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VERIFICATION OF TRANSLATION

I, Rumiko Whitehead

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declare that I am well acquainted with both the Japanese and English languages, and that the attached is an accurate translation, to the best of my knowledge and ability, of Japanese Unexamined Patent Application Publication No. H10-330938, published December 15, 1998.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the above-captioned application or any patent issued thereon.

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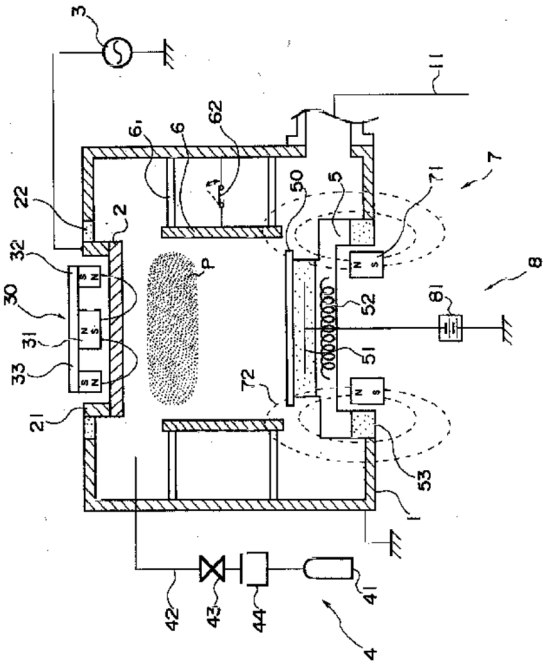
(54) [Title of Invention] Ionizing Sputtering Device and Method of Ionizing Sputtering

(57) [Abstract]

[Problem] To form a film with good bottom coverage by ionizing sputtering with respect to holes having a high aspect ratio, and to simplify inside and outside structures of a sputter chamber.

[Means to Resolve the Problem] A target 2, provided inside a sputter chamber 1 equipped with an evacuation system 11, is sputtered using a sputtering power source 3 so that sputter particles emitted therefrom are made to arrive at a substrate 50 to form a film. The sputtering power source 3 supplies an electric power of 5W/cm^2 or higher to the target 2, and sputter particles are ionized in a plasma P formed only by this electric power. A cylindrical shield 6 is provided between the target 2 and a substrate holder 5 and regulates a plasma-forming space, and an electric field establishment means 8 establishes an electric field to extract the ionized sputter particles from the plasma P and cause them to enter the substrate 50.



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[Scope of Claims]
[Claim 1] An ionizing sputtering device consisting of a sputter chamber equipped with an evacuation system, a target provided inside the sputter chamber, a gas introduction means which introduces a predetermined gas into the sputter chamber, a sputtering power source which sputters the target by generating sputter discharge in the gas introduced, and a substrate holder which holds a substrate in a position at which sputter particles released from the target by sputtering enter the substrate;
wherein the aforementioned sputtering power source is capable of ionizing the aforementioned sputter particles in a plasma formed by the aforementioned sputter discharge, using only the electric power applied by such sputtering power source.

[Claim 2] The ionizing sputtering device according to claim 1, wherein the aforementioned sputtering power source applies a high frequency electric power to the target such that a supplied-electric power area density of the high frequency electric power divided by the area of the sputtered face of the target is $5W/cm^2$ or higher.

[Claim 3] The ionizing sputtering device according to claims 1 or 2, wherein the aforementioned target and the aforementioned substrate holder are positioned so as to be coaxially facing each other, and a cylindrical shield is coaxially provided in a space between the target and the substrate holder.

[Claim 4] The ionizing sputtering device according to claims 1, 2, or 3, wherein the ionizing sputtering device is provided with an electric field establishment means which establishes an electric field for extracting the aforementioned ionized sputter particles from the aforementioned plasma and causing them to enter the substrate.

[Claim 5] An ionizing sputtering method in which a predetermined electric power is applied to a target provided inside a sputter chamber so as to generate a sputter discharge and sputter said target, and sputter particles released from said target are caused to arrive at a surface of a substrate to deposit a predetermined thin film,
wherein the inside of the aforementioned sputter chamber is maintained at a pressure between 10 mTorr and 100 mTorr and, in a plasma formed by the sputter discharge, the aforementioned sputter particles are ionized by just the electric power applied to the aforementioned target, and the aforementioned thin film is deposited by causing the ionized sputter particles to arrive at the aforementioned substrate.

[Claim 6] An ionizing sputtering method wherein the predetermined electric power applied to the aforementioned target is a high frequency electric power such that a supplied-electric power area density of the high frequency electric power divided by the area of the sputtered face of the target is $5W/cm^2$ or higher.

[Detailed Description of Invention]
[0001]
[Technical Field of the Invention] The present invention relates to a sputtering device used in the manufacture of various types of semiconductor devices and the like, and in particular an ionizing sputtering device in which sputter particles are ionized and utilized for the formation of film.

[002]
[Prior Art] With semiconductor devices, such as various types of memory and logic devices, a sputtering process is used in the production of various types of wiring films, and the production of barrier films which prevent interdiffusion of different types of layers, and a sputtering device is often used for this purpose. There are various characteristics that are required in such sputtering devices; however, there is recently a great need for the ability to coat the inner surfaces of holes formed in a substrate with good coverage.

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[0003] To be specific, in a CMOS-FET (field effect transistor), which is frequently used in a DRAM, for example, a structure is employed in which cross-contamination of a contact wiring layer and a diffusion layer is prevented by providing a barrier film to the inner surface of contact holes provided on the diffusion layer. In addition, in a multi-layered wiring structure in which memory cells are wired, a through hole is provided on an interlayer insulation film, and interlayer wiring is embedded inside the through hole to connect a lower-layer wiring and an upper-layer wiring. Here again, a structure is employed in which a barrier film is produced inside the through hole to prevent cross-contamination.

[0004] Due to the increasing degree of integration, the aspect ratio (the ratio of a depth of a hole to a diameter or width of an opening of the hole) of such holes is becoming higher, year after year. For example, the aspect ratio is around 4 with a 64 megabit DRAM, but the aspect ratio is around 5-6 with a 256 megabit DRAM.

[0005] In the case of a barrier film, it is necessary to deposit a thin film on the bottom surface of a hole in an amount that is 10 to 15% of the amount deposited to the surrounding surfaces of the hole; however, with holes with a high aspect ratio, it is difficult to form films with a high degree of bottom coverage (the ratio of the film formation speed on the surrounding surfaces of the hole to the deposition speed on the bottom surface of the hole). When the bottom coverage decreases, the barrier film on the bottom surface of the hole becomes thin, thereby creating the risk of causing critical defects in the characteristics of the device, such as junction leaks and the like.

[0006] Methods such as collimation sputtering and low-pressure, long-distance sputtering have been developed up to now as a sputtering method which increases bottom coverage. Collimation sputtering is a method where a plate (collimator), in which numerous holes have been made in a direction perpendicular to the substrate, is provided between the target and the substrate, and only those sputter particles (usually sputtering atoms) that fly more or less perpendicular to the substrate are selectively allowed to arrive at the substrate. Low-pressure, long-distance sputtering is a method in which the distance between the target and the substrate is lengthened (to three to five times the usual distance) to cause relatively more sputter particles that fly more or less perpendicular to the substrate to enter the substrate, and, by setting the pressure to a level lower than usual (about 0.8 mTorr or lower), the mean free path is lengthened and the sputter particles are prevented from dispersing.

[0007] However, with collimation sputtering, there is a problem in which the sputter particles accumulate on the collimator portion, and the loss of such sputter particles causes the film formation speed to decrease. In low-pressure, long-distance sputtering, there is problem that the film formation speed inherently decreases because the distance between the target and the substrate is lengthened by the lower pressure. Because of such problems, collimation sputtering is used only in mass-production of 16 megabit-class products with an aspect ratio of up to around 3, and low-pressure, long-distance sputtering is limited to devices having an aspect ratio of up to around 4.

[0008]
[Problems to Be Solved by the Invention] In light of this situation, an ionizing sputtering method is being considered as a technology that allows the formation of a film with good bottom coverage with respect to holes having an aspect ratio of 4 or higher. Ionizing sputtering is a method in which sputter particles released from the target are ionized, and bottom coverage is improved by the action of these ions.

[0009] However, ionizing sputtering has a number of practical problems. One of these is in the structure of the energy supply used for ionization. That is, in order to perform ionizing sputtering, it is effective to form a plasma in the flight path of the sputter particles from the target to the substrate. One possible structure is to provide a (coil or plate-shaped) electrode separately from the target and to connect a power

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source that applies electric power to the electrode, in order to form the plasma. However, a drawback to such a structure is that the structure inside the sputter chamber is complicated. Moreover, since a power source is provided separately from the sputtering power source, the structure around the sputter chamber is also complicated. Additionally, the cost is high.

[0010] The present invention was conceived to solve these problems, and the purpose thereof is to provide a device and method that enables the formation of a film with good bottom coverage by ionizing sputtering with respect to holes having a high aspect ratio, which also simplifies the inside and outside structures of a sputter chamber and reduces costs.

[0011]
[Means to Solve the Problems] In order to solve the problems set forth above, the invention set forth in claim 1 of this application is an ionizing sputtering device consisting of a sputter chamber equipped with an evacuation system, a target provided inside the sputter chamber, a gas introduction means which introduces a predetermined gas into the sputter chamber, a sputtering power source which sputters the target by generating sputter discharge in the gas introduced, and a substrate holder which holds a substrate in a position at which sputter particles released from the target by sputtering enter the substrate; wherein the aforementioned sputtering power source is capable of ionizing the aforementioned sputter particles in a plasma formed by the aforementioned sputter discharge, using only the electric power applied by such sputtering power source. Additionally, in order to solve the problems set forth above, the invention set forth in claim 2 has a structure in which the aforementioned sputtering power source applies a high frequency electric power to the target, wherein the supplied-electric power area density of the high frequency electric power divided by the area of the sputtered face of the target is $5W/cm^2$ or higher. Additionally, in order to solve the problems set forth above, the invention set forth in claim 3 has a structure according to claims 1 or 2 above, wherein the aforementioned target and the aforementioned substrate holder are positioned so as to be coaxially facing each other, and includes a cylindrical shield coaxially provided in a space between the target and the substrate holder, and is provided with an electric field establishment means which establishes an electric field perpendicular to the substrate for extracting ions from the plasma formed on the inner side of the aforementioned shield and causing them to enter the substrate. Additionally, in order to solve the problems set forth above, the invention set forth in claim 4 has a structure according to claims 1, 2, or 3 above, and is provided with an electric field establishment means which establishes an electric field for extracting the aforementioned ionized sputter particles from the aforementioned plasma and causing them to enter the substrate. Additionally, in order to solve the problems set forth above, the invention set forth in claim 5 is a sputtering method in which a predetermined electric power is applied to a target provided inside a sputter chamber so as to generate a sputter discharge and sputter said target, and sputter particles released from said target are caused to arrive at a surface of a substrate to deposit a predetermined thin film, wherein the inside of the aforementioned sputter chamber is maintained at a pressure between 10 mTorr and 100 mTorr and, in the a plasma formed by the sputter discharge, the aforementioned sputter particles are ionized by just the electric power applied to the aforementioned target, and the aforementioned thin film is deposited by causing the ionized sputter particles to arrive at the aforementioned substrate. Additionally, in order to solve the problems set forth above, the invention set forth in claim 6 has a structure according to claim 5 above, wherein the predetermined electric power applied to the aforementioned target is a high frequency electric power such that a supplied-electric power area density of the high frequency electric power divided by the area of the sputtered face of the target is $5W/cm^2$ or higher.

[0012]
[Embodiments of the Invention] An embodiment of the present invention is described below. Fig. 1 is a simplified front view describing a structure of an ionizing sputtering device according to one embodiment of the present invention. The sputtering device shown in Fig. 1 has a sputter chamber 1 equipped with an evacuation system 11, a target 2 provided inside the sputter chamber 1, a sputtering power source 3 which

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