Device and method for holding, rotating, as well as heating and/or cooling a substrate

The invention relates to a device and a method for holding, rotating as well as heating and/or cooling a substrate in accordance with the subordinate patent claims.

In the industry numerous types of sample holder are used to fix substrates, in particular wafers. These sample holders are required to perform various physical tasks. On the one hand the sample holders serve to fix the substrate. The fixing is often achieved by mechanical clamping, vacuum tracks, electrostatic charges, electrical or magnetic fields, or adhesive surfaces.

Very many sample holders also perform secondary tasks such as cooling or heating a substrate. Heated sample holders in particular are very common and are present in many different embodiments.

Sample holders are often tailored to the equipment in which they are used. Sample holders for spin coating equipment which rotate at several thousand rotations per minute, must be constructed in a highly symmetrical, light and flexible manner. They must, in particular, be correctly weighted. This type of sample holder is often required to have secondary functionalities such as heating.

The temperature of a heated sample holder is controlled directly via a heating element, which must be activated by an appropriately supplied current. The biggest problem arises in the transmission of the current to the rotating sample holder. The transmission of current between two rotating parts is normally effected via sliding contacts. Sliding contacts have a number of disadvantages. Firstly, there is a high level of wear between the sliding contact and the collector. Secondly, this type of contact can lead to spark discharge. Many fluids, especially solvents, are relatively highly flammable and have a relatively high vapour pressure. It must therefore always be assumed that there may be flammable gases

around a heated sample holder, which may lead to an explosion. Centrifuge units are regularly used to coat or to clean substrate surfaces. For this purpose chemicals are used which may be flammable. If these fluids also have high vapour pressures, even a small spark can lead to an explosion or a fire.

Embodiments of the present invention provide a device and a method for holding, rotating as well as heating and/or cooling a substrate, which do not have the disadvantages of the state of the art and which are in particular as wear-free as possible and offer as high as possible a level of operational safety.

The embodiments of the invention described below are suitable for use as a coater or a cleaner. In the former case they are also called spin coaters.

Any combinations of at least two of the characteristics set out in the description, the claims and/or the drawings also fall within the scope of the invention. Where value ranges are indicated, all values falling within the said limits shall be deemed disclosed and claimed in any random combination.

According to a first aspect of the invention, provision is made for a device for holding, rotating, as well as heating and/or cooling a substrate, in particular a wafer, with:

1) a rotor, having:
    a) at least one secondary winding;
    b) a substrate holder with a substrate holder surface and fixing elements for fixing the substrate;
    c) a rotary shaft for rotating the substrate holder around a rotary axis;
    d) at least one electric heater for heating and/or a cooler for cooling the substrate holder surface;
    e) optionally, an electronic control system to control a current and/or a voltage in the at least one primary winding;

2) a stator, having:
   a) at least one primary winding;
   b) optionally, an electronic control system to control a current and/or a voltage in the at least one primary winding;
   c) a ring-shaped base, wherein the rotary shaft of the rotor is arranged at least partially inside the base;

wherein the device is designed such that a current and/or a voltage can be induced in the at least one secondary winding by the at least one primary winding, wherein the current or voltage induced in the at least one secondary winding can be used to operate the at least one heater and/or cooler such that the substrate holder surface can be heated and/or cooled.

Devices for cooling the substrate are generally called coolers. Peltier elements in particular may be used for cooling the substrate. According to embodiments of the invention, heaters and/or coolers can be built into the inventive sample holder.

An embodiment provides that the at least one primary winding is arranged on a surface of the base. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one primary winding is arranged inside the base. This has the advantage that a particularly space-saving design is possible.

Another embodiment provides that the at least one primary winding and the at least one secondary winding are designed as flat coils, preferably as spiral coils, and even more preferably as Archimedean spiral coils. This has the advantage that a particularly space saving design is possible.

Another embodiment provides that the at least one primary winding and the at least one secondary winding are arranged parallel to one another. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one primary winding and the at least one secondary winding are arranged in and/or parallel to a plane wherein the plane is at right angles to the rotary axis. This has the advantages that a particularly space-saving realisation and a particularly good energy transfer are possible.

Another embodiment provides that the at least one primary winding is arranged on a base surface of the base facing the substrate holder. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one secondary winding is arranged on a reverse side of the substrate holder facing the base. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one primary winding and the at least one secondary winding are designed as cylinder coils. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one primary winding and the at least one secondary winding are arranged concentrically in relation to the rotary axis. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one primary winding is arranged on an inner base surface facing the rotary shaft and the at least one secondary winding is arranged on a shaft surface of the rotary shaft facing the inner base surface. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least one primary winding and the at least one secondary winding are arranged acentrically in relation to the rotary axis. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that at least two primary windings are arranged inside the base and at least two secondary windings are arranged inside the rotary shaft. This has the advantage of achieving a particularly good energy transfer.

Another embodiment provides that the at least two primary windings and the at least two secondary windings are arranged at the same angular distance around the rotary axis. This has the advantage of achieving a particularly good energy transfer along with the most space-saving design possible.

Another embodiment provides that the device has a measuring device for measuring the temperature of the heater, the substrate holder, the substrate holder surface and/or the substrate, as well as a device for transmitting the temperature measurements for the heater, the substrate holder, the substrate holder surface and/or the substrate from the rotor to the stator, preferably via the inductive coupling between the at least one primary winding and the at least one secondary winding. This has the advantage that the temperature can be particularly well controlled.

Another embodiment provides that the rotor has an identification chip, in particular an RFID chip, for unequivocal and in particular fully automated identification of the rotor, wherein the identification chip is preferably located on the rim of the rotary shaft. This has the advantage that the rotor can be exchanged particularly easily.

Another embodiment provides that the device is provided with a flushing agent for flushing the rotor using a gas flow. This has the advantage that the device is particularly safe to operate.

Furthermore, a second aspect of the invention provides a method for holding, rotating as well as heating and/or cooling a substrate, in particular a wafer, with the following steps, in particular with a device with the following characteristics:

- holding and rotating the substrate using a rotor, comprising a substrate holder with a substrate holder surface and fixing elements for fixing the substrate, wherein the substrate holder with the substrate is turned around a rotary axis by a rotary shaft;
- inducing a current, in particular by virtue of rotating the rotor, in at least one secondary winding of the rotor by at least one current-carrying primary winding of a stator;
- wherein at least one heater and/or cooler is operated by the current induced in the at least one secondary winding such that the substrate holder surface and thereby the substrate are heated and/or cooled.

An embodiment provides that the rotor is flushed by a gas flow, in particular an inert gas flow, wherein preferably externally attached electric components, in particular a primary-side capacitor component and a secondary-side capacitor component, are flushed, wherein an overpressure is built up preferably between the rotor and the stator, which is greater than an ambient pressure. This has the advantage of making the operation of the device particularly safe.

In the following text ‘stator-side’ is also described as ‘primary-side’, and ‘rotor-side’ as ‘secondary-side’. In the following text a ‘winding’ is also described as a ‘coil’. In the following text the ‘substrate holder’ is also described as ‘sample holder’.

Embodiments of the invention, in particular, consist in the transmission of the electrical power / the voltage and/or the current from a stator to a rotor by electromagnetic induction. Further, it discloses a number of possibilities for contact-free transmission of measurement signals.

Embodiments of the invention separate the mechanical components from the electrical components. In particular, there is no longer a need for sliding contacts, which in an oxidizing atmosphere in particular, pose a significant safety risk from sparking.

In particular, embodiments of the invention describe a method and a system for electromagnetically decoupled transmission of current by electromagnetic induction as well as electromagnetically decoupled temperature measurement-taking by inductive, capacitive or electromagnetic methods, and the control made possible by those processes.

Electromagnetic Induction

At the basis of embodiments of the invention is the fundamental principle of an inductive coupling for the transmission of power, voltage / current to the heating elements. The inductive coupling can also be understood as a transformer. The transformer is made up of a primary side and a secondary side. The primary and secondary sides each have at least one conductor loop, in particular a coil. As the text develops, ‘conductor loop’ and ‘coil’ will be used as synonyms. The arrangement and number of coils may vary according to the embodiment of the invention.

In particular, the coils have exactly 1 winding, preferably more than 5 windings, even more preferably more than 10 windings, most preferably more than 100 windings, most preferably of all, more than 1000 windings. In especially preferred embodiments coils with between 5 and 100 windings are used.

The primary side is a part of the stator. The secondary side is a part of the rotor. The stator is made up of the amount of all static mechanical components, which are static. The rotor is made up of the amount of mechanical parts, which rotate as a whole. The rotor and stator are completely electromagnetically decoupled from one another. By electromagnetic decoupling it is understood that the power transmission from a first mechanical part, in particular the stator, to the second mechanical part, in particular the rotor, is not effected via power lines and/or sliding contacts, but rather via electromagnetic induction. Thus,