber. Accordingly, the vacuum chamber may include at least one first vacuum feed-through 152 for transmitting the RF power from the RF power supply 120 through the wall of the vacuum chamber to the rotatable cathode 110. Further, the vacuum chamber may include at least one second vacuum feed-through 153 for transmitting the DC power from the DC power supply 125 through the wall of the vacuum chamber to the rotatable cathode 110.

[0035] The RF power supply 120 may include an RF power generator for generating RF power. Further, as exemplarily shown in FIG. 5, the RF power supply 120 may be connected to an impedance matching network, particularly a matchbox 121, for ensuring a consistent load on the power supply and for adapting the internal resistance of the power supply to the load impedance of the operating cathode. In order to provide for an optimal impedance matching, the matchbox may include adjustable capacitors for balancing purposes. Accordingly, embodiments of the deposition source as described herein provide for maintaining a constant and optimal load on the power supply for power efficient operation of the deposition source.

[0036] With exemplarily reference to FIG. 5, according to embodiments of the deposition source described herein, the rotatable cathode 110 may be supplied with DC energy at the first end 111 of the rotatable cathode 110 by means of a first power connection 141 and with RF energy at the second end 112 of the rotatable cathode 110 by means of a second power connection 142. The first power connection 141 may provide the DC energy form the DC power supply 125 to the first end 111 of the rotatable cathode via the connecting portion 113. Additionally or alternately, the first power connection 141 may provide the

DC energy form the DC power supply 125 to the first end 111 of the rotatable cathode via the coil, for example in embodiments in which the coil is conductively connected with the first end of the rotatable cathode. Accordingly, by providing RF energy and DC energy to the rotatable cathode, the sputtering deposition rate of the deposition source may be increased.

[0037] In FIG 6A, a schematic side view of a connector 200 according to embodiments described herein is shown. In particular, FIG. 6A shows a connector 200 for shielding a drive 130 for a rotatable cathode 110 of a deposition source from RF energy provided to the rotatable cathode 110. According to embodiments of the connector as described herein, the connector includes a first coupling portion 210 which is adapted for coupling the connector with the drive 130 of the rotatable cathode 110. The first coupling portion 210 may be at a first end 211 of the connector, as exemplarily shown in FIG. 6A. Further, according to embodiments of the connector as described herein, the connector includes a second coupling portion 220 which is adapted for coupling the connector 200 with the rotatable cathode 110. As exemplarily shown in FIG. 6A, the second coupling portion 220 may be at a second end 222 of the connector 200. According to embodiments of the connector 200, a connecting portion 113 may be arranged between the first coupling portion 210 and the second coupling portion 220. The first coupling portion 210 and/or the second coupling portion 220 may be configured for transmitting a turning moment from the drive 130 to the rotatable cathode via the connector. Accordingly, the connector 200 may rotate at the same angular velocity as the rotatable cathode, when the rotatable cathode is driven by the drive.

[0038] According to embodiments of the connector, a coil 140 may be arranged between the first coupling portion 210 and the second coupling portion 220, as exemplarily shown in FIGS. 6A through 7B. In particular, the coil 140 may be mounted on an insulator 114 of the connector, for example around the connecting portion 113. Accordingly, a connector coupling a rotatable cathode with a drive is provided which can be employed for retrofitting a sputter deposition source, such that the drive of the rotatable cathode can be shielded from the RF energy. In particular, embodiments of the connector as described herein provide a low pass filter for the RF energy provided to the rotatable cathode, such that the RF energy may not be transmitted into the drive and the bearings of the rotatable

cathode. Accordingly, negative effects of the RF energy on the drive and the bearings, such as heating and material stress caused by RF energy can be reduced or even eliminated by retrofitting a deposition source using a connector according to embodiments described herein.

[0039] According to embodiments of the connector, an insulator 114 may be arranged between the first end 211 of the connector 200 and the second end 222 of the connector 200, particularly the connecting portion 113 may include the insulator 114. Accordingly, the connecting portion 113 may be protected from RF-energy. The insulator 114 of the connector may include at least one material selected from the group consisting of: plastic, particularly polyethylen, polyvinyl chloride, kapton, teflon, silicon, ethylene tetrafluoroethylene; tetrafluoroethylene (PTFE); polyether ether ketone (PEEK); glass; ceramic; and porcelain, particularly Frialit (Al_2O_3).

[0040] According to embodiments of the connector which can be combined with other embodiments described herein, the insulator 114 of the connector may be protected by at least one protecting element 115. The protecting element 115 may be at least one element selected from the group consisting of: a meander shield, a glass shield, and ceramic shield. Accordingly, an improved protection of the connecting portion 113 from RF-energy may be provided

[0041] According to embodiments which can be combined with other embodiments described herein, the coil may include a conductive material, in particular a metallic material. For example, the coil may include at least one metallic material selected from the group consisting of: silver (Ag); copper (Cu); and gold (Au). According to embodiments which can be combined with other embodiments described herein, the coil may include a conductive alloy, for example an alloy including at least one material selected from the group consisting of: silver (Ag); copper (Cu); and gold (Au).

[0042] According to embodiments which can be combined with other embodiments described herein, the coil may include at least one winding. For example, the coil can include one winding, for example may be in form of a ringlike element, particularly a circular element, e.g. a ring. In particular, the number of windings, the material of the coil, the diameter of the coil, and the diameter of the wire forming the coil may be selected

according to the desired electromagnetic properties of the coil employed for shielding the drive from the RF energy.

[0043] According to embodiments of the connector which can be combined with other embodiments described herein, the coil may be a tubular coil for providing a cooling liquid into the interior of the tubular coil. The tubular coil may include an inlet for providing the cooling liquid into the tubular coil and an outlet for cooling liquid discharge.

[0044] As exemplarily shown in FIGS. 7A and 7B, according to embodiments of the connector which can be combined with other embodiments described herein, the coil 140 of the connector may be arranged inside a casing 150. The casing may include an insulating material. For example, the insulating material may be at least one material selected from the group consisting of: plastic, particularly polyethylen, polyvinyl chloride, kapton, teflon, silicon, ehylene tetrafluoroethylene; glass; and ceramic, particularly porcelain. Accordingly, the connecting portion of the connector including the coil may be electromagnetically isolated.

[0045] According to embodiments of the connector which can be combined with other embodiments described herein, the casing 150 may filled with an inert gas, vacuum or air. Accordingly, the dielectric strength of the connector assembly including the connecting portion, the coil and the casing may be increased. For example, the inert gas may be selected from the group consisting of helium, neon, argon, krypton, xenon or radon. In particular the inert gas may be argon (Ar).

[0046] FIG. 8 shows a block diagram illustrating a method 300 of operating a deposition source for sputter deposition according to embodiments described herein. According to embodiments, the method includes feeding 310 a rotatable cathode with RF energy and shielding 320 a drive 130 for rotating the rotatable cathode 110 from the RF energy. According to embodiments of the method which can be combined with other embodiments described herein, the method includes using a deposition source 100 according to embodiments described herein. Alternatively, the method may include using a connector 200 according to embodiments herein. Accordingly, a method is provided with which the drive of rotatable cathode which is used for RF sputtering can be shielded from the RF energy. In particular, embodiments of the method as described herein provide for low pass

filtering of the RF energy provided to the rotatable cathode, such that the RF energy may not be transmitted into the drive, the bearings and sliding contacts of the rotatable cathode. Accordingly, negative effects of the RF energy on the drive and the bearings, such as heating and material stress caused by RF energy, can be reduced or even eliminated by employing the method according to embodiments described herein.

[0047] In FIG. 9 a schematic view of a sputtering apparatus 400 according to embodiments described herein is shown. According to embodiments, the sputtering apparatus includes a vacuum chamber 410 and a deposition source 100 according to embodiments described herein. Alternatively, a sputtering apparatus 400 according to embodiments described herein may include a vacuum chamber 410 and a rotatable cathode 110 connected to a drive 130 for rotating the rotatable cathode 110, wherein the rotatable cathode 110 is connected to the drive 130 via a connector 200 according to embodiments described herein.

[0048] With exemplary reference to FIG. 9, according to embodiments of the sputtering apparatus which can be combined with other embodiments described herein, the multiple deposition sources in accordance with any of the embodiments described herein may be provided within the vacuum chamber 410. In the embodiment shown in FIG. 9, the apparatus includes four deposition sources each having a rotatable cathode 110. As exemplary shown in FIG. 9, each rotatable cathode 110 may include magnet assemblies or magnetrons 431. The magnetrons 431 may be provided within backing tubes that are equipped with the target material on an outer surface. Further, according to embodiments of the apparatus, corresponding anodes 430 facing the cathodes 110 may be provided inside the vacuum chamber 410.

[0049] According to embodiments of the sputtering apparatus which can be combined with other embodiments described herein, an RF power supply 120 for supplying RF power to each rotatable cathode 110 may be arranged outside the vacuum chamber 410 and electrically connected to each rotatable cathode 110 and the corresponding anodes 430 via respective power connections. According to embodiments of the sputtering apparatus which can be combined with other embodiments described herein, the housing of the vacuum chamber may be electrically connected to the RF power supply 120. Accordingly, the housing of the vacuum chamber may be used as a corresponding anode for the rotatable

cathodes. As is shown in FIG. 9, each of the rotatable cathodes 110 may be associated with a first power connection 141 to a DC power supply 125 for providing the rotatable cathode with DC energy and a second power connection 142 for providing the respective rotatable cathode 110 with RF energy from the RF power supply 120. Further, with exemplary reference to FIG. 9, according to embodiments of the sputtering apparatus which can be combined with other embodiments described herein, each RF power supply 120 for supplying RF power to the respective rotatable cathode 110 may be connected to an arc-synchronisation device 170 for synchronizing the RF power supplied to the respective rotatable cathodes.

[0050] As indicated in FIG. 9, according to embodiments of the sputtering apparatus described herein, further chambers 411 can be provided adjacent to the vacuum chamber 410. The vacuum chamber 410 can be separated from the adjacent chambers by valves having a valve housing 404 and a valve unit 405, respectively. Accordingly, after a carrier 406 with a substrate 407 to be coated is inserted in the vacuum chamber 410, as indicated by arrow 401, the valve units can be closed. Accordingly, the atmosphere in the vacuum chambers 410 can be individually controlled by generating a technical vacuum, for example, with vacuum pumps connected to the vacuum chambers 410, and/or by inserting process gases in the deposition region of the vacuum chamber 410.

[0051] According to embodiments of the sputtering apparatus which can be combined with other embodiments described herein, process gases can include inert gases such as argon and/or reactive gases such as oxygen, nitrogen, hydrogen and ammonia, ozone, activated gases or the like. Further, within the vacuum chamber 410, rollers 408 may be provided in order to transport a carrier 406 with a substrate 407 into and out of the vacuum chamber 410. For example, the substrate may be an inflexible substrate, e.g., a glass substrate, a wafer, slices of transparent crystal such as sapphire or the like. Alternatively, the substrate may be a flexible substrate, such as a web or a foil.

[0052] Accordingly, the present disclosure provides a deposition source for sputter deposition, a connector for a sputter deposition source, a method of operating a deposition source, and a sputtering apparatus with which negative effects of RF energy, e.g. heating and material stress caused by RF energy, can be reduced or even eliminated. Accordingly,

embodiments as described herein provide for improved RF sputtering utilizing rotatable targets.

CLAIMS

1. A deposition source (100) for sputter deposition, comprising:

a rotatable cathode (110) having a first end (111) and a second end (112),

a RF power supply (120) for providing the rotatable cathode with RF energy,

wherein the first end (111) is connected to a drive (130) for rotating the rotatable cathode (110) via a connecting portion (113), and

wherein a coil (140) is arranged around the connecting portion (113) for shielding the drive (130) from the RF energy.

2. The deposition source (100) according to claim 1,
wherein the connecting portion (113) comprises an insulator (114), and wherein the coil (140) is mounted on the insulator (114).

3. The deposition source (100) according to claim 2,
wherein the insulator (114) is coupled to the drive (130), such that the insulator (114) and the coil (140) mounted on the insulator are rotatable with the rotatable cathode (113).

4. The deposition source (100) according to any of claims 1 to 3, wherein the coil (140) is a tubular coil for providing a cooling liquid into the interior of the tubular coil.

5. The deposition source (100) according to any of claims 1 to 4, wherein the first end (111) of the rotatable cathode (110) is connected to a DC power supply (125) for providing the rotatable cathode with DC energy.

6. The deposition source (100) according to claim 5,
wherein the first end (111) of the rotatable cathode (110) is connected to the DC power supply via the coil (140) for providing the rotatable cathode with DC energy.

7. The deposition source (100) according to any of claims 2 to 6,
wherein the insulator (114) is protected by at least one protecting element (115) selected from the group consisting of: a meander shield, a glass shield, and ceramic shield.

8. The deposition source (100) according to any of claims 1 to 7,
wherein the coil is arranged inside a casing (150), particularly an insulator casing.

9. The deposition source (100) according to claim 8,
wherein the casing (150) is filled with an inert gas, vacuum or air.

10. The deposition source (100) according to claim 1,
wherein the connecting portion comprises an insulator (114),
wherein the insulator (114) comprises at least one material selected from the group consisting of: plastic, particularly polyethylen, polyvinyl chloride, kapton, teflon, silicon, ethylene tetrafluoroethylene; tetrafluoroethylene (PTFE); polyether ether ketone (PEEK); glass; ceramic;and porcelain, particularly Frialit (Al_2O_3);
wherein the coil (140) is mounted on the insulator (114),
wherein the coil (140) comprises at least one metallic material selected from the group consisting of: silver (Ag); copper (Cu); and gold (Au); and aluminium (Al) and
wherein the second end (112) of the rotatable cathode (110) is connected to a DC power supply (125) for providing the rotatable cathode with DC energy.

11. A connector (200) for shielding a drive (130) for a rotatable cathode (110) of a deposition source from RF energy provided to the rotatable cathode, the connector comprising:

a first coupling portion (210) adapted for coupling the connector with the drive (130) of the rotatable cathode (110) at a first end (211) of the connector,

a second coupling portion (220) adapted for coupling the connector (200) with the rotatable cathode (110) at a second end (222) of the connector (200),

wherein an insulator (114) is arranged between the first end (211) of the connector (200) and the second end (222) of the connector (200), and

wherein a coil (140) is mounted on the insulator (114).

12. The connector (200) according to claim 11,
wherein the coil (140) is a tubular coil for providing a cooling liquid into the interior of the tubular coil.

13. The connector (200) according to claim 11 or 12,
wherein the coil is arranged inside a casing, particularly wherein the casing is filled with an inert gas, vacuum or air.

14. A method (300) of operating a deposition source for sputter deposition, particularly of any of claims 1 to 11, the method comprising:

- feeding (310) a rotatable cathode with RF energy, and

- shielding (320) a drive (130) for rotating the rotatable cathode (110) from the RF energy.

15. A sputtering apparatus (400), comprising:

a vacuum chamber (410);

a deposition source (100) according to any of claims 1 to 11, or

a rotatable cathode (110) connected to a drive (130) for rotating the rotatable cathode (110), wherein the rotatable cathode (110) is connected to the drive (130) via a connector (200) according to any of claims 11 to 13.

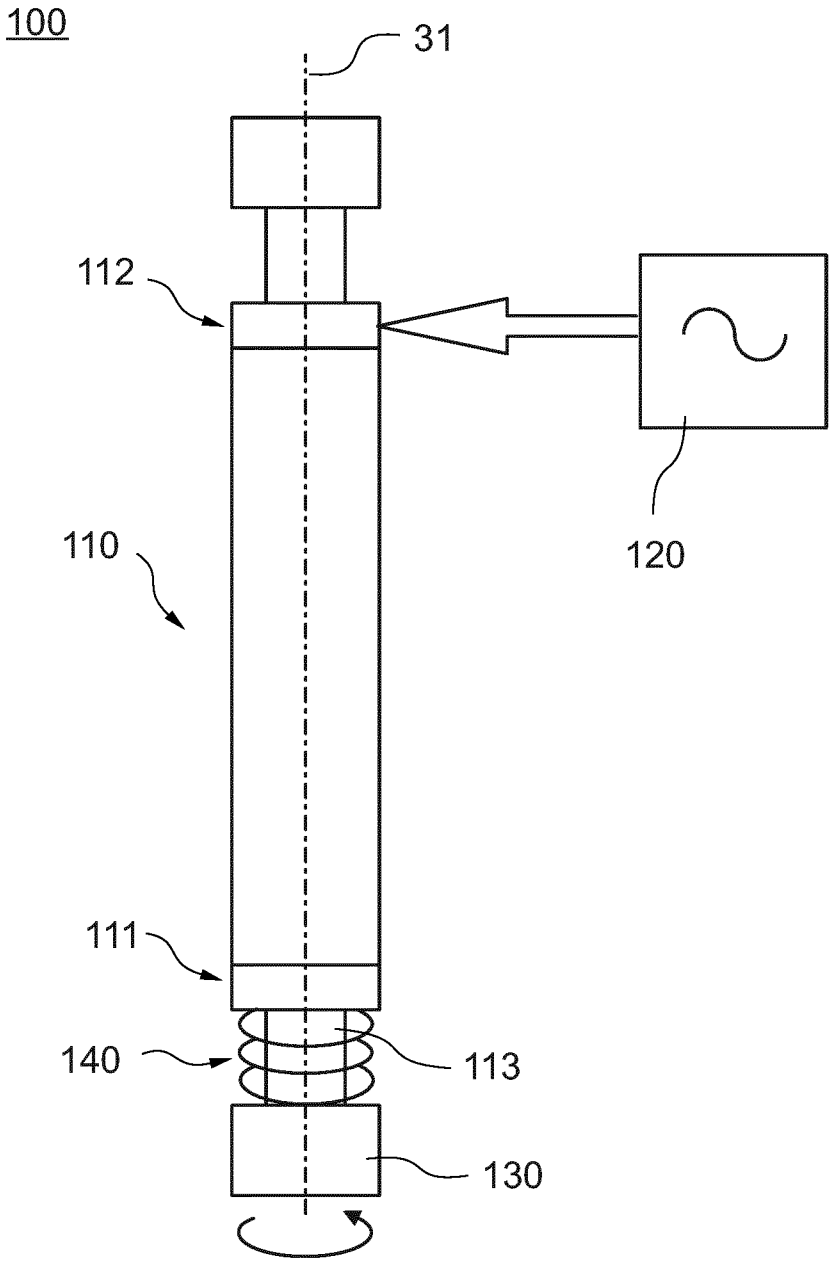


FIG. 1

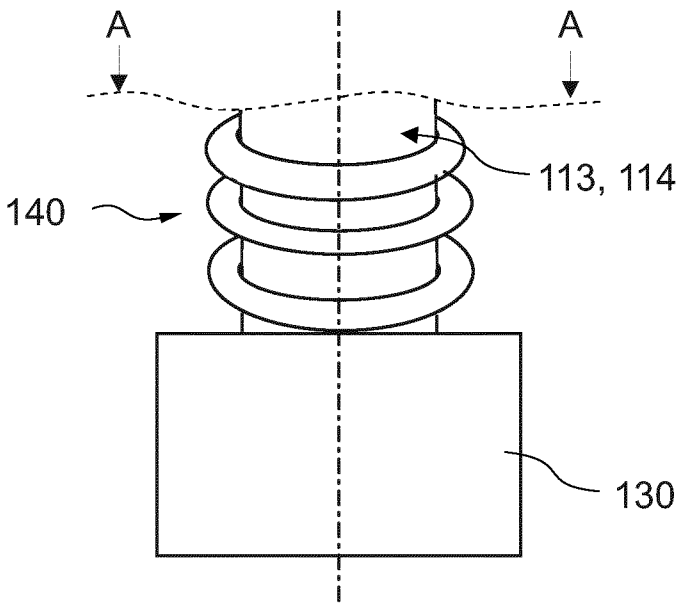


FIG. 2A

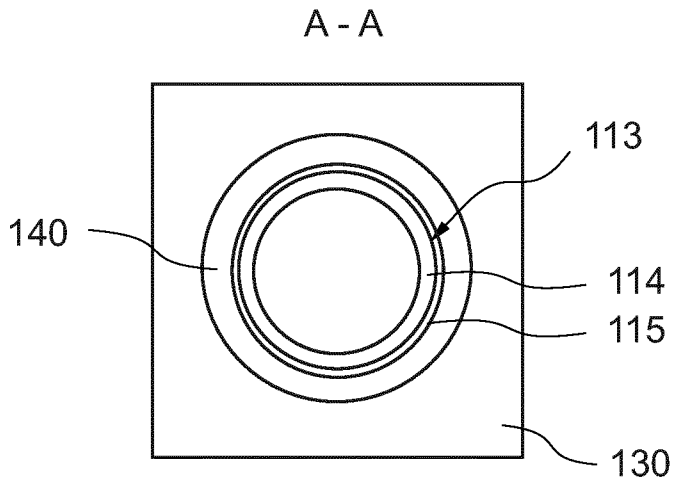


FIG. 2B

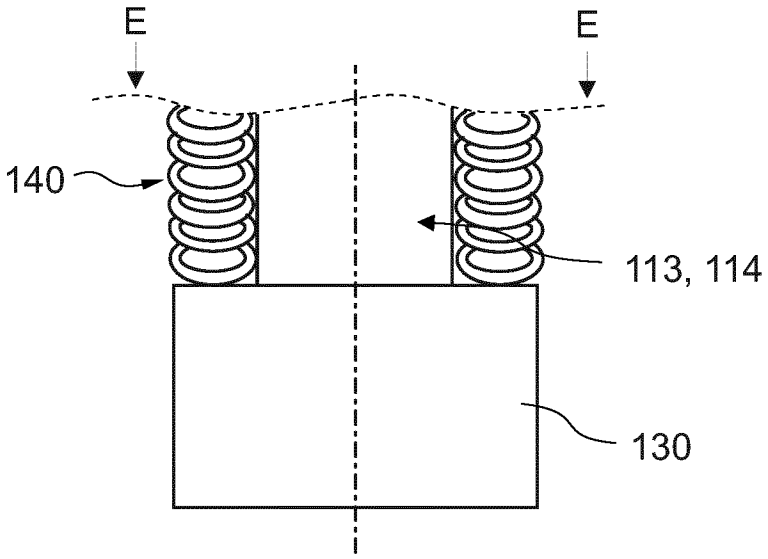


FIG. 2C

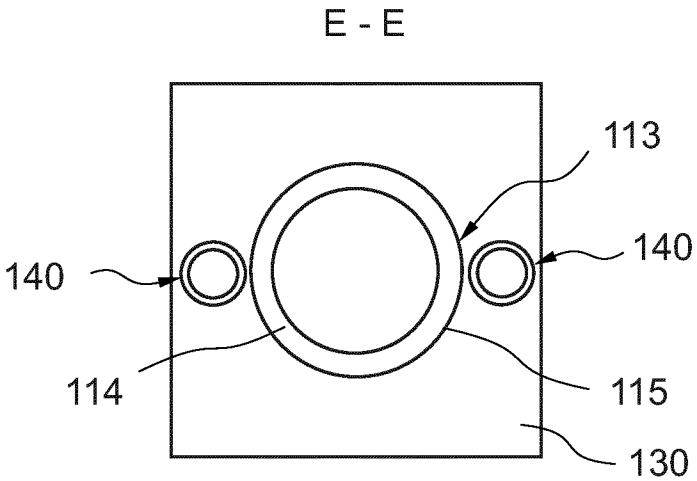


FIG. 2D

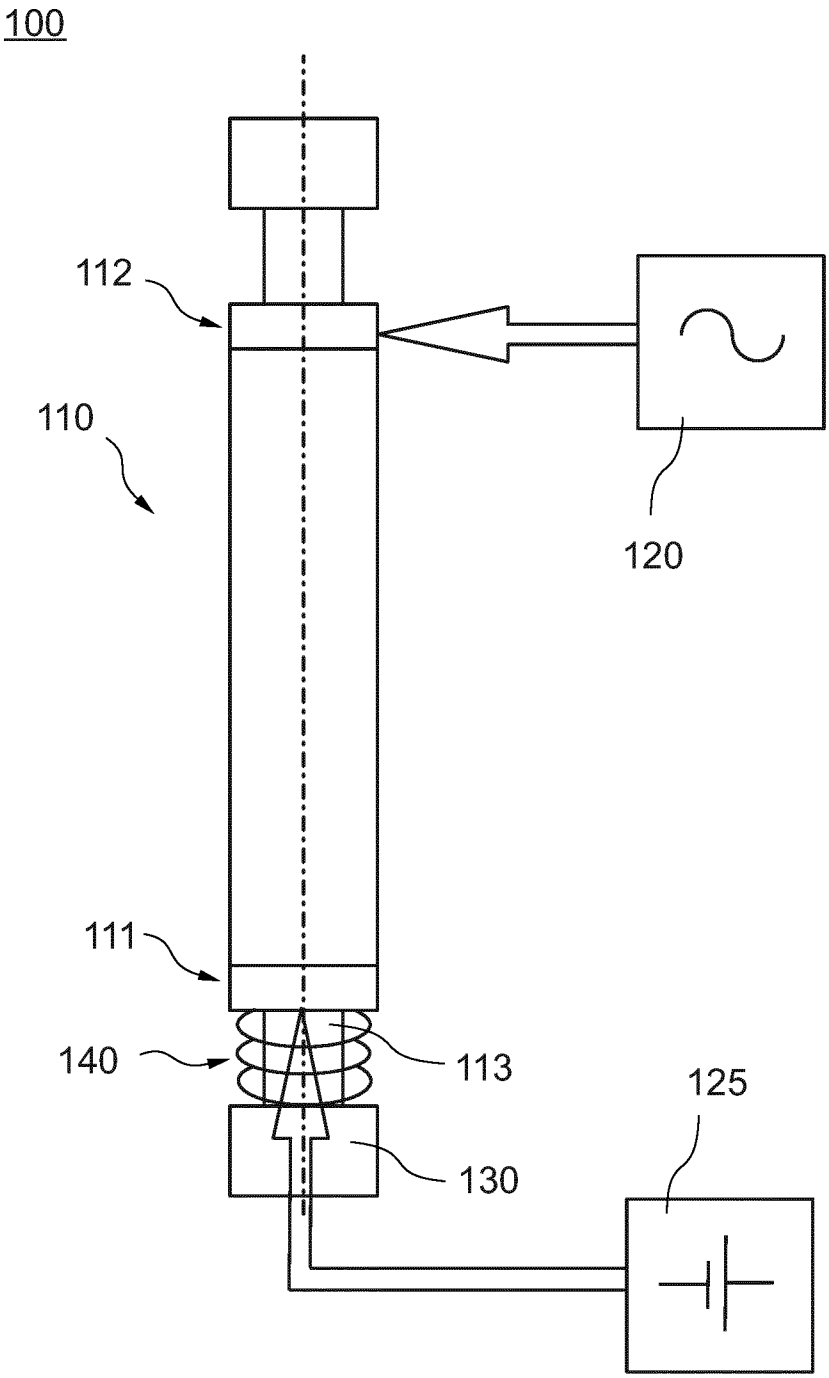


FIG. 3

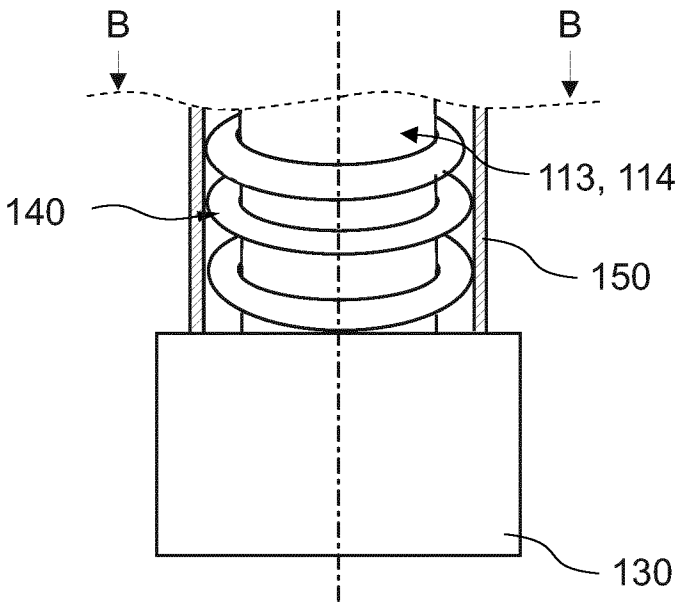


FIG. 4A

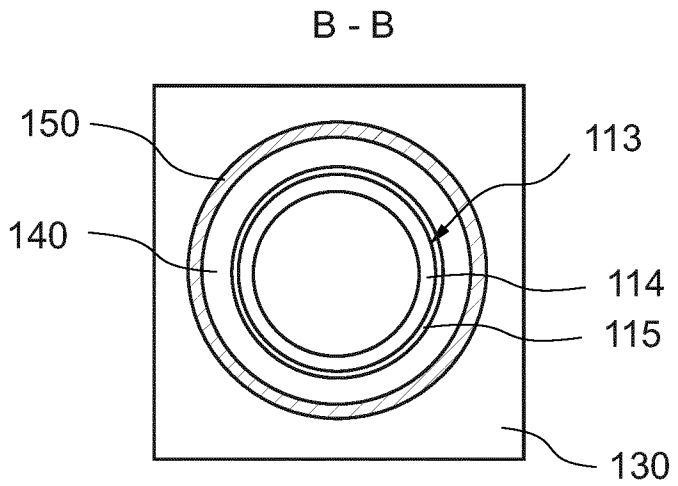


FIG. 4B

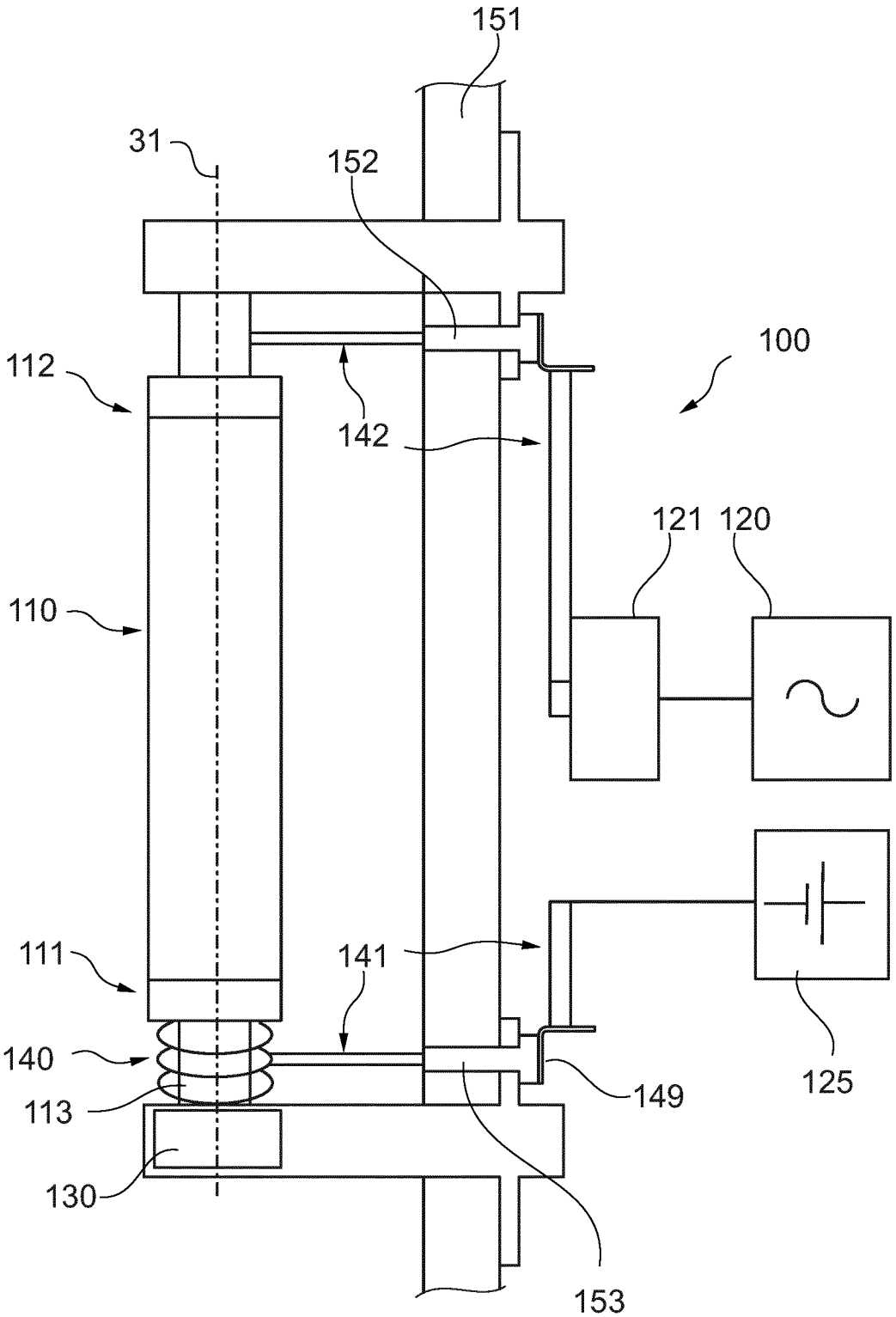

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FIG. 5

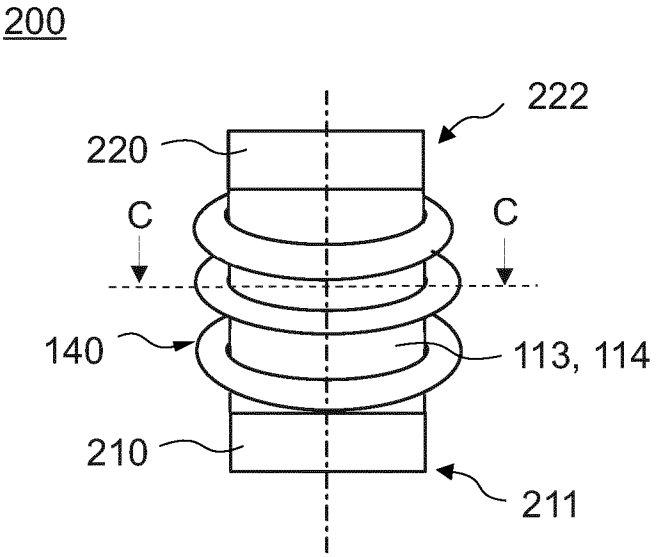


FIG. 6A

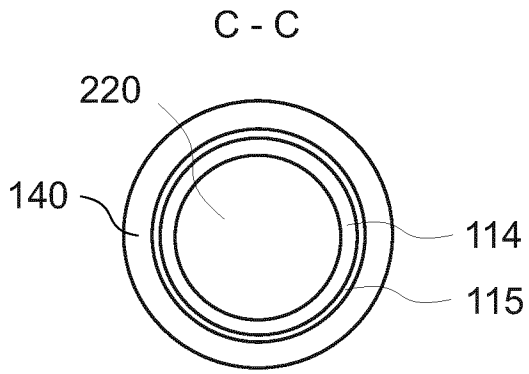


FIG. 6B

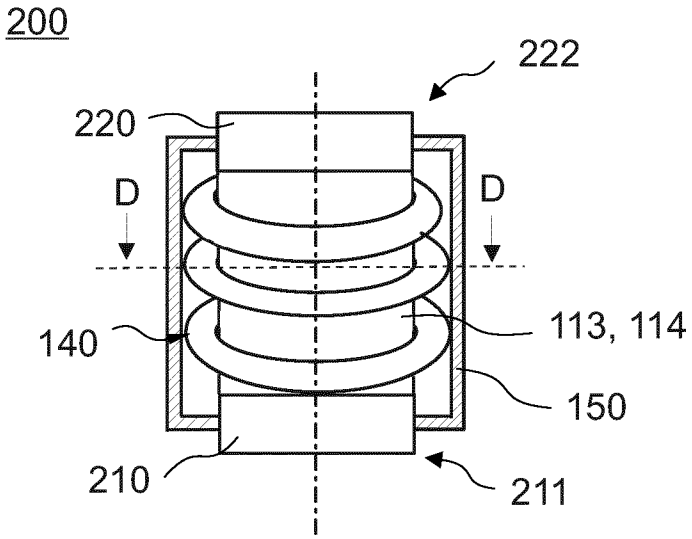


FIG. 7A

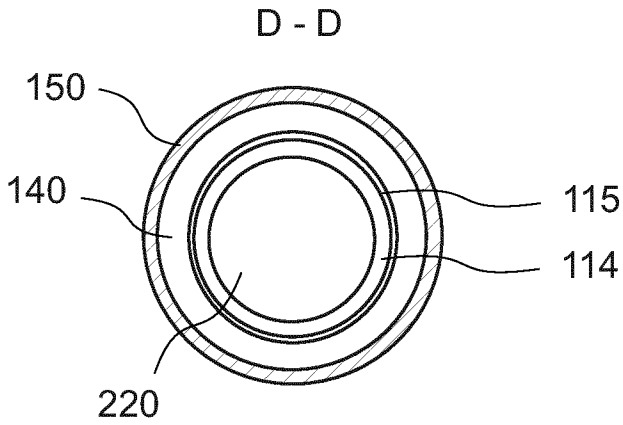


FIG. 7B

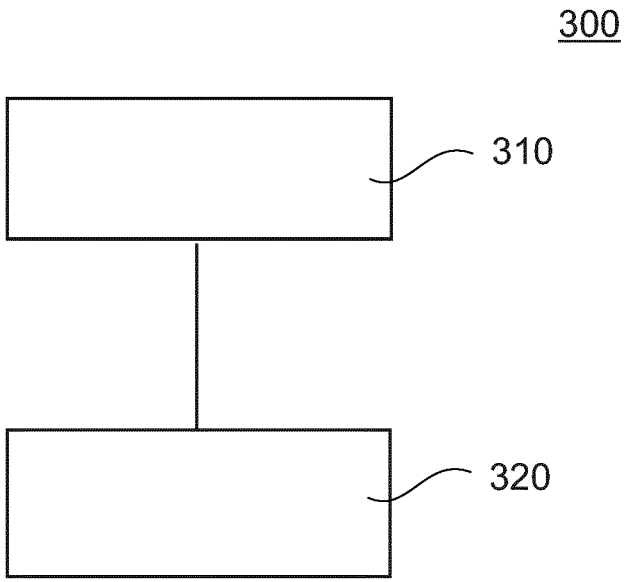


FIG. 8

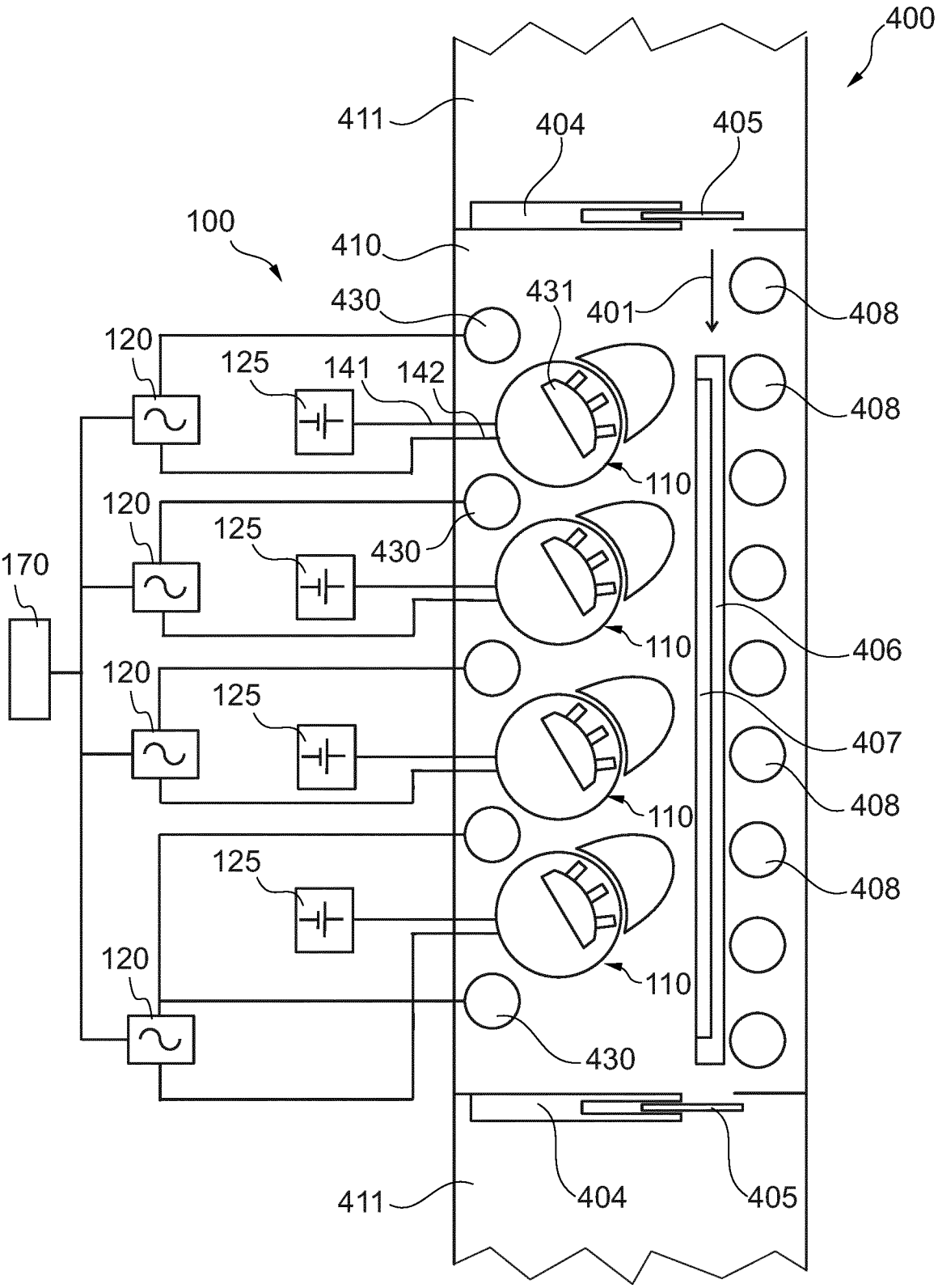

400
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FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/060229

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C14/34
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 H01J

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, WPI Data, IBM-TDB, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/173217 A1 (CROWLEY DANIEL T [US]) 18 September 2003 (2003-09-18) Abstract; paragraphs [0004], [0017], [0028], [0032] - [0042]; figures 1,4 -----	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 September 2015	02/10/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Peijzel, Paul

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/060229

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003173217 A1	18-09-2003	EP 1355343 A2	22-10-2003
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