Description

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates to plasma etching equipment and, more particularly, to a gas distribution system for a plasma etcher.

2. Prior Art.

Previously, plasma etching equipment used to etch thin oxide films in semiconductor devices have had problems with contamination of a semiconductor device by polymer particles. Thin layers of polymer materials are deposited over the interior surface of a reaction chamber. The polymers are produced as a result of the chemical reactions involved in the oxide etching process. Gases for the plasma etching process are injected into the reaction chamber through gas inlet holes in a gas distribution plate, which is positioned within the reaction chamber directly over a semiconductor wafer mounted on a cathode structure. A plasma is formed in the reaction chamber and the plasma may even extend through the gas outlet holes and into the gas supply manifold so that polymer material is formed within the gas inlet holes and even in the gas manifold. Particles of polymer material formed in the gas supply manifold and in the gas outlet holes of the gas distribution plate break off and fall on a semiconductor wafer being etched. These particles contaminate the wafers and, consequently, reduce the yield obtained from a wafer.

SUMMARY OF THE INVENTION

It is an object of the invention to provide apparatus and a method for reducing polymer particle contamination in a plasma etching process for silicon dioxide.

In accordance with the invention, an improved system, including an improved gas distribution plate as given in claim 1, and an improved method for plasmaetching an oxide layer on a semiconductor wafer as given in claim 10 is provided. It was discovered that, by reducing the cross-sectional area of the gas inlet holes to a plasma-etching chamber to the point where plasma does not form with the gas inlet holes, it is possible to significantly reduce the amount of contamination caused by polymer particles falling on a semiconductor wafer in a plasma-assisted etching process for silicon dioxide. A particular plasma-assisted process for etching silicon dioxide uses CHF_3, Ar and CF_4 as input gases with the CHF_3 and SiO_2 producing polymers which coat the interior of the chamber. Deposition of this polymer within the gas inlet holes appears to promote flaking of polymer particles from the walls of the gas inlet holes. The particles drop on a wafer being processed to contaminate an electronic structure being formed thereupon.

The improved system includes a plasma chamber in which a semiconductor wafer is contained. The plasma chamber has a certain portion which performs a gas distribution function. It has a number of gas inlet holes formed therein for distributing gas into the plasma chamber. An important aspect of the invention is that the gas inlet holes are sized for a particular set of etching process parameters such that their cross-sectional area is sufficiently small to prevent plasma from forming therein. This inhibits formation of polymer material on the interior surfaces of the holes which eliminates subsequent flaking of contamination particles. A particular embodiment of the gas distributor having the holes less than a critical size is a quartz gas distribution plate. In one preferred embodiment of the invention, the holes are arranged to be equally spaced apart in a circular pattern with the quartz plate being positioned over a wafer to be processed. In an alternative preferred embodiment of the invention, a gas distribution plate member includes a number of radially extending channels, each of which terminate in a gas inlet hole to the chamber, with the gas inlet holes being located not above a wafer. This arrangement prevents contamination particles, if any, from falling on a wafer. The channels terminate in holes which are located on the peripheral edge surface of a distribution plate. In one embodiment of the invention, I have found that gas inlet holes with diameters of 0.035"(0.89mm) or less are preferred, with 0.020" (0.51mm) being a preferred size that I have used.

The improved method, in principle, includes the step of feeding a reaction gas including CHF_3 into a reaction chamber through a plurality of gas inlet holes which have a cross-section sufficiently small to prevent plasma from forming therein and from depositing polymer material on the interior surfaces of the gas inlet holes. The gas is fed through holes formed as described above in connection with the structural description of the aluminum and quartz plates. In one embodiment of the invention the reaction chamber is maintained at less than atmospheric pressure with the gas inlet holes preferably being less than 0.035" (0.89mm) in diameter.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

FIGURE 1 is a cross-sectional view of a plasma-etching reaction chamber according to the invention.

FIGURE 2 is a plan view of a gas outlet plate according to the invention.

FIGURE 3 is sectional view of a gas outlet plate taken along section line 3-3 of FIGURE 2.

FIGURE 4 is a top plan view of a gas distribution manifold plate.

FIGURE 5 is a bottom plan view of the gas distribution manifold plate of FIGURE 4.

FIGURE 6 is a sectional view of the gas distribution manifold plate of FIGURE 4, taken along section line 6-6 of FIGURE 4-4.

FIGURE 7A is a graph of the number of contamination particles versus the number of wafers processed in a typical prior art plasma oxide-etching chamber.

FIGURE 7B is a graph of the number of contamination particles versus the numbers of wafers processed in a plasma oxide-etching chamber according to the invention.

FIGURE 8 is a cross-sectional view of an alternative embodiment of a plasma etching chamber according to the invention.

FIGURE 9 is a plan view of a one-piece gas distribution plate according to the invention.

FIGURE 10 is a cross-sectional view of the gas distribution plate if FIGURE 9, taken along section line 10-10.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to those embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the scope of the invention as defined by the appended claims.

FIGURE 1 shows a cylindrically-shaped plasma chamber 10 for containing a silicon semiconductor wafer 12 to be plasma-etched. The plasma chamber and the associated components described hereinbelow are incorporated into a low-pressure reactive-ion etching system with a magnetically-enhanced plasma which is produced by Applied Materials, Inc. of Santa Clara, California, as the Precision 5000 Etch System.

The wafer 12 is mounted on a cathode pedestal assembly 14. The top portion of the low-pressure chamber 10 includes a gas distribution structure 16 including a gas distribution manifold plate 18 and a quartz gas distribution plate 20 for delivering gases such as CHF_3 and Ar to the chamber for selective etching of silicon dioxide, as commonly required in the fabrication of semiconductor integrated circuit devices. The gas distribution manifold plate 18 and the quartz gas distribution plate 20 are mounted above the semiconductor wafer 12, as shown.

FIGURE 2 shows a plan view of a thin quartz gas distribution plate 20. A plurality of equally-spaced gas inlet holes 22 (typically shown) are formed through the quartz plate 20. In prior art quartz distribution plates, gas inlet holes with diameters of 0.070" (1.78mm) were used. However, it was found that plasma containing polymers, which are produced when CHF_3 reacts with SiO_2, tends to be coated onto the interior surfaces of the holes. During start-up of an etching cycle, the initial gas pressure tends to dislodge particles of polymer material which falls down onto the surface of the semiconductor wafer being etched and contaminates the wafer. In accordance with the invention, reducing the size of the holes prevents formation of plasma within the gas inlet holes and consequent deposition of polymer material on the interior surfaces defined by the holes. It was found that using 72 equally-spaced holes with a diameter of 0.035"(0.89mm) or 0.020" (0.51mm) provides reduction in particle contamination of semiconductors being processed. The gas distribution plate 20 also contains a large central aperture 24 and four holes 26 for mounting screws. The plate 20 is also hard anodized.

FIGURES 4, 5, and 6 show the details of the gas distribution manifold plate 18. Corresponding to each of the gas inlet holes 22 of the quartz plate 20 are a corresponding number of gas through-holes (typically shown as 32). A circular channel 34 is formed in the top surface of the plate 18 to channel gases to the holes 32 and to the corresponding gas inlet holes 22 in the quartz plate 22. Four mounting-screw holes are provided in the plate 18 corresponding to the holes 26 in the quartz plate. Eight countersunk holes 38 are also provided for mounting the plate 18 to the top wall of the chamber 10 and a large central aperture 40 is also provided for access to plasma contained within the chamber. When assembled together, the plates 18,20 direct gases into the plasma chamber through the various gas inlet holes 22.

FIGURE 7A is a graph showing the number of particles greater than 0.3 micrometers as a function of the number of wafers processed through a plasma-etching chamber using the prior art gas inlet holes with a diameter of 0.070" (1.78mm). After 200 wafers, the number of particles exceeds 100. The full scale value for the number of particles is 180.

FIGURE 7B is a graph showing the number of particles greater than 0.3 micrometers as a function of the number of wafers processed through a plasma-etching chamber having gas inlet holes of 0.035" (0.89mm), Note that the full scale value for the number of particles is 20. After 400 wafers, the number of particles is still less than 20, showing significant improvement over the prior art gas inlet holes. Note that examination of the holes and circular channel 34 of the gas manifold and of the holes 22 in the quartz plate according to the invention has

showed no deposition of polymer material therein. It is believed that this absence of polymer formation accounts for the significant reduction in particles.

FIGURE 8 shows another embodiment of the invention in which a gas manifold plate and a quartz distribution plate are combined together in a one-piece gas distribution plate 40. Figure 9 shows that the plate 40 has a number of radially extending channels (typically shown as 42). For example, 72 channels are provided in the plate 40. FIGURE 10 shows a cross-sectional view of the channel. The diameter of the channel is equal to or less than 0.89mm with 0.51mm being a typical value. Figure 8 shows that the gas inlet holes 44 at the ends of the channels are located not above the wafer, but at a position located outside the wafer. If particles were to be formed they would fall to the side of the wafer and not contaminate the wafer itself.

In one specific embodiment of the invention, the following process parameters were used in an Applied Material, Inc. Precision 5000 Etch system: 650 watts of RF power; 60 Gauss of magnetic field; 60 ccm/s of Ar; 30ccm/s of CHF_3; and 2 ccm/s of CF_4.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto.

Claims

1. A system for plasma-etching a silicon dioxide layer on a semiconductor wafer (12) using a reaction gas including CHF_3, comprising:
   - a plasma chamber (10) for containing the semiconductor wafer (12) to be etched; and
   - a gas distribution portion (16) of said plasma chamber (10) having a plurality of gas inlet holes (22; 44) formed therein for distributing a reaction gas into said plasma chamber, said inlet holes (22; 44) having a cross-sectional area sufficiently small to prevent a plasma from being present in said inlet holes (22; 44) and to inhibit formation of polymer material on the interior surfaces defined by said inlet holes (22; 44).

2. The system of claim 1, wherein said gas distribution portion (16) includes a gas distribution plate member (20) having said plurality of gas inlet holes (22) formed therein.

3. The system of claim 2, wherein said gas distribution plate member (20) is formed of quartz.

4. The system of claim 1, 2 or 3, wherein said plurality of gas inlet holes (22) are arranged in a circular pattern.

5. The system of claim 1, 2, 3 or 4, wherein said gas distribution portion (16) is located above said semiconductor wafer (12) with said plurality of gas inlet holes (22) being located above said semiconductor wafer (12).

6. The system of any of claims 2 to 4, wherein said gas distribution plate member (40) includes a plurality of radially extending channels (42) formed in said plate with each channel (42) terminating in a gas inlet hole (44) in said gas distribution plate member (40) at a location not above said semiconductor wafer (12).

7. The system of claim 6, wherein said gas inlet holes (44) are arranged along the peripheral edge of said gas distribution plate member (40).

8. The system of any preceding claim, wherein said inlet holes (44) have a diameter less than 0.90 mm.

9. The system of claim 8, wherein said inlet holes (44) have a diameter less than 0.50 mm.

10. A method for reducing polymer formation when plasma-etching a silicon dioxide layer on a semiconductor wafer (12) using a reaction gas including CHF_3 comprising the steps of:
    - placing said semiconductor wafer (12) in a reaction chamber (10);
    - feeding the reaction gas into said reaction chamber (10) through a plurality of gas inlet holes (20; 44) which gas inlet holes have a cross-sectional area sufficiently small to prevent plasma from being formed in said gas inlet holes (20; 44); and
    - forming a plasma within said reaction chamber but not within said gas inlet holes (20; 44).

11. The method of claim 10, including the step of maintaining the pressure in said reaction chamber (10) at less than atmospheric pressure.

showed no deposition of polymer material therein. It is believed that this absence of polymer formation accounts for the significant reduction in particles.

FIGURE 8 shows another embodiment of the invention in which a gas manifold plate and a quartz distribution plate are combined together in a one-piece gas distribution plate 40. Figure 9 shows that the plate 40 has a number of radially extending channels (typically shown as 42). For example, 72 channels are provided in the plate 40. FIGURE 10 shows a cross-sectional view of the channel. The diameter of the channel is equal to or less than 0.89mm with 0.51mm being a typical value. Figure 8 shows that the gas inlet holes 44 at the ends of the channels are located not above the wafer, but at a position located outside the wafer. If particles were to be formed they would fall to the side of the wafer and not contaminate the wafer itself.

In one specific embodiment of the invention, the following process parameters were used in an Applied Material, Inc. Precision 5000 Etch system: 650 watts of RF power; 60 Gauss of magnetic field; 60 ccm/s of Ar; 30ccm/s of CHF_3; and 2 ccm/s of CF_4.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the Claims appended hereto.

Claims

1. A system for plasma-etching a silicon dioxide layer on a semiconductor wafer (12) using a reaction gas including CHF_3, comprising:

   - a plasma chamber (10) for containing the semiconductor wafer (12) to be etched; and
   - a gas distribution portion (16) of said plasma chamber (10) having a plurality of gas inlet holes (22; 44) formed therein for distributing a reaction gas into said plasma chamber, said inlet holes (22; 44) having a cross-sectional area sufficiently small to prevent a plasma from being present in said inlet holes (22; 44) and to inhibit formation of polymer material on the interior surfaces defined by said inlet holes (22; 44).

2. The system of claim 1,
wherein said gas distribution portion (16) includes a gas distribution plate member (20) having said plurality of gas inlet holes (22) formed therein.

3. The system of claim 2,
wherein said gas distribution plate member (20) is formed of quartz.

4. The system of claim 1, 2 or 3,
wherein said plurality of gas inlet holes (22) are arranged in a circular pattern.

5. The system of claim 1, 2, 3 or 4,
wherein said gas distribution portion (16) is located above said semiconductor wafer (12) with said plurality of gas inlet holes (22) being located above said semiconductor wafer (12).

6. The system of any of claims 2 to 4,
wherein said gas distribution plate member (40) includes a plurality of radially extending channels (42) formed in said plate with each channel (42) terminating in a gas inlet hole (44) in said gas distribution plate member (40) at a location not above said semiconductor wafer (12).

7. The system of claim 6,
wherein said gas inlet holes (44) are arranged along the peripheral edge of said gas distribution plate member (40).

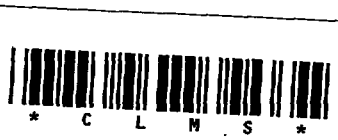
8. The system of any preceding claim,
wherein said inlet holes (44) have a diameter less than 0.90 mm.

9. The system of claim 8,
wherein said inlet holes (44) have a diameter less than 0.50 mm.

10. A method for reducing polymer formation when plasma-etching a silicon dioxide layer on a semiconductor wafer (12) using a reaction gas including CHF_3 comprising the steps of:

    - placing said semiconductor wafer (12) in a reaction chamber (10);
    - feeding the reaction gas into said reaction chamber (10) through a plurality of gas inlet holes (20; 44) which gas inlet holes have a cross-sectional area sufficiently small to prevent plasma from being formed in said gas inlet holes (20; 44); and
    - forming a plasma within said reaction chamber but not within said gas inlet holes (20; 44).

11. The method of claim 10,
including the step of maintaining the pressure in said reaction chamber (10) at less than atmospheric pressure.



12. The method of claim 10 or 11, including the step of providing said gas inlet holes (44) arranged in a circular pattern above said semiconductor wafer (12).

13. The method of claim 10 or 11, including the step of feeding the reaction gas through gas inlet holes (44) located along the peripheral edge surface of said distribution plate (40) positioned above said semiconductor wafer (12) such that said gas inlet holes (44) are not positioned directly over said semiconductor wafer (12).

Patentansprüche

1. Ein System zum Plasmaätzen einer Siliziumdioxidschicht auf einer Halbleiterscheibe (12) unter Verwendung eines Reaktionsgases, das CHF_3 einschließt, aufweisend:

   - eine Plasmakammer (10) zum Aufnehmen der zu ätzenden Halbleiterscheibe (12); und
   - ein Plasmakammer-Gasverteilungsteil (16) mit einer Vielzahl darin ausgebildeter Gaseinlaßlöcher (22;44) zum Verteilen eines Reaktionsgases in der Plasmakammer, wobei die Einlaßlöcher (22; 44) eine Querschnittsfläche aufweisen, die klein genug ist, ein Plasma daran zu hindern, in den Einlaßlöchern (22; 44) vorzuliegen, und eine Ausbildung von Polymermaterial an den Innenflächen zu verhindern, die durch die Einlaßlöcher (22; 44) festgelegt sind.

2. Das System nach Anspruch 1, wobei das Gasverteilungsteil (16) ein Gasverteilungs-Plattenelement (20) mit der Vielzahl von darin ausgebildeten Gaseinlaßlöchern (22) umfaßt.

3. Das System nach Anspruch 2, wobei das Gasverteilungs-Plattenelement (20) aus Quarz ausgebildet ist.

4. Das System nach Anspruch 1, 2 oder 3, wobei die Vielzahl von Gaseinlaßlöchern (22) in einem ringförmigen Muster angeordnet ist.

5. Das System nach Anspruch 1, 2, 3 oder 4, wobei das Gasverteilungsteil (16) über der Halbleiterscheibe (12) angeordnet ist, wobei die Vielzahl von Gaseinlaßlöchern (22) über der Halbleiterscheibe (12) angeordnet ist.

6. Das System nach irgendeinem der Ansprüche 2 bis 4, wobei das Gasverteilungs-Plattenelement (40) eine Vielzahl von in der Platte ausgebildeten, sich radial erstreckenden Kanälen (42) umfaßt, wobei jeder Kanal (42) in einem Gaseinlaßloch (44) in dem Gasverteilungs-Plattenelement (40) an einer Stelle endet, die nicht über der Halbleiterscheibe (12) liegt.

7. Das System nach Anspruch 6, wobei die Gaseinlaßlöcher (44) längs des peripheren Randes des Gasverteilungs-Plattenelements (40) angeordnet sind.

8. Das System nach irgendeinem vorhergehenden Anspruch, wobei die Einlaßlöcher (44) einen Durchmesser von weniger als 0,90 mm aufweisen.

9. Das System nach Anspruch 8, wobei die Einlaßlöcher (44) einen Durchmesser von weniger als 0,50 mm aufweisen.

10. Ein Verfahren zum Verringern der Polymerausbildung beim Plasmaätzen einer Siliziumdioxidschicht auf einer Halbleiterscheibe (12) unter Verwendung eines CHF_3 einschließenden Reaktionsgases, aufweisend die Schritte :

    - Einsetzen der Halbleiterscheibe (12) in eine Reaktionskammer (10);
    - Zuführen des Reaktionsgases in die Reaktionskammer (10) über eine Vielzahl von Gaseinlaßlöchern (20; 44), wobei die Gaseinlaßlöcher eine Querschnittsfläche aufweisen, die ausreichend klein ist, das Plasma zu hindern, in den Gaseinlaßlöchern (20; 44) ausgebildet zu werden; und
    - Ausbilden eines Plasmas in der Reaktionskammer, jedoch nicht in den Gaseinlaßlöchern (20; 44).

11. Das Verfahren nach Anspruch 10, das den Schritt des Beibehaltens des Drucks in der Reaktionskammer (10) bei weniger als dem atmosphärischen Druck umfaßt.

12. Das Verfahren nach Anspruch 10 oder 11, das den Schritt des Vorsehens der Gaseinlaßlöcher (44) durch Anordnen in einem kreisförmigen Muster über der Halbleiterscheibe (12) umfaßt.

13. Das Verfahren nach Anspruch 10 oder 11, umfassend den Schritt des Zuführens des Reaktionsgases durch über der Halbleiterscheibe (12) positionierte Gaseinlaßlöcher (44), die längs der peripheren Randfläche der Verteilungsplatte (40) angeordnet sind, so daß die Gaseinlaßlöcher (44) nicht direkt über der Halbleiterscheibe (12) positioniert sind.

* C L M S *

Revendications

1. Système destiné à la gravure au plasma d'une couche de dioxyde de silicium sur une tranche de semi-conducteur (12) en utilisant un gaz de réaction comprenant du CHF_3, comportant :

   - une enceinte à plasma (10) destinée à contenir la tranche de semi-conducteur (12) à graver, et
   - une partie de distribution de gaz (16) de ladite enceinte à plasma (10) comportant une pluralité de trous d'admission de gaz (22, 44) formée dans celle-ci afin de distribuer un gaz de réaction dans ladite enceinte à plasma, lesdits trous d'admission (22, 44) présentant une section transversale suffisamment petite pour empêcher un plasma d'être présent dans lesdits trous d'admission (22, 44) et pour inhiber la formation de matériau de polymère sur les surfaces intérieures définies par lesdits trous d'admission (22, 44).

2. Système selon la revendication 1, dans lequel ladite partie de distribution de gaz (16) comprend un élément de plaque de distribution (20) comportant ladite pluralité de trous d'admission de gaz (22) formée dans celui-ci.

3. Système selon la revendication 2, dans lequel ledit élément de plaque de distribution de gaz (20) est formé de quartz.

4. Système selon la revendication 1, 2 ou 3, dans lequel ladite pluralité de trous d'admission de gaz est disposée suivant un motif circulaire.

5. Système selon la revendication 1, 2, 3 ou 4, dans lequel ladite partie de distribution de gaz (16) est située au-dessus de ladite tranche de semi-conducteur (12), ladite pluralité de trous d'admission de gaz (22) étant située au-dessus de ladite tranche de semi-conducteur (12).

6. Système selon l'une quelconque des revendications 2 à 4, dans lequel ledit élément de plaque de distribution de gaz (40) comprend une pluralité de canaux s'étendant radialement (42) formés dans ladite plaque, chaque canal (42) aboutissant dans un trou d'admission de gaz (44) dans ledit élément de plaque de distribution de gaz (40) à un emplacement qui n'est pas situé au-dessus de ladite tranche de semi-conducteur (12).

7. Système selon la revendication 6, dans lequel lesdits trous d'admission de gaz (44) sont disposés le long du bord périphérique dudit élément de plaque de distribution de gaz (40).

8. Système selon l'une quelconque des revendications précédentes, dans lequel lesdits trous d'admission (44) présentent un diamètre inférieur à 0,90 mm.

9. Système selon la revendication 8, dans lequel lesdits trous d'admission (44) présentent un diamètre inférieur à 0,50 mm.

10. Procédé destiné à réduire la formation de polymères pendant la gravure au plasma d'une couche de dioxyde de silicium sur une tranche de semi-conducteur (12) en utilisant un gaz de réaction comprenant du CHF_3, comportant les étapes consistant à :

    - placer ladite tranche de semi-conducteur (12) dans une enceinte de réaction (10),
    - alimenter le gaz de réaction dans ladite enceinte de réaction (10) par l'intermédiaire d'une pluralité de trous d'admission de gaz (20, 44), les trous d'admission de gaz présentant une surface en section transversale suffisamment petite pour empêcher le plasma d'être formé dans lesdits trous d'admission de gaz (20, 44), et
    - former un plasma à l'intérieur de ladite enceinte de réaction mais pas à l'intérieur desdits trous d'admission de gaz (20, 44).

11. Procédé selon la revendication 10, comprenant l'étape consistant à maintenir la pression dans ladite enceinte de réaction (10) inférieure à la pression atmosphérique.

12. Procédé selon la revendication 10 ou 11, comprenant l'étape consistant à prévoir lesdits trous d'admission de gaz (44) disposés suivant un motif circulaire au-dessus de ladite tranche de semi-conducteur (13).

13. Procédé selon la revendication 10 ou 11, comprenant l'étape consistant à alimenter le gaz de réaction par l'intermédiaire de trous d'admission de gaz (44) situés suivant la surface du bord périphérique de ladite plaque de distribution (40), positionnés au-dessus de ladite tranche de semi-conducteur (12) de telle façon que lesdits trous d'admission de gaz (44) ne soient pas positionnés directement au-dessus de ladite tranche de semi-conducteur (12).

* C L M S *