IMPROVED CLEANING OF A PLASMA PROCESSING SYSTEM SILICON ROOF

By: Jennifer Sun

BACKGROUND OF THE INVENTION

Plasma processing systems, and especially inductively coupled plasma systems are important in semiconductor processing. Very thin, well controlled layers may be formed and shaped. However, the energies induced in the plasma tend to cause significant erosion and contamination of the chamber, especially the roof of the chamber.

The use of various forms of silicon, such as silicon carbide (SiC) or polycrystalline silicon, reduces problems due to erosion, but contamination is more difficult to combat. Single crystal material has also been considered, but when all aspects of the materials that could be used are considered, such as cost and mechanical strength, polycrystalline material is preferred. Such dielectric roofs are also important for inductively coupled plasma sources (IPS) wherein the RF power from the coil or coils to be coupled to the plasma and the interior of the chamber.

New and faster devices use copper to form contact lines. The process of making copper lines is known as dual-damascene. However, this process introduces copper contamination, which is widely known to be an especially problematic contaminant, since it is not volatile. It is very important that as much of such contaminants as possible be removed from the chamber parts in cleaning operations, after use of the chamber.

Coatings, such as polymer films, are often used to further stabilize the surface, and much of the contamination can be removed by ablating or etching the polymer films. However, contaminants also penetrate into the base material, and must be removed or contained.

Since these contaminants are relatively fixed in the chamber material, it is apparent that they may be removed by ablating the chamber surfaces, and in the instant

case, the roof material. The favored methods include ablating with SiC, since it is a very hard material (comparable to diamond) and is composed of silicon and carbon, both benign materials for semiconductor processing. The ablation causes debris on the surface, but it is well known that some acids, and especially hydrofluoric acid (HF), are very effective in cleaning up debris. HF has an advantage that it vigorously etches glass (SiO2), which often forms on silicon surfaces such as the surface of a chamber of an IPS having, for example, a silicon (Si) roof.

After ablating and etching a surface, deionized water (DI water) is used to clean up the residual acid and remaining debris, since DI water is an inert material, which can be dissipated as water vapor.

While the above cleaning method cleans very well, particulate matter is often found in the chamber in subsequent processing. The source of this matter can be traced with reasonable certainty to the chamber surfaces, and reducing the number and size of the particles has been an increasing problem. The particle sizes and count have remained high, while the effect of the particles, due to reducing feature sizes with improving technology, has increased. For example, with larger size features in the processing technology, a small particle size, such as 0.2 microns, was not much of a concern, even though smaller particles are also proportionally more numerous. However, with features now at and below 0.2 microns, both the size and the number of even small particles becomes a very great concern.

It is known that particles are subject to breaking away due to the reactive ablation of the processes within the chamber, such as reactive ion etching, or even ionic deposition processing. It seems that reducing particulate matter might require less active processing, which would have a negative impact on throughput and capability. However, this would be unacceptable.

The need for reducing both particle size and particle count could inhibit future growth in electronics, such as in semiconductor chips, if not satisfactorily resolved.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved cleaning method and apparatus for a chamber used in processing semiconductor wafers, and especially for chambers used in material deposition or in reactive ion etching (RIE).

The present invention solves the problem of cleaning a chamber while reducing particulate matter by reducing the activity of the ablation and of the etch. In the present invention, a relatively soft ablative material such as teflon or acrylic beads may be used for removing the surface of a contaminated chamber, such as the roof. Less damage is done to the grain structure of the silicon-based material used for the chamber surfaces with softer ablating materials, preventing a weakening of the grain integrity. Additionally, or preferably alternatively, a relatively gentle cleaning or etching material is used after or instead of the ablating materials. The use of a relatively gentle acid or base, such as a trinary system of acetic, nitric, and HF acids, in which the HF is heavily Abuffered@ by milder acids, reduces damage to the grain boundaries of the silicon-based material used for the chamber surfaces. The cleaning material can be an acid, in what is often called an acid chemical polishing (ACP), or a base in a base cleaning process (BCP). However, base etching is slower, more selective as a function of the material composition, and very sensitive to the specific polycrystalline structure. BCP is also more susceptible to faceting the material being etched, and may shorten the life of the roof being cleaned. Consequently, ACP is preferred. As a result of the gentle processing of the present invention, damage to the silicon-based surface material is reduced, and particles of the material are more tightly bound on the surface. During subsequent operations, erosion of the surface, such as a surface of a chamber roof, is reduced due to improved surface integrity.

Relatively soft materials, in a form often call Abeads@, may be used in the present invention for ablating, sometimes called Abead blasting@ (BB), but a purely chemical approach using a relatively mild trinary acidic mixture is preferred. Since the chamber roof material is removed with much less violence, the crystalline structure is believed to

be less damaged, resulting in particle counts being reduced. The initial ablating is followed, or replaced by, a relatively mild etch, such as with a trinary acid mixture of C_2H_300H (acetic), HNO_3 (nitric) and HF (hydrofluoric), as shown in the figures. The mixture is chosen and adjusted to reduce or even eliminate damage to grain boundaries so that the material grain structure is less prone to fracturing. There is a dependence of the etch rate on the crystal structure of a roof. A desirable etch rate is substantially 1 micron per minute, but the achieved rate depends on the characteristics of the silicon roof and may be in a range of about 0.1 to 10 microns per minute. The surface roughness or morphology (R_A) is desirably substantially 150, but may be in a range of about 100 to 200. The gentle etch of the invention results in less particulate matter being dispersed from the roof in subsequent processing operations. The result is less particulate matter being present on, for example, silicon wafers in semiconductor processing, and has been demonstrated to be below a 100,000 (100K) particles per cubic centimeter baseline for the present invention.

Another advantage of the present invention is that the particulate matter has been isolated and reduced to the point that it can be quantized, such as by a particulate matter count (PMC) in the deionized (DI) water used for final rinsing of the chamber surfaces. Quantity determinations of particulate matter in DI, such as by measuring the resistance of the water, are well known. Relating these measurements, other than in a quantitative way, to particulate matter on wafers has not been known or even suspected. The present invention, by reducing the PMC well below previous levels, also allows qualitative, rather than the prior art quantitative, measurements, where wafer rejections due to particulate matter can be predicted with considerable accuracy based on the resulting PMC in the water. This results in a reliable qualitative method for determining how many particles can be expected to be deposited on the semiconductor wafers .

Other objects, features and advantages of the present invention will become apparent from the following detailed description when taken in conjunction with the

accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 1A illustrates an IPS system having an IPS chamber in accordance with the present invention.

Fig. 1B illustrates the energies involved in binding particulate matter to a chamber roof as a function of the chemical structure of the particle.

Fig. 2 illustrates the dispersion of copper (Cu) in a contaminated chamber roof.

Fig. 3 is a picture of a surface prepared by bead blasting with SiC and cleaning with a strong HF etch in the prior art at substantially 100X magnification.

Fig. 4 is a picture of a surface prepared by bead blasting with SiC and cleaning with a strong HF etch in the prior art at substantially 1000X magnification.

Fig. 5 illustrates the etch rates of a trinary system of acids when applied to a chamber roof.

Fig. 6 illustrates particulate matter in water after ultrasonic agitation, both with and without HF clean steps.

Fig. 7 is a picture at substantially 200X magnification of faceting of a silicon surface after a base cleaning process (BCP).

Fig. 8 is a picture at substantially 2000X magnification of faceting of a silicon surface after a base cleaning process (BCP).

Fig. 9 is a picture at 200X magnification of faceting of a silicon surface after an acid chemical polishing (ACP).

Fig. 10 is a picture at 2000X magnification of faceting of a silicon surface after an acid chemical polishing (ACP).

Fig. 11 illustrates laser particle counts (LPC) from a silicon roof after BCP operations, and a BKM#2 cleaning.

Fig. 12 illustrates laser particle counts (LPC) from a silicon roof after ACP operations, and a BKM#2 cleaning.

Fig. 13 illustrates the effectiveness of the present invention in removing metal contamination and particle reduction from a chamber roof for both Base clean and Acid chemical polishing processes.

Fig. 14 illustrates the effectiveness of the present invention in reducing silicon (Si) particulate count with BCP.

Fig. 15 illustrates the effectiveness of the present invention in reducing silicon (Si) particulate count with ACP.

Fig 16 provides an example of a particulate material count (PMC) for a 200 mm silicon wafer in accordance with the present invention. The graph at the bottom of the figure gives the PMC in terms of particle size.

Fig 17 provides an example of a particulate material count (PMC) for a 200 mm silicon wafer in accordance with the prior art. The graph at the bottom of the figure gives the PMC in terms of particle size.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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

The present invention relates to cleaning of plasma type processing chambers in terms of a complete solution, as opposed to merely improving on a single parameter or

problem. It is therefore necessary to consider both reducing contamination levels, especially copper (Cu) contamination, and reducing particulate matter counts, primarily silicon based particles. Cleaning the surfaces, and especially removing Cu from the surfaces, is also crucial in controlling the operation of the chamber. The roof, or window, of an IPS, when contaminated, changes the coupling of the RF power from the coil to the plasma and results in process drift, which affects controllability. Most sputtered particles are volatile, and are easily removed. Copper, however, is non volatile and is hard to remove from the chamber.

It will be appreciated by one of ordinary skill in the art that particulate matter counts are not absolute indices of processing excellence. A particle count that would be quite acceptable, for example, for high voltage devices known to have large geometries and therefore relaxed tolerances, would be disastrous for a high density integrated circuit having very small geometries and tight tolerances. Even so, at least quantitative, and in accordance with the present invention, qualitative data is important in all cases, so while the particle count size limits of concern may be, for example, either 1 micron, or 0.2 micron or less, the relative particle count is of the greatest importance. Additionally, the present invention recites that reducing the particulate matter count (PMC) below a baseline quantity results in a very substantial reduction in the PMC on a material being processed, such as a silicon wafer. In one embodiment of the invention, the baseline quantity is 100K per milliliter (mL).

As the particle size of concern continues to be smaller, megahertz agitation of the solutions will be required, because higher frequencies will be necessary to resonate the smaller particles. It will also be important to improve the removal of contaminant levels. Contaminant levels that might not be important in a large power device may be of concern with very high level or ultra high level integrated circuits (VLSI or ULSI), and relative levels of contamination are always of great interest.

Reducing particulate count and reducing contamination are both accomplished by the gentle cleaning of the present invention. Prior art approaches assumed that

contamination is best handled by harsh ablation and etching of the surfaces, and particulate matter was assumed to be a function only of the surface smoothness, which was also believed to be best accomplished by harsh ablation and vigorous etching.

Fig. 1A illustrates an IPS chamber system 10 of the present invention. In Fig. 1, IPS chamber 12 having roof 22 is connected to a jungle 14 through plumbing 16 below false floor 20. When chamber 12 is in use, materials within chamber 12 (not shown) are acted upon by a plasma (not shown). Roof 22, which helps form a near-vacuum inside plasma chamber 24, is acted upon by the plasma, including being bombarded by material within the chamber.

Fig. 1B shows XPS/ESCA Analysis of Si Roof Particles, which is X-ray Spectroscopy and electron spectroscopy with chemical analysis (XPS/ESCA), which are being used to determine the binding energies and chemical composition of particles in a Si roof for a processing chamber. In Fig. 1, an overall particle count (C/S) is shown 103, then decomposed into constituent particles. The first large peak 105 is SiO2 (glass). The second large peak 107 is silicon (Si). Silicates, SiX, where X may be, for example, a nitride or similar materials, are shown by peak 109. This type of particle is likely not large enough, either in particle size or particle numbers to be of great concern. The next peak 111 is likely to be pieces of the silicon carbide (SiC) often used for bead blasting (BB). BB is similar to micro scale Asand blasting@ such as for removing paint on buildings. The peak 111 is also likely not of any great concern. Additionally, the present invention does not use SiC, and preferably does not use BB.

It will be apparent to a person of ordinary skill in the art that reducing particle counts requires not weakening the silicon based material bonds.

Fig. 2 is a Cu Contamination SIMS Depth Profile: Plasma Side, and illustrates Cu contamination in the Si roof of several processing chambers after the chambers have been used, for example, for Cu deposition. In Fig. 2, it is known to persons with ordinary skill that Cu is both a very desirable material for forming interconnections, and a disastrous contaminant for integrated circuits, such as Si based integrated circuits. A

chamber of the present invention includes Cu as a processing material when that material is desired, but with Cu reduced as much as possible when it is not desired.

As shown in Fig. 2, Cu forms a heavy surface concentration, and is dispersed to relatively large depths below the surface. For example, Cu is shown to be at an unacceptably high concentration 203, such as 1X10^16 atoms/cubic centimeter (cc), at more than substantially 1.5 microns in depth, and in one instance of Fig. 2, nearly 10 microns in depth. It has been determined by the present invention that for some applications, the concentration of Cu contamination is problematic out to about 20 microns in depth, and as a precaution, cleaning of a roof should go out to 50 microns

Fig. 3 shows Si Roof: SEM Surface Microstructure Post Bead Blasting & HF Treatment (Current BKM) and shows a silicon roof that has been subjected to SiC BB and an HF etch of the prior art. The surface appears to be very smooth, and intuitively one would expect that particulate matter would remain attached to the roof, in spite of small particles apparently lying loosely on the surface 213 and 215. This appears to confirm the prior art assumption that the BB and etch of the prior art would provide the best control of particulate matter.

Fig. 4 illustrates how the surface of a roof of the prior art as shown in Fig. 3 appears at a much higher magnification. In Fig. 4, a person of ordinary skill in the art would see a solid surface, confirming that particulate matter dispersal has been minimized. However, a more informed look at the surface in the light of the present invention shows evidence of flaking 221 from the otherwise smooth surface such as at plateau 223. Viewed in this light, one might expect that the surface is prone to flaking off of particulate matter, which is believed to be the case.

Fig. 5 shows a HNO3-HF-CH3COOH Trinary Etch Diagram useful for determining etch activity, such as etch rate, on a Si roof of a chamber of the present invention. In Fig. 5, the present invention uses HNO_3 to oxidize Si into SiO_2 to trap contaminants. HF is used to remove the SiO_2 formed by the HNO_3, while the C_2H_300H provides wetting of the material to facilitate the forming and subsequent removal of the

SiO_2. This is a relatively gentle process with little damage to the silicon based structure of the roof.

It is known in the prior art that heavy concentrations of hydrofluoric acid (HF) are beneficial for quickly removing contaminated surfaces. HF is also useful in removing glass, which HF attacks vigorously. It is also known that applying an HF Aclean@ after a, for example, SiC bead blasting (BB) operation, is particularly effective in removing surface debris created by the BB. SiC is one of the hardest materials known, so relatively little SiC Adust@ is produced in BB, and SiC BB is known to provide substantial surface removal in relatively short times.

The prior art has depended on SiC BB and a highly concentrated HF cleaning to recover contaminated chamber roof material, and especially roof material contaminated with Cu, which is very difficult to remove from a chamber surface. Cu also affects the coupling of the plasma to the RF source, and creates problems with system stability. Intuitively, the combination of harsh ablation of the surface coupled with vigorous (also called strong) etching would appear to result in the most economic and effective way to provide the lowest contamination and the lowest particulate matter.

However, the present invention shows that the SiC BB of the prior art results in a weakening of the binding of particles to the roof material. Further, the relatively concentrated HF apparently attacks the grain boundary of the material, especially where the SiC BB has weakened the material, resulting in a high particulate matter count and possible migration of contaminants into the material. The invention avoids the weakening of the material of the prior art BB and harsh HF clean. This advantageous result is not apparent with only the use of a softer material in the BB, or with a less vigorous HF etch after a SiC BB. Rather, the primary result of either a softer material in bead blasting or a less vigorous HF etch without the present invention is reducing throughput and correspondingly increasing cost. Considerable improvements are seen, however, when both the BB and the HF treatments are properly modified, or if only an

optimized base or preferably an optimized acid etch is used in accordance with the present invention, such as at the point 303 in the trinary diagram.

Fig. 6 is an embodiment of the invention including LPC Particle Count Analysis Si Roof Coupon: Post Bead Blasting and illustrates the effect on particulate matter of a Post HF Clean versus No HF Clean. In Fig. 6, using HF versus not using HF seems to result in equivalent results, but multiple Ultrasonification steps, and in this figure, more than ten ultrasonification steps, indicates degradation due to the use of the prior art methods of using vigorous HF cleaning. The present invention uses HF, but with much less vigorous cleaning, in contrast to the prior art. Reduction of the use of HF in cleaning a roof is shown to result in a reduction of particulate matter from the roof in this figure.

Fig. 7 is an embodiment of the invention including a SEM Microstructure Post Base Solution Treatment (w/o Bead Blasting) and illustrates how BCP results in highly faceted surfaces in polycrystalline silicon. Further, the anisotropic nature of BCP is seen by the discernable micro pitting between the faceted crystals. In Fig. 7, we can see how crystal boundaries are preferentially etched 503. It is clear that without careful control, the process could result in damage to these boundaries.

Fig. 8 illustrates BCP as in Fig. 7 with the invention at much higher magnification, showing as long as care is used, damage to the crystal boundaries is not very significant. In Fig. 8, faceting, which is largely a consequence of the anisotropic etch, is pronounced, with reflecting surfaces in some profusion, but the integrity of the surface is seen to be quite good, with no obvious flaking as in the prior art BB and HF etch process.

Fig. 9 is a SEM Microstructure Post ACP Treatment Si Coupon #2 and illustrates ACP in accordance with the present invention. In Fig. 9, a rather dull, substantially non reflecting surface is apparent. While there is little or no evidence of pitting or similar problems, the lighter surfaces suggest a relatively rugged surface on a very small scale.

Fig. 10 illustrates ACP in an embodiment in accordance with the present invention as in Fig. 9 but at a higher magnification. In Fig. 10, we can see the nature of

the relatively rugged surface. Here, the isotropic etch of ACP creates a series of scalloped valleys surrounded by very small ridges, with a substantially mountainous appearance, though at a very small scale, as mentioned. It can be seen that the highly reflective faceting of the material surface of BCP is avoided by ACP.

Fig. 11 is a IPS Roof Metal Concentration level Base Treatment w/o Bead Blasting + BKM2 rinse illustrating an embodiment of the base cleaning of the present invention. In Fig. 11, starting with a "dirty" roof, or Ceiling Before Clean, with, for example, 28,000,000 X 10^10 atoms per square centimeter of Cu contamination, a Typical BKM (best known method) Clean is compared to a Ceiling Post Base Clean. All significant trace metals are shown reduced in this figure, and the most important contaminant, Cu, is reduced by a factor of more than 20 and is below a baseline level of about 1 X 10^10. With the exception of potassium, which is not shown for the prior art Typical BKM Clean, all trace metals are shown to be reduced. This reduction is especially important with respect to copper (Cu), since copper has been shown to be a cause of instability in the plasma.

Fig. 12 is a IPS Roof Metal Concentration level ACP Treatment w/o Bead Blasting + BKM2 rinse illustrating an embodiment of a preferred acid chemical polishing of the present invention. In Fig. 12, a "dirty" roof, with, for example, Cu contamination of 112,000,000 X 10^10 atoms per square centimeter, corresponding to 2.8 X 10^17 atoms per square centimeter, is cleaned with ACP. The result of the ACP is a large reduction in trace metals over the Typical BKM Clean of the prior art. For example, the reduction of Cu, the most important trace metal contaminant, is by a factor of more than 100. With the reduction shown, the stability of the IPS process, which is adversely affected by copper, is improved so that typically, a cleaned roof can be used for nearly 300 (294 confirmed) hours before being cleaned again. This advantageous result is achieved with a copper contamination level of less than about 1 X 10^10 atoms per square centimeter, such as 0.2 X 10^10 atoms per square centimeter. In the prior art, a cleaned roof could be used for only about 200 hours before cleaning was again needed.

The concentrations achieved reduce the trace metal concentrations to substantially insignificant levels, and restore a roof to essentially the condition of an unused roof with respect to trace metal contamination.

Fig. 13 illustrates an embodiment of the present invention with respect to base cleaning (BCP) and acid chemical polishing (ACP). In Fig. 13, while the processes in accordance with the present invention give similar results, it will be noted that BCP requires roughly 6 hours, versus about 0.5 to 1 hour for ACP. BCP etches anisotropically versus the isotropic etch of ACP, and it will be appreciated that BCP will consequently be harder to control. It will often be important that ACP results in a rounded contouring of the semiconductor surface as opposed to the highly faceted surface resulting from BCP. However, the main teaching of this figure is that either an acid or a base may be used in accordance with the teachings of the present invention.

Fig. 14 is an embodiment of the present invention which illustrates how particulate matter counts are affected by a subsequent BKM#2, that is, the more advanced BKM clean up, after a base etch (BCP) of the present invention. In this Fig. 14, it is clear that BCP is an inherently clean process, since very little residue was subject to removal by the BKM#2 process. This is most clearly shown by the difference in particulate matter after 40 minutes of Sonification time, or time in an ultrasonic agitation environment. Here, a net change of only 215,698 minus 123,529 particle counts per square centimeter results. In accordance with the present invention, a further ultrasonification to 70 minutes reduces the PMC well below a baseline of 200,000, and preferably 100,000, particulate matter counts (PMC), both with and without BKM#2 treatment.

Fig. 15 is an embodiment which illustrates how particulate matter counts are affected by a subsequent BKM#2, that is, the more advanced BKM clean up, after an acid etch (ACP) of the present invention. In Fig. 15 it is clear that ACP is an inherently clean process, since very little residue was subject to removal by the BKM#2 process. This is most clearly shown by the difference in particulate matter after 40 minutes of

Sonification time, or time in an ultrasonic agitation environment. Here, a net change of only 263,521 minus 242,936 particle counts per square centimeter, or a little more than 21,000 particle counts per square centimeter, results. It will be understood that these numbers are approximate numbers, and will vary in the practice of the present invention. In accordance with the present invention, a further ultrasonification to 70 minutes reduces the PMC well below a baseline of 200,000 PMC, with or without BKM#2 treatment.

Fig. 16 is an embodiment of the invention which illustrates a silicon wafer with particles after being processed in a chamber of the invention. In Fig. 16, an embodiment of the present invention achieved a particle count of less than 100K (100,000) particles per milliliter (mL) in water used to rinse the roof surface. It is believed that a particle count that low will result in relatively insignificant problems with particulate matter on the material being processed in a chamber of the present invention, such as a silicon wafer 703. This belief is verified by the almost total absence of particles 705 on the wafer shown, the wafer having a total of four particles 0.2 microns or larger.

The graph 707 at the bottom of Figure 16 shows the PMC in terms of particle size. There were three particles with a diameter of slightly more than 0.2 microns, and one with a diameter of about 0.8 microns.

Fig. 17 illustrates by way of contrast the particulate count achieved with the prior art BB and HF etch. In Fig. 17, particulate matter 803 is randomly dispersed on a wafer 805. Depending on the size of the integrated circuits on the wafer, as well as the feature size and density of these circuits, the particulate matter is capable of severely impacting the production, called Ayield@, of the circuits on this silicon wafer.

The graph 807 at the bottom of Fig. 17 shows the PMC in terms of size for the wafer. The bulk of the particles were are about 0.3 microns in diameter, but the diameters range up to about 1.5 microns, with four greater than 1 micron in diameter.

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 present invention to the precise forms disclosed, and it should be understood that 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 present invention and its practical application, to thereby enable others skilled in the art to best utilize the present invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the present invention be defined by the Claims appended hereto and their equivalents.

WHAT IS CLAIMED IS

1. A method for cleaning a silicon roof of a plasma chamber comprising the steps of:

etching the roof;

cleaning the roof after the etching;

rinsing the roof with deionized water after the cleaning;

determining the amount of first particulate matter of at least a certain size in the deionized water; and

comparing the first particulate matter to a predetermined baseline amount of particulate matter.

2. The method of claim 1 wherein the etching is without substantial damage to the silicon structure

3. The method of claim 1 wherein the etching is by an acid.

4. The method of claim 1 wherein the etching is by a base.

5. The method of claim 1 wherein the silicon roof is polycrystalline silicon.

6. The method of claim 1 wherein the material being processed is a silicon wafer.

7. A method for cleaning a silicon roof of a plasma chamber comprising the steps of:

etching the roof until trace metal contamination has been reduced below a predetermined level;

cleaning the roof after the etching.

8. The method of claim 7 wherein the etching is by an acid.

9. The method of claim 7 wherein the etching is by a base.

10. The method of claim 9 wherein the base is ammonium hydroxide or potassium hydroxide.

11. The method of claim 7 comprising the silicon roof being polycrystalline silicon.

12. The method of claim 7 wherein the material being processed is a silicon wafer.

13. A process for cleaning a silicon roof of a plasma chamber comprising:

etching the roof without substantial damage to the silicon structure until trace metal contamination has been reduced below a predetermined level;

cleaning the roof after etching; and

rinsing the roof with an inert substance after cleaning.

14. The process of claim 13 wherein the inert substance is deionized water.

15. The process of claim 13 wherein the trace metal contaminant is copper.

16. The process of claim 15 wherein the level of copper trace metal is below about 1 X 10^10 atoms per square centimeter.

17. A process for cleaning an silicon roof of a plasma chamber including determining an amount of particulate matter from the silicon roof comprising:

etching the roof without substantial damage to the silicon structure;

cleaning the roof after the etching;

rinsing the roof with an inert substance; and

reducing a first particulate matter count of the particulate matter below a

predetermined baseline particulate matter count.

18. The process of claim 17 wherein the inert substance is deionized water.

19. The process of claim 17 wherein the matter being processed is a silicon wafer.

20. A process for cleaning a silicon roof including improving the stability of an IPS plasma comprising:

etching the roof;

cleaning the roof after the etching;

rinsing the roof with an inert substance; and

thereby, reducing copper contamination of the roof below a predetermined baseline level of copper.

21. An apparatus for cleaning a silicon roof of a plasma chamber comprising:

means for etching the roof until trace metal contamination has been reduced below a predetermined level;

means for cleaning the roof after the etching;

deionized water means for rinsing the roof after the cleaning;

means for determining qualitatively how much particulate matter of at least a certain size is in the deionized water after rinsing the roof; and

means for comparing the amount of particulate matter to a predetermined baseline amount.

22. The apparatus of claim 21 wherein the means for etching is an acid.

23. The apparatus of claim 21 wherein the means for etching is a base.

24. The apparatus of claim 21 comprising the silicon roof being polycrystalline silicon.

25. The apparatus of claim 21 wherein the material being processed is a silicon wafer.

26. An apparatus for cleaning a silicon roof of a plasma chamber comprising:

means for etching the roof;

means for cleaning the roof after the etching;

inert substance means for rinsing the roof after the cleaning;

means for determining qualitatively how much particulate matter of at least a certain size is in the inert substance after rinsing the roof; and

means for comparing the amount of particulate matter to a predetermined baseline amount.

27. The apparatus of claim 26 wherein the inert substance is deionized water.

28. The apparatus of claim 26 wherein the baseline is less than 200,000 counts of particulate matter per cubic centimeter.

29. The apparatus of claim 26 wherein the baseline is preferably less than 100,000 counts of particulate matter per cubic centimeter.