

DEVICE FOR DETECTING LOOP CURRENT OF ELECTROSTATIC CHUCK POWER SUPPLY AND SEMICONDUCTOR PROCESS EQUIPMENT

TECHNICAL FIELD

[0001] The present application belongs to the technical field of semiconductors, and particularly relates to a device for detecting a loop current of an electrostatic chuck power supply and semiconductor process equipment.

BACKGROUND

[0002] A chuck is a support platform located in a processing chamber of semiconductor process equipment and used to secure and support a to-be-processed wafer or a tray loading the wafer in a process of processing the wafer. An electrostatic chuck (ESC) is a chuck that uses a principle of electrostatic attraction to secure the wafer or the tray. Chuck electrodes are embedded in a body of the ESC. An ESC power supply provides a direct-current high voltage for the chuck electrodes, thereby generating an electrostatic force between the chuck and the wafer, which secures the wafer or the tray onto the chuck.

[0003] To facilitate understanding of an operating status of the semiconductor process equipment and to protect the safety of the equipment and personnel, it is necessary to accurately detect a loop current of the ESC power supply and design a necessary short-circuit protection circuit, etc. The ESC power supply has the characteristics of outputting a high voltage and a microcurrent, which brings certain difficulties to current detection.

[0004] In related art, a detection scheme for the loop current of the ESC power supply is as shown in FIG. 1. A sampling resistor R is connected in series at an output terminal of the electrostatic chuck power supply 010, so as to convert a current signal flowing through the sampling resistor R into a voltage signal, and use an operational amplifier 012 to amplify this voltage signal. Since voltages HV_+ and HV_+-U to ground (GND) (U is generally less than 10 volts) at input terminals (IN_+ and IN_-) of the operational amplifier 012 are both direct-current high voltages (typically ranging from one thousand to tens of thousands of volts), while a reference potential terminal of the operational amplifier 012 is grounded (GND), and thus there is a voltage difference of one thousand to tens of thousands of volts between the input terminals (IN_+ and IN_-) of the operational amplifier 012 and the reference potential terminal. To ensure the voltage withstand

requirements of the operational amplifier 012, a high-voltage isolated operational amplifier needs to be adopted as the operational amplifier 012. That is, the input terminals and output terminal of the operational amplifier 012 are isolated, and an isolation voltage U_{iso} is greater than or equal to the voltage HV_+ outputted by the ESC power supply to a load. By detecting the voltage at the output terminals of the operational amplifier 012, the magnitude of the loop current in the ESC power supply may be calculated according to an amplification ratio. However, the high-voltage isolated operational amplifier is high in cost and has a limited isolable voltage range. When the voltage at the output terminals of the electrostatic chuck power supply is too high, the accuracy of current detection is poor.

SUMMARY

[0005] The objectives of the embodiments of the present application are to provide a device for detecting a loop current of an electrostatic chuck power supply and semiconductor process equipment, so as to solve the problems in the related art that a high-voltage isolated operational amplifier is high in cost and has a limited isolable voltage range, and when the voltage at an output terminal of the electrostatic chuck power supply is too high, the accuracy of current detection is poor.

[0006] In order to implement the above object, embodiments of the present application adopt the following technical solutions.

[0007] In a first aspect, an embodiment of the present application provides a device for detecting a loop current of an electrostatic chuck power supply, including: a sampling resistor, connected in series to an output terminal of the electrostatic chuck power supply; and an operational amplifier, wherein a positive input terminal of the operational amplifier is connected to an input terminal of the sampling resistor, a negative input terminal of the operational amplifier is connected to an output terminal of the sampling resistor, a reference potential terminal of the operational amplifier is configured to input a first reference voltage, an absolute voltage difference between the first reference voltage and an output voltage at an output terminal of the electrostatic chuck power supply is less than a withstand voltage difference of the operational amplifier, a power supplying terminal of the operational amplifier is configured to input a first power supplying voltage, the first power supplying voltage is higher than the first reference voltage by a preset first voltage value, and an output terminal of the operational amplifier is configured to output a voltage signal proportional to the loop current.

[0008] In a second aspect, an embodiment of the present application provides semiconductor process equipment, including: an electrostatic chuck, an electrostatic chuck power supply, and the device for detecting the loop current of the electrostatic chuck power supply as described in the first aspect of the present application.

[0009] The above at least one technical solution adopted in the embodiments of the present application can achieve the following beneficial effects.

[0010] In the embodiment of the present application, the reference potential terminal of the operational amplifier is configured to input the first reference voltage, the absolute voltage difference between the first reference voltage and the output voltage at the output terminal of the electrostatic chuck power supply is less than the withstand voltage difference of the operational amplifier, the power supplying terminal of the operational amplifier is configured to input the first power supplying voltage, and the first power supplying voltage is higher than the first reference voltage by the preset first voltage value. By setting the first reference voltage at the reference potential terminal of the operational amplifier such that the absolute voltage difference between the first reference voltage and the output voltage at the output terminal of the electrostatic chuck power supply is less than the withstand voltage difference of the operational amplifier, voltages to ground at the input terminals (the positive input terminal, the negative input terminal) and the output terminal of the operational amplifier are all direct current high voltages. However, the voltage differences between any two of these terminals are very low. As a result, an ordinary non-high-voltage-isolated operational amplifier may be used as the operational amplifier, which avoid the problems that a high-voltage isolated operational amplifier is high in cost and has a limited isolable voltage range, and when the high voltage at the output terminal of the electrostatic chuck power supply is too high, the accuracy of current detection is poor, thereby reducing the costs and improving the accuracy of current detection.

BRIEF DESCRIPTION OF DRAWING(S)

[0011] The accompanying drawings illustrated herein are intended to provide a further understanding of the present application, and form a part of the present application, and schematic embodiments of the present application and their illustration are used to explain the present application, but do not constitute an inappropriate limitation to the present application. In the accompanying drawings:

- [0012] FIG. 1 is a schematic structural diagram of a device for detecting a loop current of an electrostatic chuck power supply in related art.
- [0013] FIG. 2 is a schematic diagram of an electrostatic chuck electrical system provided by an embodiment of the present application.
- [0014] FIG. 3 is a schematic structural diagram of a device for detecting a loop current of an electrostatic chuck power supply provided by an embodiment of the present application.
- [0015] FIG. 4 is a schematic structural diagram of a device for detecting a loop current of an electrostatic chuck power supply provided by another embodiment of the present application.
- [0016] FIG. 5 is a schematic structural diagram of a power supplying unit provided by an embodiment of the present application.
- [0017] FIG. 6 is a schematic structural diagram of a power supplying unit provided by another embodiment of the present application.
- [0018] FIG. 7 is a schematic structural diagram of semiconductor process equipment provided by an embodiment of the present application.

DETAILED DESCRIPTION

- [0019] In order to make objectives, technical solutions and advantages of the present application clearer, the technical solutions of the present application will be described below clearly and completely with reference to specific embodiments of the present application and corresponding accompanying drawings. Apparently, the described embodiments are only part of the embodiments of the present application, but not all the embodiments. All other embodiments obtained by those ordinarily skilled in the art based on the embodiments in the present application without creative efforts shall fall within the protection scope of the present application.
- [0020] Terms “first,” “second” and the like in the present application are used for distinguishing similar objects, but are not used for describing a specific sequence or precedence order. It should be understood that data used in this way may be interchanged where appropriate, so that the embodiments of the present application can be implemented according to sequences other than those illustrated or described here. In addition, “and/or” in the present application represents at least one of the connected objects. A character “/” generally represents that the association objects in front of and behind “/” are in an “or” relationship. It should be noted that all data involved in the present application are acquired with user’s permission.

[0021] A chuck is a support platform located in a processing chamber of semiconductor process equipment and used to secure and support a to-be-processed wafer or a tray loading the wafer in a process of processing the wafer. An electrostatic chuck (ESC) is a chuck that uses a principle of electrostatic attraction to secure the wafer or the tray. Chuck electrodes are embedded in a body of the ESC. An ESC power supply provides a direct-current high voltage for the chuck electrodes, thereby generating an electrostatic force between the chuck and the wafer, which secures the wafer or the tray onto the chuck.

[0022] FIG. 2 is a schematic diagram of an electrostatic chuck electrical system. As shown in FIG. 2, a body of an electrostatic chuck 23 includes a first ceramic layer 22 and a second ceramic layer 26. A first electrode 21 and a second electrode 25 are embedded in the first ceramic layer 22 and the second ceramic layer 26, respectively. The first electrode 21 and the second electrode 25 are made of metal and are wrapped on all four sides by the first ceramic layer 22 and the second ceramic layer 26, respectively. Two high-voltage output terminals HV₊Output and HV.Output of the electrostatic chuck power supply 010 are respectively connected to the first electrode 21 and the second electrode 25 via a first filter circuit 24 and a second filter circuit 27.

[0023] Voltage values at the two high-voltage output terminals of the electrostatic chuck power supply 010 generally range from one thousand to tens of thousands of volts (V). Since both the ceramic layers are made of insulating materials, a loop current of the electrostatic chuck power supply 010 is extremely small. For example, in a Coulomb-type electrostatic chuck, both the ceramic layers are made of high-purity ceramic materials. It is generally required that resistance between each of the two electrodes and ground exceeds 1000 G Ω , or that the loop current I of the electrostatic chuck power supply 010 is less than 10 μ A. In a JR-type electrostatic chuck, the two ceramic layers are doped with conductive materials, resulting in a slightly higher loop current I, and it is generally required that the loop current I is less than 200 μ A.

[0024] To facilitate understanding of an operating status of the semiconductor process equipment and to protect the safety of the equipment and personnel, it is necessary to accurately detect a loop current of the ESC power supply and design a necessary short-circuit protection circuit, etc. The ESC power supply has the characteristics of outputting a high voltage and a microcurrent, which brings certain difficulties to current detection.

[0025] In related art, a high-voltage isolated operational amplifier is used to detect the loop current of the ESC power supply. However, the high-voltage isolated operational amplifier is high in cost and has a limited isolable voltage range. When the voltage at the output terminals of the

electrostatic chuck power supply is too high, the accuracy of current detection is poor. To this end, the present application proposes a device for detecting a loop current of an electrostatic chuck power supply and semiconductor process equipment, so as to solve the problems in the related art that the high-voltage isolated operational amplifier is high in cost and has a limited isolable voltage range, and when the voltage at the output terminal of the electrostatic chuck power supply is too high, the accuracy of current detection is poor.

[0026] The technical solutions provided by the embodiments of the present application are described in detail below in combination with the accompanying drawings.

[0027] FIG. 3 is a schematic structural diagram of a device for detecting a loop current of an electrostatic chuck power supply provided by an embodiment of the present application. As shown in FIG. 3, the device for detecting the loop current of the electrostatic chuck power supply according to the embodiment of the present application may specifically include: a sampling resistor R and a voltage detecting unit 31.

[0028] The sampling resistor R is connected in series to an output terminal of the electrostatic chuck power supply 10.

[0029] It should be noted here that the output terminal of the electrostatic chuck power supply 10 may be either a positive output terminal or a negative output terminal of the electrostatic chuck power supply 10. An output voltage at the positive output terminal of the electrostatic chuck power supply 10 is HV_+ , an output voltage at the negative output terminal of the electrostatic chuck power supply 10 is HV_- , and voltages outputted to a load are denoted as $HV_+Output$ and $HV_-Output$, respectively. For ease of description, the following description will take the output terminal of the electrostatic chuck power supply 10 being the positive output terminal of the electrostatic chuck power supply 10 as an example.

[0030] The voltage detecting unit 31 is configured to perform processing such as amplification on sampling voltages U at two ends of the sampling resistor R, generate a detection voltage, and output the detection voltage via an output terminal of the voltage detecting unit 31. The sampling voltages U at the two ends of the sampling resistor R may be calculated according to the detection voltage, and then the loop current I of the electrostatic chuck power supply 10 flowing through the sampling resistor R may be calculated according to the sampling voltages U and a resistance value R of the sampling resistor R, where $I=U/R$.

[0031] The voltage detecting unit 31 may specifically include an operational amplifier 12.

[0032] The positive input terminal $IN+$ of the operational amplifier 12 is connected to the input terminal of the sampling resistor R , the negative input terminal $IN-$ of the operational amplifier 12 is connected to the output terminal of the sampling resistor R , and the output terminal of the operational amplifier 12 is configured to output a voltage signal proportional to the loop current. An input voltage U of the operational amplifier 12 is $U=R*I$. The operational amplifier 12 amplifies the voltage U , and a gain (amplification factor) of the operational amplifier 12 is adjustable, and is denoted as K_{12} . A voltage U_{12} at the output terminal of the operational amplifier 12 is $U_{12}=K_{12}*U=K_{12}*R*I$, $U_{12}\propto I$. Through circuit conversion of the operational amplifier 12 and the sampling resistor R , a current signal I of the sampling resistor R is converted into a voltage signal U_{12} .

[0033] To overcome the drawbacks of the high-voltage isolated operational amplifier 012 in FIG. 1, the operational amplifier 12 in the embodiment of the present application employs an ordinary operational amplifier, as long as an isolation voltage between its input terminal and output terminal is greater than a preset voltage (e.g., 12 V).

[0034] In an electric field, when a different reference voltage is selected, the voltage at a certain point is different. In an electronic circuit, a metal base plate is typically used as the reference voltage, meaning that the ground in the electronic circuit serves as the reference voltage, which is stipulated as zero. In this way, voltages lower than the reference voltage are negative voltages, and voltages higher than the reference voltage are positive voltages. If the voltage at a certain point is positive, it indicates that the voltage at that point is higher than the reference voltage; and if the voltage at a certain point is negative, it indicates that the voltage at that point is lower than the reference voltage. The voltage between each point and the reference voltage is calculated as the voltage at that point. The voltage value at a certain point in a circuit is relative. If a different reference voltage is selected, the voltages at various points in the circuit may change accordingly. However, the voltage value between two points in the circuit is fixed and does not change with different reference voltages, that is, it is independent of the selection of the reference voltage. A specific voltage value may also be selected as the reference voltage.

[0035] A power supplying voltage $VDD+$ of the operational amplifier 012 in FIG. 1 is equal to 12 V, a reference potential terminal of the operational amplifier 012 in FIG. 1 is grounded (GND), with the corresponding reference voltage $VDD-=0$ V. That is, the power supplying voltage $VDD+$ of the operational amplifier 012 is 12 V higher than the reference voltage $VDD-$.

[0036] Unlike the operational amplifier 012 in FIG. 1, the reference potential terminal of the operational amplifier 12 in the embodiment of the present application is configured to input a first reference voltage $VDD1_-$. An absolute voltage difference $\Delta VDD1$ between the first reference voltage $VDD1_-$ and the output voltage HV_+ at the output terminal of the electrostatic chuck power supply 10 is less than a withstand voltage difference $U1_{max}$ of the operational amplifier 12. That is, a value range of $VDD1_-$ is $(HV_+ - U1_{max}, HV_+ + U1_{max})$. For example, the reference potential terminal of the operational amplifier 12 may be connected to the output terminal (the corresponding voltage is denoted as HV_+) of the electrostatic chuck power supply 10, that is, the first reference voltage $VDD1_-$ to ground of the reference potential terminal of the operational amplifier 12 is equal to HV_+ . Correspondingly, a power supplying terminal of the operational amplifier 12 is configured to input a first power supplying voltage $VDD1_+$, and the first power supplying voltage $VDD1_+$ is higher than the first reference voltage $VDD1_-$ by a preset first voltage value $\Delta v1$. That is, $VDD1_+ = VDD1_- + \Delta v1$. A value range of the first voltage value $\Delta v1$ is 3.3 V to 36 V. For example, it may be 12 V. In this case, $VDD1_+ = VDD1_- + 12V$. Taking the first reference voltage $VDD1_- - HV_+ = \Delta VDD1$ as an example, wherein $\Delta VDD1$ is less than the withstand voltage difference $U1_{max}$ of the operational amplifier 12. If the voltage HV_+ to ground is +2000 V, then the voltage $VDD1_-$ to ground is $(+2000V) + \Delta VDD1$. That is, the first reference voltage of the operational amplifier 12 is $(+2000V) + \Delta VDD1$ (relative to ground), and the voltage $VDD1_+$ to ground is $(+2012V) + \Delta VDD1$. The voltage difference between the voltage IN_+ at the positive input terminal of the operational amplifier 12 and the first reference voltage $VDD1_-$ is $HV_+ - VDD1_- = 2000 - 2000 - \Delta VDD1 = -\Delta VDD1$, and the voltage difference between the voltage IN_- at the negative input terminal of the operational amplifier 12 and the first reference voltage $VDD1_-$ is $HV_+ - U - VDD1_- = 2000 - U - 2000 - \Delta VDD1 = -U - \Delta VDD1$, wherein U is the voltage difference between the two ends of the sampling resistor R (i.e., the sampling voltage). Typically, $U < 10$ V. That is, the voltage difference between the input terminal and the output terminal of the operational amplifier 12 is less than $10V + \Delta VDD1$, while $\Delta VDD1$ is less than the withstand voltage difference $U1_{max}$ of the operational amplifier 12. Therefore, an ordinary non-high-voltage-isolated operational amplifier may be used. For example, the withstand voltage difference $U1_{max}$ may be selected as 10 V, and in this case, the value range of $VDD1_-$ is (1990, 2010)V. In some embodiments, $\Delta VDD1 = 0$, in this case, the first reference voltage $VDD1_-$ to ground at the reference potential terminal of the operational amplifier 12 is equal to HV_+ , that is, the first reference voltage $VDD1_-$ is at the same potential as HV_+ . The first power supplying voltage

$VDD1_+ = HV_+ + \Delta v_1$, that is, the first power supplying voltage $VDD1_+$ is higher than HV_+ by Δv_1 , the voltage difference between the voltage IN_+ at the positive input terminal of the operational amplifier 12 and the first reference voltage $VDD1_-$ is 0, the voltage difference between the voltage IN_- at the negative input terminal of the operational amplifier 12 and the first reference voltage $VDD1_-$ is $-U$, and thus an ordinary non-high-voltage-isolated operational amplifier may be adopted.

[0037] Further, the voltage detecting unit 31 may further include a photocoupler 13.

[0038] Since the voltages at the input terminals (IN_+ and IN_-) of the operational amplifier 12 relative to ground are HV_+ and $HV_+ - U$, and are both direct current high voltages, the voltage U_{12} at the output terminal of the operational amplifier 12 after amplification is also a direct current high voltage, and equipment that receives the detection voltage outputted by the voltage detecting unit 31 for calculating the current I is generally low-voltage tolerant equipment, high-voltage isolation processing needs to be performed on the voltage U_{12} at the output terminal of the operational amplifier 12 to ensure the accuracy of current detection.

[0039] Specifically, one photocoupler 13 may be disposed between the operational amplifier 12 and the output terminal of the voltage detecting unit 31. An input terminal of the photocoupler 13 is connected to the output terminal of the operational amplifier 12, and an output terminal of the photocoupler 13 is connected to an output terminal of the voltage detecting unit 31.

[0040] The photocoupler 13 may specifically be a linear photocoupler, such as an ISO224 series. The photocoupler 13 includes a light emitter T1 and a light receiver T2. There is no electrical connection between the light emitter T1 and the light receiver T2, and information is transmitted through light intensity, enabling an isolation voltage ranging from ten thousand to several tens of thousands of volts. A voltage U_{13} at the output terminal of the linear photocoupler 13 is proportional to its voltage U_{12} at the input terminal, and the proportion is adjustable, and is denoted as K_{13} . The voltage U_{13} at the output terminal of the photocoupler 13 is $U_{13} = K_{13} * U_{12} = K_{13} * K_{12} * U = K_{13} * K_{12} * R * I$, and $U_{13} \propto I$. Through the circuit conversion, the current signal I of the sampling resistor R is converted into a voltage signal U_{13} . By detecting the voltage signal U_{13} , the loop current I may be calculated.

[0041] A positive input terminal of the light emitter T1 is connected to the output terminal of the operational amplifier 12, a negative input terminal and a reference potential terminal of the light emitter T1 are respectively configured to input a second reference voltage $VDD2_-$, and an absolute voltage difference $\Delta VDD2$ between the second reference voltage $VDD2_-$ and the

output voltage HV_+ at the output terminal of the electrostatic chuck power supply 10 is less than a withstand voltage difference U_{2max} of the light emitter T1. That is, a value range of $VDD2_-$ is $(HV_+ - U_{2max}, HV_+ + U_{2max})$. For example, the negative input terminal and the reference potential terminal of the light emitter T1 may be connected to the output terminal (the corresponding voltage is denoted as HV_+) of the electrostatic chuck power supply 10, that is, the second reference voltage $VDD2_-$ to ground of the reference potential terminal of the light emitter T1 is equal to HV_+ . Correspondingly, a power supplying terminal of the light emitter T1 is configured to input a second power supplying voltage $VDD2_+$, and the second power supplying voltage $VDD2_+$ is higher than the second reference voltage $VDD2_-$ by a preset second voltage value $\Delta v2$. That is, $VDD2_+ = VDD2_- + \Delta v2$. A value range of the second voltage value $\Delta v2$ is 3.3 V to 36 V. For example, it may be 12 V, in this case, $VDD2_+ = VDD2_- + 12V$. Similarly, in some embodiments, $\Delta VDD2 = 0$.

[0042] A reference potential terminal of the light receiver T2 is grounded (GND), a power supplying terminal of the light receiver T2 is configured to input a third power supplying voltage, and the third power supplying voltage is a preset third voltage value (e.g., 12 V). An output terminal of the light receiver T2 is connected to the output terminal of the voltage detecting unit 31.

[0043] Further, the voltage detecting unit 31 may further include a voltage follower 14. The photocoupler 13 is connected to the output terminal of the voltage detecting unit 31 via the voltage follower 14. The basic principle of the voltage follower 14 is to use negative feedback to achieve matching between an output voltage and an input voltage. The voltage follower 14 includes an amplifier and a feedback circuit. The feedback circuit compares an output signal of the amplifier with an input signal of the amplifier and feeds a difference therebetween back to the input terminal of the amplifier to maintain the stability of the output voltage.

[0044] Specifically, a positive input terminal IN_+ of the voltage follower 14 is connected to a positive output terminal of the photocoupler 13 and an output terminal of the voltage follower 14 respectively, and a negative input terminal IN_- of the voltage follower 14 is connected to a negative output terminal of the photocoupler 13. The output terminal of the voltage follower 14 is the output terminal of the voltage detecting unit 31.

[0045] A reference potential terminal of the voltage follower 14 is grounded (GND), a power supplying terminal of the voltage follower 14 is configured to input a fourth power supplying voltage, and the fourth power supplying voltage is a preset fourth voltage value (e.g., 12 V). Since the voltages at the input terminal, the output terminal, and the power supplying terminal of the

voltage follower 14 are all within 12 V to ground (when the third voltage value and the fourth voltage value are 12 V), an ordinary non-high-voltage-isolated operational amplifier may be adopted as the voltage follower 14. A voltage U_{14} at the output terminal of the voltage follower 14 is $U_{14}=U_{13}=K_{13}*U_{12}=K_{13}*K_{12}*U=K_{13}*K_{12}*R*I$, $U_{14}\propto I$. Through the circuit conversion, the current signal I of the sampling resistor R is converted into a voltage signal U_{14} . By detecting the voltage signal U_{14} , the loop current I may be calculated.

[0046] As shown in FIG. 4, considering that the loop current I is extremely weak, in order to improve sampling accuracy, a tunneling magneto resistive (TMR) sensor 11 may be disposed before the input terminal of the operational amplifier 12 based on FIG. 3. The TMR sensor 11 has a built-in integrated coil and is designed to resist external magnetic interference, offering extremely high precision. For example, a TMR-MAC005 sensor has a resolution of 150 nanoamperes (nA), which meets the micro-current sampling requirements of the ESC power supply 10.

[0047] A positive input terminal IN_+ of the TMR sensor 11 is connected to the input terminal of the sampling resistor R , a negative input terminal IN_- of the TMR sensor 11 is connected to the output terminal of the sampling resistor R , a positive output terminal Out_+ of the TMR sensor 11 is connected to the positive input terminal IN_+ of the operational amplifier 12, and a negative output terminal Out_- of the TMR sensor 11 is connected to the negative input terminal IN_- of the operational amplifier 12. The TMR sensor 11 is a linear sensor. A voltage U_{11} at the output terminal of the TMR sensor 11 is proportional to its voltage U at the input terminal, and the proportion is adjustable, denoted as K_{11} . The voltage U_{11} at the output terminal of the TMR sensor 11 is $U_{11}=K_{11}*U$. Correspondingly, a voltage U_{14} at the output terminal of the voltage follower 14 is $U_{14}=U_{13}=K_{13}*U_{12}=K_{13}*K_{12}*U_{11}=K_{13}*K_{12}*K_{11}*R*I$, $U_{14}\propto I$. Through the circuit conversion, the current signal I of the sampling resistor R is converted into a voltage signal U_{14} . By detecting the voltage signal U_{14} , the loop current I may be calculated.

[0048] Similar to the operational amplifier 12, to overcome the drawbacks of the high-voltage isolated operational amplifier 012 in FIG. 1, the TMR sensor 11 in the embodiment of the present application employs an ordinary linear sensor, as long as an isolation voltage between its input terminal and output terminal is greater than a preset voltage (e.g., 12 V).

[0049] Specifically, a reference potential terminal of the TMR sensor 11 is configured to input a fifth reference voltage $VDD5_-$. An absolute voltage difference $\Delta VDD5$ between the fifth reference voltage $VDD5_-$ and the output voltage HV_+ at the output terminal of the electrostatic chuck power supply 10 is less than a withstand voltage difference $U5_{max}$ of the TMR sensor 11. That is,

a value range of VDD5. is $(HV_+ - U_{5_{\max}}, HV_+ + U_{5_{\max}})$. For example, the reference potential terminal of the TMR sensor 11 may be connected to the output terminal (the corresponding voltage is denoted as HV_+) of the electrostatic chuck power supply 10, that is, the fifth reference voltage VDD5. to ground of the reference potential terminal of the TMR sensor 11 is equal to HV_+ . The power supplying terminal of the TMR sensor 11 is configured to input a fifth power supplying voltage VDD5₊, and the fifth power supplying voltage VDD5₊ is higher than the fifth reference voltage VDD5. by a preset fifth voltage value Δv_5 . That is, $VDD5_+ = VDD5 + \Delta v_5$. A value range of the fifth voltage value Δv_5 is 3.3 V to 36 V. For example, it may be 12 V, in this case, $VDD5_+ = VDD5 + 12V$. Similarly, in some embodiments, $\Delta VDD5 = 0$.

[0050] If the voltage HV_+ to ground is +2000 V, then the voltage VDD5. to ground is $(+2000V) + \Delta VDD5$. That is, the fifth reference voltage of the TMR sensor 11 is $(+2000V) + \Delta VDD5$ (relative to ground), and the voltage VDD5₊ to ground is $(+2012V) + \Delta VDD5$. A voltage difference between the voltage IN_+ at the positive input terminal of the TMR sensor 11 and the fifth reference voltage VDD5. is $HV_+ - VDD5 = 2000 - 2000 - \Delta VDD5 = -\Delta VDD5$, and a voltage difference between the voltage IN_- at the negative input terminal of the TMR sensor 11 and the fifth reference voltage VDD5. is $HV_- - VDD5 = 2000 - U - 2000 - \Delta VDD5 = -U - \Delta VDD5$, wherein U is the voltage difference (i.e., the sampling voltage) between the two ends of the sampling resistor R. Typically, $U < 10$ V. That is, the voltage difference between the input terminal and the output terminal of the TMR sensor 11 is less than $10V + \Delta VDD5$, while $\Delta VDD1$ is less than the withstand voltage difference $U_{1_{\max}}$ of the operational amplifier. Therefore, an ordinary non-high-voltage-isolated linear sensor may be used. For example, the withstand voltage difference $U_{5_{\max}}$ may be selected as 12 V, and in this case, the value range of VDD1. is $(1988, 2012)V$.

[0051] Correspondingly, the input terminals IN_+ and IN_- of the operational amplifier 12 are the output terminals Out_+ and Out_- of the TMR sensor 11. Assuming that both the first reference voltage VDD1. and the fifth reference voltage VDD5. are HV_+ , the voltage values of Out_+ and Out_- relative to the reference voltage are denoted as V_{Out+} and V_{Out-} , the voltage difference between the voltage at the positive input terminal IN_+ of the operational amplifier 12 and its reference voltage VDD. is $V_{Out+} + HV_+ - VDD = V_{Out+}$, and the voltage difference between the voltage at the negative input terminal IN_- of the operational amplifier 12 and its reference voltage VDD. is $V_{Out-} + HV_+ - VDD = V_{Out-}$. V_{Out+} and V_{Out-} are both less than 12 V (when the power supplying voltage to ground of the TMR sensor 11 is 12 V, according to a rail-to-rail rule, the output voltage to ground is $\leq 12V$), that is, the voltage difference between the input terminal and the output

terminal of the operational amplifier 12 is ≤ 12 V. Although the voltages to ground at the input terminals (IN₊ and IN₋) and the output terminal of the operational amplifier 12 are all direct current high voltages, the voltage differences between any two of them are very low. Therefore, an ordinary non-high-voltage-isolated operational amplifier may be used.

[0052] In some embodiments, the first power supplying voltage VDD1₊ required by the operational amplifier 12, the second power supplying voltage VDD2₊ required by the light emitter T1 in the photocoupler 13, and the fifth power supplying voltage VDD5₊ required by the TMR sensor 11 are all equal. Additionally, the reference voltages of the operational amplifier 12, the light emitter T1 in the photocoupler 13, and the TMR sensor 11 are all equal.

[0053] Further, the device for detecting the loop current of the electrostatic chuck power supply according to the embodiment of the present application may further include a power supplying unit, configured to output high-voltage power supplying voltages required by various components in the voltage detecting unit 31. For example, the power supplying unit outputs the first power supplying voltage VDD1₊ required by the operational amplifier 12 to the operational amplifier 12, outputs the second power supplying voltage VDD2₊ required by the light emitter T1 in the photocoupler 13 to the photocoupler 13, and outputs the fifth power supplying voltage VDD5₊ required by the TMR sensor 11 to the TMR sensor 11. In a case where the first power supplying voltage VDD1₊, the second power supplying voltage VDD2₊, and the fifth power supplying voltage VDD5₊ are all equal, the power supplying unit is configured to output the same power supplying voltage to the operational amplifier 12, the light emitter T1 of the photocoupler 13, and the TMR sensor 11.

[0054] As shown in FIG. 5, the power supplying unit is a direct current to direct current (DC/DC) circuit. The power supplying unit may specifically include a voltage conversion module T5. A first input terminal of the voltage conversion module T5 is configured to input a sixth power supplying voltage, and the sixth power supplying voltage is a preset sixth voltage value (e.g., 24 V). A second input terminal of the voltage conversion module T5 is grounded (GND) via a chopping module IC2. A first output terminal (SGND) of the voltage conversion module T5 is connected to the output terminal of the electrostatic chuck power supply, i.e., connected to the reference potential terminals of the operational amplifier 12, the photocoupler 13, and the TMR sensor 11 in FIG. 3 and FIG. 4. The corresponding voltage is denoted as SGND. A second output terminal of the voltage conversion module T5 is configured to output a target power supplying voltage (i.e., the first power supplying voltage, the second power supplying voltage, or the fifth power

supplying voltage). FIG. 5 illustrates an example where a voltage of the target power supplying voltage relative to SGND is 12V, i.e., the voltage relative to ground (GND) is (SGND+12)V. That is, the second output terminal of the voltage conversion module T5 is connected to the power supplying terminals of the operational amplifier 12, the photocoupler 13, and the TMR sensor 11 in FIG. 3 and FIG. 4.

[0055] The voltage conversion module T5 may specifically be a transformer. In FIG. 5, a power supplying voltage on a primary side of the transformer is 24 V, with the reference voltage being ground (GND), and an output voltage on a secondary side of the transformer is 12 V, with the reference voltage being SGND=HV₊. At this time, the voltage to ground of 12 V (relative to SGND) is (HV₊+12)V. If the voltage HV₊ to ground is +2000 V, that is, voltage SGND to ground is +2000 V, then the voltage to ground of 12 V (relative to SGND) is +2012 V. There is a voltage difference of 2000 V between SGND and the primary side ground (GND) of the transformer. This requires that the isolation voltage U_{iso} between the primary and secondary sides of the transformer satisfy U_{iso}>HV₊=2000V, which can generally be achieved by means such as winding insulation, overall potting, and increasing a distance between the primary side and the secondary side.

[0056] The power supplying unit can maintain the stability of the output voltage of the power supplying unit by adjusting an output pulse width modulation (PWM) duty cycle of the chopping module IC2.

[0057] A power supply input pin VIN (corresponding to pin 13) of the chopping module IC2 is connected to the first input terminal of the voltage conversion module T5, a soft start pin SS (corresponding to pin 14) of the chopping module IC2 is grounded, a switching pin SW (corresponding to pins 9-11) of the chopping module IC2 is connected to the second input terminal of the voltage conversion module T5, and the chopping module IC2 is configured to periodically connect or disconnect the switching pin SW and the second input terminal of the voltage conversion module T5.

[0058] The power supplying unit may further include an input circuit, and the power supply input pin VIN of the chopping module IC2 is connected to the first input terminal of the voltage conversion module T5 via the input circuit. The input circuit includes a second resistor R2 and a tenth capacitor C10. A first terminal of the second resistor R2 is connected to the first input terminal of the voltage conversion module T5, and a second terminal of the second resistor R2 is connected to the power supply input pin VIN of the chopping module IC2. A first terminal of the

tenth capacitor C10 is connected to the power supply input pin VIN of the chopping module IC2, and a second terminal of the tenth capacitor C10 is grounded (GND).

[0059] The power supplying unit may further include an input feedback circuit. The input feedback circuit includes a fifth resistor R5 and a sixth resistor R6. A first terminal of the fifth resistor R5 is connected to the first input terminal of the voltage conversion module T5, a second terminal of the fifth resistor R5 is connected to a first terminal of the sixth resistor R6, and a second terminal of the sixth resistor R6 is connected to a compensation pin COMP (corresponding to pin 1) of the chopping module IC2.

[0060] The power supplying unit may further include a voltage regulation and filtering circuit. The voltage regulation and filtering circuit includes a fourteenth capacitor C14 and a second voltage-regulator diode Z2. A first terminal of the fourteenth capacitor C14 is connected to the second terminal of the fifth resistor R5, and a second terminal of the fourteenth capacitor C14 is grounded (GND). A first terminal of the second voltage-regulator diode Z2 is connected to the second terminal of the fifth resistor R5, and the second terminal of the fourteenth capacitor C14 is grounded (GND).

[0061] The power supplying unit may further include a power supplying circuit that provides an operating voltage for the chopping module IC2. The power supplying circuit includes a fourth resistor R4 and a ninth resistor R9. A first terminal of the fourth resistor R4 is connected to the first input terminal of the voltage conversion module T5, and a second terminal of the fourth resistor R4 is connected to a pin SHDN (corresponding to pin 3) of the chopping module IC2. A first terminal of the ninth resistor R9 is connected to the second terminal of the fourth resistor R4, and a second terminal of the ninth resistor R9 is grounded (GND).

[0062] The power supplying unit may further include a voltage spike snubber circuit. The voltage spike snubber circuit includes a first voltage-regulator diode Z1 and a second diode D2; and the first voltage-regulator diode Z1 and the second diode D2 are connected in series between the first input terminal and the second input terminal of the voltage conversion module T5.

[0063] The power supplying unit may further include a soft-start circuit. The soft-start circuit includes a fifteenth capacitor C15 and a sixteenth capacitor C16. A first terminal of the fifteenth capacitor C15 is connected to the soft start pin SS of the chopping module IC2, and a second terminal of the fifteenth capacitor C15 is grounded (GND). A first terminal of the sixteenth capacitor C16 is connected to a bypass control pin BYP (corresponding to pin 12) of the chopping module IC2, and a second terminal of the sixteenth capacitor C16 is grounded (GND).

- [0064] The power supplying unit may further include an isolation capacitor C12, configured to isolate the ground GND at the input terminal of the voltage conversion module T5 from the ground SGND at the output terminal. A first terminal of the isolation capacitor C12 is connected to a compensation pin COMP (corresponding to pin 1) of the chopping module IC2, and a second terminal of the isolation capacitor C12 is grounded.
- [0065] The power supplying unit may further include an RCD snubber circuit. The RCD snubber circuit includes a first diode D1, a first capacitor C1, and a third resistor R3. A first terminal of the first diode D1 is connected to the second output terminal of the voltage conversion module T5, and a second terminal of the first diode D1 is configured to output the target power supplying voltage. A first terminal of the first capacitor C1 is connected to the second output terminal of the voltage conversion module T5, a second terminal of the first capacitor C1 is connected to a first terminal of the third resistor R3, and a second terminal of the third resistor R3 is connected to the first output terminal (SGND) of the voltage conversion module T5.
- [0066] The power supplying unit may further include a third filter capacitor C3, a first terminal of the third filter capacitor C3 is connected to the second terminal of the first diode D1, and a second terminal of the third filter capacitor C3 is connected to the first output terminal (SGND) of the voltage conversion module T5.
- [0067] The power supplying unit may further include a sixth filter capacitor C6, a first terminal of the sixth filter capacitor C6 is connected to the second terminal of the first diode D1, and a second terminal of the sixth filter capacitor C6 is connected to the first output terminal (SGND) of the voltage conversion module T5.
- [0068] The power supplying unit may further include a ninth filter capacitor C9, a first terminal of the ninth filter capacitor C9 is connected to the second terminal of the first diode D1, a second terminal of the ninth filter capacitor C9 is connected to the first output terminal (SGND) of the voltage conversion module T5, and the second terminal of the third resistor R3 is connected to the first output terminal (SGND) of the voltage conversion module T5 via the ninth filter capacitor C9.
- [0069] The power supplying unit may further include a second photocoupler IC1, a positive input terminal of the second photocoupler IC1 is connected to the first output terminal (SGND) of the voltage conversion module T5 via an eleventh capacitor C11, a negative input terminal of the second photocoupler IC1 is connected to the first output terminal (SGND) of the voltage conversion module T5 via an output feedback circuit, a positive output terminal of the second

photocoupler IC1 is connected to the first terminal of the isolation capacitor C12, and a negative output terminal of the second photocoupler IC1 is grounded (GND).

[0070] The output feedback circuit includes an eighth resistor R8, a thirteenth capacitor C13, a seventh resistor R7, a tenth resistor R10, and a reference voltage source IC3. A first terminal of the eighth resistor R8 is connected to the negative input terminal of the second photocoupler IC1, a second terminal of the eighth resistor R8 is connected to the first output terminal (SGND) of the voltage conversion module T5 via the reference voltage source IC3, a first terminal of the thirteenth capacitor C13 is connected to the second terminal of the eighth resistor R8, a second terminal of the thirteenth capacitor C13 is connected to the first output terminal (SGND) of the voltage conversion module T5 via the tenth resistor R10, a first terminal of the seventh resistor R7 is connected to the second terminal of the first diode D1, and a second terminal of the seventh resistor R7 is connected to the first output terminal (SGND) of the voltage conversion module T5 via the tenth resistor R10.

[0071] Further, as shown in FIG. 6, based on the embodiment shown in FIG. 5, the power supplying unit may further include a second filter capacitor C2, a seventh filter capacitor C7, and an eighth filter capacitor C8 which are disposed at the input terminal of the voltage conversion module T5. Selecting a combination of capacitors with different capacitance values and dielectric materials may filter interference signals of different frequencies, thereby enhancing the anti-interference capability of the input terminal. First terminals of the second filter capacitor C2, the seventh filter capacitor C7, and the eighth filter capacitor C8 are all connected to the first input terminal of the voltage conversion module T5, and second terminals of the second filter capacitor C2, the seventh filter capacitor C7, and the eighth filter capacitor C8 are all grounded (GND).

[0072] The power supplying unit may further include a fourth filter capacitor C4 and a fifth filter capacitor C5 which are disposed at the output terminal of the voltage conversion module T5. Selecting a combination of capacitors with different capacitance values and dielectric materials may filter interference signals of different frequencies, thereby enhancing the anti-interference capability of the output terminal, ensuring the stability of the output voltage, and reducing ripple. The fourth filter capacitor C4 and the fifth filter capacitor C5 are each connected in parallel with the sixth filter capacitor C6.

[0073] The power supplying unit may further include a dummy load resistor R93 connected in parallel with the sixth filter capacitor C6 to ensure the stability of the output voltage.

[0074] The power supplying unit may further include an output indication circuit. The output indication circuit includes an indicator light LED1 and a first resistor R1 which are connected in series to provide output indication. The output indication circuit is connected in parallel with the sixth filter capacitor C6.

[0075] In summary, in the device for detecting the loop current of the electrostatic chuck power supply according to the embodiment of the present application, the reference potential terminal of the operational amplifier is connected to the output terminal of the electrostatic chuck power supply, the power supplying terminal of the operational amplifier is configured to input the first power supplying voltage, and the first power supplying voltage is higher than the output voltage at the output terminal of the electrostatic chuck power supply by the preset first voltage value. By setting the reference voltage at the reference potential terminal of the operational amplifier as the output voltage at the output terminal of the electrostatic chuck power supply, the voltages to ground at the input terminals (the positive input terminal, the negative input terminal) and the output terminal of the operational amplifier are all direct current high voltages. However, the voltage differences between any two of these terminals are very low. Thus, the ordinary non-high-voltage-isolated operational amplifier may be used as the operational amplifier, which avoid the problems that the high-voltage isolated operational amplifier is high in cost and has a limited isolable voltage range, and when the high voltage at the output terminal of the electrostatic chuck power supply is too high, the accuracy of current detection is poor, thereby reducing the costs and improving the accuracy of current detection. High-voltage isolation is achieved through the photocoupler 13, low-cost high-voltage isolation is achieved, and the precision of current detection is ensured. The stability of the outputted detection voltage is ensured through the voltage follower, thereby further improving the accuracy of current detection. Through the TMR sensor, the precision of current sampling is improved. By increasing the reference voltage of the TMR sensor, the non-high-voltage-isolated TMR sensor may be used, thereby avoiding the problem of high cost of high-voltage isolation. The power supplying unit provides the required high-voltage power supplying voltage for the various components in the voltage detecting unit.

[0076] An embodiment of the present application further provides semiconductor process equipment. As shown in FIG. 7, the semiconductor process equipment 70 according to the embodiment of the present application includes: an electrostatic chuck 23, an electrostatic chuck power supply

10, and the device 71 for detecting the loop current of the electrostatic chuck power supply in the above embodiment.

[0077] The system, device, module or unit illustrated in the above embodiments may be specifically embodied by a computer chip or entity, or by a product having a certain function. A typical implementation device is a computer. In particular, the computer may be, for example, a personal computer, a laptop computer, a cellular phone, a camera phone, a smart phone, a personal digital assistant, a media player, a navigation device, an email device, a game console, a tablet computer, a wearable device, or any combination of these devices.

[0078] For the ease of description, the above device is divided into various units according to functions to be described respectively when the device is described. Certainly, the functions of the units may be implemented in the same or multiple software and/or hardware when the present application is implemented.

[0079] Those skilled in the art should understand that the embodiments of the present application may be provided as methods, systems or computer program products. Therefore, the present application can adopt forms of full hardware embodiments, full software embodiments, or embodiments combining software and hardware aspects. Moreover, the present application may adopt a form of the computer program products implemented on one or more computer available storage mediums (including but not limited to a disk memory, a CD-ROM, an optical memory and the like) containing computer available program codes.

[0080] The present application is described with reference to the flow diagram and/or block diagram of the method, device (system), and computer program product according to the embodiments of the present application. It should be understood that each flow and/or block in the flow diagram and/or block diagram and the combination of flows and/or blocks in the flow diagram and/or block diagram can be implemented by computer program instructions. These computer program instructions can be provided to processors of a general-purpose computer, a special-purpose computer, an embedded processor or other programmable data processing devices to generate a machine, so that instructions executed by processors of a computer or other programmable data processing devices generate a device for implementing the functions specified in one or more flows of the flow diagram and/or one or more blocks of the block diagram.

[0081] These computer program instructions may also be stored in a computer readable memory which can guide the computer or other programmable data processing devices to work in a specific mode, thus the instructions stored in the computer readable memory generates an article of

manufacture that includes a commander device that implement the functions specified in one or more flows in the flow diagrams and/or one or more blocks in the block diagrams.

[0082] These computer program instructions may also be loaded to the computer or other programmable data processing devices, so that a series of operating steps are executed on the computer or other programmable devices to generate computer-implemented processing, such that the instructions executed on the computer or other programmable devices provide steps for implementing the functions specified in one or more flows in the flow diagrams and/or one or more blocks in the block diagrams.

[0083] In a typical configuration, a computing device includes one or more processors (CPUs), input/output interfaces, network interfaces, and an internal storage.

[0084] The internal storage may include a volatile memory, a random access memory (RAM), and/or a non-volatile memory in the computer readable medium, such as a read-only memory (ROM) or a flash RAM. The internal storage is an example of the computer readable medium.

[0085] The computer readable medium, including permanent and non permanent, removable and non removable media, can be used by any method or technology to achieve information storage. Information may be computer-readable instructions, data structures, modules of programs, or other data. Examples of the computer storage medium include, but not limited to, a phase-change random access memory (PRAM), a static random access memory (SRAM), a dynamic random access memory (DRAM), other types of random access memories (RAM), a read-only memory (ROM), an electrically erasable programmable read-only memory (EEPROM), a flash memory or other internal storage technologies, a compact disc read-only memory (CD-ROM), a digital versatile disc (DVD) or other optical storage and magnetic cassette tape, magnetic-tape magnetic-disk storage or other magnetic storage devices or any other non-transmission media, and may be used to store information that can be accessed by a computing device. According to the definition herein, the computer readable medium does not include a transitory computer-readable media such as modulated data signals and carriers.

[0086] It should be further noted that terms “including,” “containing,” or any other variations are intended to cover non-exclusive inclusion, such that a process, method, commodity or device that includes a series of elements not only includes those elements, but also other elements that are not explicitly listed, or further include elements inherent in such the process, method, commodity or device. Without further restrictions, the elements defined by the sentence

“including a...” do not exclude that there are other same elements in the process, method, article or device including the elements.

[0087] The present application may be described in the general context of computer-executable instructions executed by a computer, such as a program module. Generally, the program module includes routines, programs, objects, components, data structures, etc. that perform specific tasks or implement specific abstract data types. The present application can also be practiced in distributed computing environments. In these distributed computing environments, remote processing devices connected through a communication network perform tasks. In the distributed computing environments, program modules can be located in local and remote computer storage media including storage devices.

[0088] The various embodiments in this specification are described in a progressive manner, and the same or similar parts between the various embodiments can be referred to each other. Each embodiment focuses on contents different from other embodiments. In particular, as for the system embodiments, as they are basically similar to the method embodiments, the description is relatively simple. As for related parts, please refer to part of the description in the method embodiments.

[0089] The above is merely the embodiments of the present application and is not intended to limit the present application. For those skilled in the art, the present application may have various modifications and changes. Any modifications, equivalent replacements, improvements, etc. made within the spirit and principle of the present application shall fall within the scope of the claims of the present application.

Claims

1. A device for detecting a loop current of an electrostatic chuck power supply, comprising:

a sampling resistor, connected in series to an output terminal of the electrostatic chuck power supply; and

an operational amplifier, wherein a positive input terminal of the operational amplifier is connected to an input terminal of the sampling resistor, a negative input terminal of the operational amplifier is connected to an output terminal of the sampling resistor, a reference potential terminal of the operational amplifier is configured to input a first reference voltage, an absolute voltage difference between the first reference voltage and an output voltage at an output terminal of the electrostatic chuck power supply is less than a withstand voltage difference of the operational amplifier, a power supplying terminal of the operational amplifier is configured to input a first power supplying voltage, the first power supplying voltage is higher than the first reference voltage by a preset first voltage value, and an output terminal of the operational amplifier is configured to output a voltage signal proportional to the loop current.

2. The device according to claim 1, further comprising: a photocoupler, wherein the photocoupler comprises a light emitter and a light receiver;

a positive input terminal of the light emitter is connected to the output terminal of the operational amplifier, a negative input terminal and a reference potential terminal of the light emitter are respectively configured to input a second reference voltage, an absolute voltage difference between the second reference voltage and an output voltage at the output terminal of the electrostatic chuck power supply is less than a withstand voltage difference of the light emitter, and a power supplying terminal of the light emitter is configured to input a second power supplying voltage, and the second power supplying voltage is higher than the second reference voltage by a preset second voltage value; and

a reference potential terminal of the light receiver is grounded, a power supplying terminal of the light receiver is configured to input a third power supplying voltage, and the third power supplying voltage is a preset third voltage value.

3. The device according to claim 2, further comprising:

a voltage follower, wherein a positive input terminal of the voltage follower is connected to a positive output terminal of the photocoupler and an output terminal of the voltage follower respectively, and a negative input terminal of the voltage follower is connected to a negative output terminal of the photocoupler.

4. The device according to claim 3, wherein a reference potential terminal of the voltage follower is grounded, a power supplying terminal of the voltage follower is configured to input a fourth power supplying voltage, and the fourth power supplying voltage is a preset fourth voltage value.

5. The device according to claim 1, further comprising:

a tunneling magneto resistive sensor, wherein the operational amplifier is connected to two ends of the sampling resistor via the tunneling magneto resistive sensor; and

a positive input terminal of the tunneling magneto resistive sensor is connected to the input terminal of the sampling resistor, a negative input terminal of the tunneling magneto resistive sensor is connected to the output terminal of the sampling resistor, a positive output terminal of the tunneling magneto resistive sensor is connected to the positive input terminal of the operational amplifier, a negative output terminal of the tunneling magneto resistive sensor is connected to the negative input terminal of the operational amplifier, a reference potential terminal of the tunneling magneto resistive sensor is configured to input a fifth reference voltage, an absolute voltage difference between the fifth reference voltage and the output voltage at the output terminal of the electrostatic chuck power supply is less than a withstand voltage difference of the tunneling magneto resistive sensor, a power supplying terminal of the tunneling magneto resistive sensor is configured to input a fifth power supplying voltage, and the fifth power supplying voltage is higher than the fifth reference voltage by a preset fifth voltage value.

6. The device according to any one of claims 1 to 5, further comprising:

a power supplying unit, configured to output the first power supplying voltage to the operational amplifier.

7. The device according to claim 6, wherein the power supplying unit comprises:

a voltage conversion module, wherein a first input terminal of the voltage conversion module is configured to input a sixth power supplying voltage, the sixth power supplying voltage is a preset sixth voltage value, a second input terminal of the voltage conversion module is grounded via a chopping module, a first output terminal of the voltage conversion module is connected to the output terminal of the electrostatic chuck power supply, and a second output terminal of the voltage conversion module is configured to output the first power supplying voltage; and

a power supply input pin of the chopping module is connected to the first input terminal of the voltage conversion module, a soft start pin of the chopping module is grounded, a switching pin of the chopping module is connected to the second input terminal of the voltage conversion module,

and the chopping module is configured to periodically connect or disconnect the switching pin and the second input terminal of the voltage conversion module.

8. The device according to claim 7, wherein the power supplying unit further comprises: an input circuit, and the power supply input pin of the chopping module is connected to the first input terminal of the voltage conversion module via the input circuit; and

the input circuit comprises:

a second resistor, wherein a first terminal of the second resistor is connected to the first input terminal of the voltage conversion module, and a second terminal of the second resistor is connected to the power supply input pin of the chopping module; and

a tenth capacitor, wherein a first terminal of the tenth capacitor is connected to the power supply input pin of the chopping module, and a second terminal of the tenth capacitor is grounded.

9. The device according to claim 7, wherein the power supplying unit further comprises: an input feedback circuit and a voltage regulation and filtering circuit;

the input feedback circuit comprises: a fifth resistor and a sixth resistor; and a first terminal of the fifth resistor is connected to the first input terminal of the voltage conversion module, a second terminal of the fifth resistor is connected to a first terminal of the sixth resistor, and a second terminal of the sixth resistor is connected to a compensation pin of the chopping module; and

the voltage regulation and filtering circuit comprises: a fourteenth capacitor and a second voltage-regulator diode; a first terminal of the fourteenth capacitor is connected to the second terminal of the fifth resistor, and a second terminal of the fourteenth capacitor is grounded; and a first terminal of the second voltage-regulator diode is connected to the second terminal of the fifth resistor, and the second terminal of the fourteenth capacitor is grounded.

10. The device according to claim 7, wherein the power supplying unit further comprises: a voltage spike snubber circuit and a soft-start circuit;

the voltage spike snubber circuit comprises: a first voltage-regulator diode and a second diode; and the first voltage-regulator diode and the second diode are connected in series between the first input terminal and the second input terminal of the voltage conversion module; and

the soft-start circuit comprises: a fifteenth capacitor and a sixteenth capacitor; a first terminal of the fifteenth capacitor is connected to the soft start pin of the chopping module, and a second terminal of the fifteenth capacitor is grounded; and a first terminal of the sixteenth capacitor is connected to a bypass control pin of the chopping module, and a second terminal of the sixteenth capacitor is grounded.

11. The device according to claim 7, wherein the power supplying unit further comprises:

an RCD snubber circuit, wherein the RCD snubber circuit comprises a first diode, a first capacitor, and a third resistor; a first terminal of the first diode is connected to the second output terminal of the voltage conversion module, and a second terminal of the first diode is configured to output the first power supplying voltage; and a first terminal of the first capacitor is connected to the second output terminal of the voltage conversion module, a second terminal of the first capacitor is connected to a first terminal of the third resistor, and a second terminal of the third resistor is connected to the first output terminal of the voltage conversion module;

a third filter capacitor, wherein a first terminal of the third filter capacitor is connected to the second terminal of the first diode, and a second terminal of the third filter capacitor is connected to the first output terminal of the voltage conversion module;

a sixth filter capacitor, wherein a first terminal of the sixth filter capacitor is connected to the second terminal of the first diode, and a second terminal of the sixth filter capacitor is connected to the first output terminal of the voltage conversion module; and

a ninth filter capacitor, wherein a first terminal of the ninth filter capacitor is connected to the second terminal of the first diode, a second terminal of the ninth filter capacitor is connected to the first output terminal of the voltage conversion module, and the second terminal of the third resistor is connected to the first output terminal of the voltage conversion module via the ninth filter capacitor.

12. The device according to claim 11, wherein the power supplying unit further comprises:

an isolation capacitor, wherein a first terminal of the isolation capacitor is connected to a compensation pin of the chopping module, and a second terminal of the isolation capacitor is grounded; and

a second photocoupler, wherein a positive input terminal of the second photocoupler is connected to the first output terminal of the voltage conversion module via an eleventh capacitor, a negative input terminal of the second photocoupler is connected to the first output terminal of the voltage conversion module via an output feedback circuit, a positive output terminal of the second photocoupler is connected to the first terminal of the isolation capacitor, and a negative output terminal of the second photocoupler is grounded; wherein

the output feedback circuit comprises an eighth resistor, a thirteenth capacitor, a seventh resistor, a tenth resistor, and a reference voltage source; and a first terminal of the eighth resistor is connected to the negative input terminal of the second photocoupler, a second terminal of the

eighth resistor is connected to the first output terminal of the voltage conversion module via the reference voltage source, a first terminal of the thirteenth capacitor is connected to the second terminal of the eighth resistor, a second terminal of the thirteenth capacitor is connected to the first output terminal of the voltage conversion module via the tenth resistor, a first terminal of the seventh resistor is connected to the second terminal of the first diode, and a second terminal of the seventh resistor is connected to the first output terminal of the voltage conversion module via the tenth resistor.

13. The device according to claim 7, wherein the power supplying unit further comprises: a second filter capacitor, a seventh filter capacitor, and an eighth filter capacitor which are disposed at the input terminal of the voltage conversion module; and

first terminals of the second filter capacitor, the seventh filter capacitor, and the eighth filter capacitor are all connected to the first input terminal of the voltage conversion module, and second terminals of the second filter capacitor, the seventh filter capacitor, and the eighth filter capacitor are all grounded.

14. The device according to claim 11, wherein the power supplying unit further comprises: a fourth filter capacitor, a fifth filter capacitor, and a dummy load resistor which are disposed at the output terminal of the voltage conversion module; and

the fourth filter capacitor, the fifth filter capacitor, and the dummy load resistor are each connected in parallel with the sixth filter capacitor.

15. The device according to claim 11, wherein the power supplying unit further comprises: an output indication circuit; and

the output indication circuit comprises an indicator light and a first resistor which are connected in series, and the output indication circuit is connected in parallel with the sixth filter capacitor.

16. Semiconductor process equipment, comprising: an electrostatic chuck, an electrostatic chuck power supply, and the device for detecting the loop current of the electrostatic chuck power supply according to any one of claims 1 to 15.