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(54) **Combustive destruction of noxious substances**

Zerstörung giftiger Substanzen durch Verbrennung

Destruction de substances toxiques par combustion

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Description

[0001] This invention relates to the disposal by combusive destruction of noxious substances, especially global-warming, air-polluting halogenated compounds, such as fluorocarbons, and particulate-forming matter upon oxidation, such as silane.

[0002] Fluorocarbon gases such as hexafluoroethane (C_2F_6) and tetrafluoromethane (CF_4) are global-warming compounds when released into the atmosphere where they have extremely long lifetimes. These gases as well as other fluorinated gases such as nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6) are used in the manufacture of semiconductors during the etching, modification and construction of silicon wafers, and during the cleaning of the machines used in the process. Hydrides, such as silane (SiH_4), which ignites upon exposure to air, are also used in the process of making silicon wafers. The fluorinated gases and hydrides and even particulate matter are swept out of the machines with nitrogen, sometimes together and sometimes sequentially.

[0003] According to current practice, the nitrogen stream containing the noxious gases is subjected to thermal destruction using electrical heat or gas firing. However, complete destruction of the undesired gases is achieved only with a large consumption of thermal energy. Another current technique of mixing the stream with hydrogen and effecting combustion is unsatisfactory because of the large usage of expensive hydrogen.

[0004] It is significant that these expensive and unsatisfactory disposal methods are in use even though several patents propose other procedures. For example, US Patent Specification No. 4 627 388 discloses the burning of halogenated hydrocarbon waste in a horizontal fire tube boiler requiring a refractory lined combustion chamber of substantial length to contain the flame front near adiabatic conditions. US Patent Specification No. 4 206 711 discloses the use of a vertical combustion chamber in which liquid waste is sprayed down from the top, while several flat flame radiation type burners in the walls of the chamber provide flames that totally surround the sprayed waste.

[0005] US Patent Specification No. 4 828 481 discloses the elimination of the large and costly equipment of the aforesaid patents by proposing a combustion chamber comprising two opposed porous plates between which combustion is carried out. A mixture of gaseous fuel, air, and waste vapour is fed through one porous plate, burned in the chamber and the combustion products are exhausted through the other porous plate. However, the waste material must be free of particles or the inlet porous plate will become plugged. Even in the absence of particles in the waste material, there is the real danger that particles, such as soot or silica (if silane is in the waste), will form during combustion and plug the outlet porous plate. The need for a practical disposal system still exists.

[0006] DE-A-42 01 650 discloses apparatus for the thermal incineration of waste gas contaminated with oxidisable pollutants, in particular of waste gas from heat-treatment furnaces. The apparatus has a combustion zone that is laterally surrounded by the exit surface of a porous gas burner. Fuel gas and air supplied to the burner undergoes combustion upon discharging in to the combustion zone, while waste gas and added air flow through the combustion zone.

[0007] In industrial practice, the gaseous stream carrying one or more halogenated compounds may also contain particulate-forming matter upon oxidation, simultaneously or sequentially. Silane which oxidises in air to silica, and another often used hydride, arsine (AsH_3) which oxidises to a troublesome sticky oxide (As_2O_3), are illustrative of particulate-forming matter commonly associated with halogenated compounds, particularly the fluorocarbons used in the semiconductor industry.

[0008] Besides the fluorinated gases of the semiconductor industry, air pollutants encountered in other industries include chlorinated hydrocarbons such as carbon tetrachloride, trichloroethylene, chlorobenzene and vinyl chloride. The refrigeration industry has long favoured chlorofluorohydrocarbons as refrigerant gases but these gases are now being phased out. A satisfactory system for the disposal of all these halogenated compounds is still wanting.

[0009] The invention is concerned with the provision of a simple and economic system for the combusive destruction of halogenated compounds and/or particulate-forming matter upon oxidation and also with the provision of an apparatus and a process that achieve substantially complete combusive destruction of noxious substances while suppressing the formation of air pollutants, namely, nitrogen oxides (NO_x), carbon monoxide (CO) and unburned hydrocarbons (UHC), that are commonly formed during combustion.

[0010] An important aim of the invention is to utilise apparatus which is simple and economic to construct and operate.

[0011] In accordance with a first aspect of the invention, there is provided a process for the combusive destruction of noxious substances, which comprises injecting a gas stream containing at least one noxious substance and added fuel gas in to a combustion zone that is laterally surrounded by the exit surface of a foraminous gas burner, simultaneously supplying fuel gas and air to the foraminous gas burner to effect combustion at the exit surface, the amount of the fuel gas supplied to said foraminous gas burner being, on a kg-cal (BTU) basis, greater than that of said added fuel gas, and the amount of the air being in excess of the stoichiometric requirement of all the combustibles entering the combustion zone, and discharging the resulting combustion product stream from the combustion zone. Generally, the gas stream injection will be at the top of the combustion zone and the discharge will be from the bot-

tom of the zone.

[0012] In the process of the invention, noxious (troublesome) substances, especially halogenated compounds and particulate-forming matter upon oxidation are substantially completely (as least 95%) destroyed by combustion in a process comprising the steps of mixing a fuel gas with the stream containing noxious substances and injecting the mixture into a destructive combustion zone maintained at a temperature of at least 1038°C (1900°F) by effecting flameless combustion of a fuel and excess air mixture on the exit surface of a foraminous gas burner that surrounds the combustion zone. The excess air passing through the foraminous burner is sufficient to consume not only the fuel supplied to the burner but also all the combustibles in the mixture injected directly into the destructive combustion zone. Even then, there should be enough excess air so that free oxygen remains in the product gas stream leaving the combustion zone. Generally, to achieve substantially complete (at least 95%) combustion of the troublesome substances, the amount of excess air should be at least about 10% more than the stoichiometric requirement to burn all the combustibles entering the combustion zone.

[0013] In most cases, natural gas is the most cost-effective fuel that can be supplied to the foraminous gas burner and that which is separately admixed with the noxious substance containing gas stream injected into the combustion zone. Other hydrocarbons and hydrogen are alternative fuels but generally are used only where natural gas is not available.

[0014] In accordance with a second aspect of the invention, there is provided apparatus for the combustive destruction of noxious substances, which comprises a combustion chamber laterally surrounded by the exit surface of a foraminous gas burner and having an open bottom, means for injecting a stream containing at least one noxious substance directly in to the combustion chamber, a cooling column below and in flow-communication with said combustion chamber, means for maintaining a flow of water down the inner surface of the walls of said column, and a gas-liquid separator connected to the bottom of said column.

[0015] The foraminous gas burner used in accordance with this invention includes two basic forms: a porous fibre layer and a perforated plate. The porous fibre layer form involves a porous coherent layer of non-combustible fibres of either the mineral type or the metallic type. US Patent Specification No. 3 179 156 discloses the deposition of alumina-silica fibres on a screen from an aqueous suspension of the fibres containing a binding agent which interconnects the fibres to one another and to the screen.

[0016] This basic porous fibre burner made with ceramic fibres preferably contains a small amount of aluminium powder as disclosed in US Patent Specification No. 3 383 159 or aluminium alloy powder as disclosed in US Patent Specification No. 4 746 287. US Patent

Specification No. 3 173 470 discloses a porous fibre burner in which a layer of metal fibres is made coherent by sintering. A recently developed hybrid fibre burner formed from a mixture of metal fibres and ceramic fibres is disclosed in US Patent Specification No. 5 326 631.

[0017] The perforated plate form of a foraminous gas burner is shown in numerous patents. US Patent Specification No. 2 775 294 discloses an early example of a perforated plate burner. Other forms of such burners are disclosed in US Patent Specification Nos. 3 683 058 and 3 954 387.

[0018] All such foraminous gas burners as well as variations thereof widely described in patents and technical publications can serve the purpose of this invention.

[0019] The exit surface of the foraminous burner, where flameless combustion takes place, surrounds the destructive combustion zone into which the noxious substance containing gas stream and added fuel is injected. The resulting incandescent exit surface of the burner emits infrared radiation that helps to maintain the destructive combustion zone at a temperature of at least 1038°C (1900°F). The burners may be made from modular form from a number of component parts or may be made as an integral construction.

[0020] The fuel gas fed together with excess air to the foraminous burner is consumed by flameless combustion at the exit surface of the burner and the resulting combustion product gas flowing outwardly from that surface prevents the deposition therein of particulate matter entering or forming in the destructive combustion zone, for example because of a hydride such as arsine injected thereto. The deposition of particulate matter at the exit of any burner is troublesome and is extremely so when the particulate matter is a sticky substance such as As₂O₃ formed when arsine is present in the stream injected into the destructive combustion zone.

[0021] The selection of foraminous burners to prevent the deposition of particulate matter within the destructive combustion zone is essential to the successful performance of the invention.

[0022] In contrast to the flameless surface combustion of the fuel gas supplied to the foraminous burner, the combustibles of the stream separately injected into the destructive combustion zone burn with a diffusion flame. Inasmuch as the air required to burn the combustibles in the injected stream is separately fed to the combustion zone through the porous fibre burner, it is prudent to inject that stream in the form of several small streams so that the excess air leaving the exit surface of the foraminous burner can more rapidly react with the waste combustibles. Clearly, it takes longer for the air to reach all the combustibles in a stream of large diameter than it does in several divisions of that stream. Stated another way, several small streams will have a shorter flame than that of a single stream having a volume equal to the total volume of the several small streams.

[0023] The combustion product stream leaving the destructive combustion zone is noteworthy for two rea-

sons: commonly at least 95% of the halogenated compounds fed to the zone have been destroyed and the formation of NO_x , CO and UHC have been suppressed to very low values. The combustion product stream will contain HF and HCl to the extent that fluorine and chlorine were present in the halogenated compounds fed to the combustion zone. Oxide particles will be in the combustion product stream to the extent that hydrides such as silane and arsine were present in the stream entering the combustion zone. The product stream will also contain any non-combustible particles present in the waste stream fed to the combustion zone.

[0024] The combustion product stream must be cooled and scrubbed to capture the HF and HCl and particulate matter present therein as well as sulphur dioxide if SF_6 was present in the stream of halogenated compounds. A simple and effective way of cooling and even starting the capture of HF and HCl is to discharge the product stream from the combustion zone directly into a column in which a flow of water coats the inner surface. Spraying water into the product stream discharged from the destructive combustion zone is also effective. The thus quenched product stream is then passed through a scrubber which may be in any of its known forms. The scrubbed gas is vented to the atmosphere as an environmentally safe gas.

[0025] To facilitate the further description and understanding of the invention, reference will be made, by way of exemplification only, to the accompanying drawings of which:

Figure 1 is a sectional view of a rectangular pan-type porous fibre layer burner;

Figure 2 is a diagrammatic horizontal sectional view of four burners of Figure 1 arranged to form a vertical furnace for the practice of the invention; and

Figure 3 is a diagrammatic sectional elevation of a preferred form of furnace, shown in association with desirable equipment for feeding the furnace and for treating the gaseous effluent therefrom.

[0026] With reference to the drawings, Figure 1 is a cross-section of a typical pan-type porous fibre layer burner 10 transverse to its length. A metal pan 11 has side walls 12 with a screen 13 welded to ends 14 of the side walls 12. A porous layer 15 of ceramic fibres is deposited on, and attached to, the screen 13. The porous layer 15 provides the exit surface at which a mixture of fuel gas and air will burn without visible flame and become radiant. The fuel gas-air mixture is fed to burner 10 through a pipe 16 connected to the metal pan 11.

[0027] Figure 2 shows a furnace 20 useful for the practice of this invention by having four porous surface burners 10 of the type shown in Figure 1 arranged to form a square adiabatic combustion zone 21. Where each pair of burners 10 meet at right angles to one an-

other, a refractory post 22 is cemented to the side walls 12 of the contiguous burners 10 so that the products of combustion cannot leak along the vertical (normal to Figure 2) juncture line 23 of contiguous burners 10. By this arrangement, four burners 10 act as an inwardly fired furnace with a destructive combustion zone 21 surrounded by the exit surface 15 of burners 10. Figure 2 demonstrates that a furnace suitable for this invention may be formed of modular burners 10.

[0028] A waste stream containing halogenated compounds and/or particulate-forming matter and added fuel gas enters the top of the furnace 20 through multiple openings 25 as small streams that flow down into the combustion zone 21 where excess air exiting from porous fibre layers 15 achieves the combustive destruction of the troublesome compounds. It is understood that the bottom end of furnace 20 is open and connected to a water-cooling column for the capture, as previously explained, of any HF, HCl, SO_2 and particles in the combustion product stream flowing from combustion zone 21.

[0029] A preferred furnace 30 is shown in Figure 3 with desirable auxiliary equipment for feeding a waste stream of halogenated compounds and/or particulate-forming matter and added hydrocarbon gas to the combustion zone 31 and for treating the combustion product stream issuing therefrom. The furnace 30 is formed by a cylindrical steel shell 32 with flanges 33,34 at its opposite ends. The bottom flange 34 extends inwardly and outwardly from shell 32. A cylindrical metal screen 35 having its top connected to screen 36 and having inward screen flange 37 connected to flange 34 is concentrically held within shell 30 and spaced therefrom.

[0030] Weld 35A fastens screen 35 to the inner edge of flange 34. Several tubes 38 extend through and are welded to top screen 36. All of the inner face of screen 35,36,37 has an adherent porous layer 39 of ceramic and/or metal fibres. Shell 32 has one or more pipes 40 for introducing a mixture of fuel gas and excess air into the space around screens 35,36 so that the mixture will flow through porous fibre layer 39 and, upon ignition, will maintain flameless combustion at the exit surface of fibre layer 39.

[0031] A steel plate 41 supported by and attached to the top flange 33 by bolts (not shown) holds as many tubes 42 as there are tubes 38. Tubes 42 are of a smaller diameter than that of tubes 38 and are long enough so that the bottom ends of tubes 42 reach the bottom ends of tubes 38. The spacing of tubes 42 extending vertically through plate 41 and welded thereto must be carefully laid out so that, when plate 41 is brought down to rest on flange 33 of shell 32, each tube 42 will slide through a tube 38. Any leakage of the gas-air mixture from the space above screen 36 through the clearance between concentric tubes 38 and tubes 42 is generally tolerable. However, if desired, such leakage can be easily stopped by a ring 43 of elastomer on each tube 42 positioned to seat against the top end of tube 38 when tube 42 has

been fully inserted in tube 38.

[0032] The furnace 30 is connected to a cooling column 50 so that the bottom open end of the combustion zone 31 is aligned with the column 50 which has an annular trough 51 around its top end. Water is supplied to the trough 51 through a pipe 52 and overflows the top end of the column 50 to provide a continuous flow of water down the inner surface of the column 50 thereby cooling the combustion product stream leaving zone 31 and preventing particles in that stream from adhering to the inner surface of column 50. The gaseous stream and water discharge from the bottom end of the column 50 into a separator 54 having a drain pipe 55 for the withdrawal of water containing particulate matter and soluble compounds such as HF, HCl, and SO₂. The cooled gaseous stream exits from the separator 54 through a pipe 56 and is passed through a scrubber (not shown) in any of its many known forms to capture residual soluble compounds in the gaseous stream leaving separator 54. The scrubbed gas can be vented to the atmosphere as an environmentally safe exhaust.

[0033] In use, a waste stream containing halogenated compounds and/or particulate-forming matter is fed to tubes 42 while fuel gas is added to that stream via tubes 44. The resulting mixture flows down the tubes 42 into the combustion zone 31 where the combustibles thereof are consumed as separate flames projecting from the bottom ends of tubes 42 upon meeting excess air supplied through porous fibre layer 39.

[0034] Tests were conducted with a furnace having a cylindrical - 7.6cm (3 inches) in diameter and 30.5cm (12 inches long) - combustion zone surrounded by a porous ceramic fibre burner as illustrated by the screen 35 and the porous fibre layer 39 in the furnace 30 of Figure 3. A nitrogen stream containing 8% by volume of C₂F₆ was injected into the combustion zone at the rate of 20 litres (l) per minute, while natural gas and excess air were passed through the porous fibre burner to effect surface combustion at the rate of 11.39kg-cal (42,000 BTU (British Thermal Unit)) per hour per square centimetre (foot) of burner surface. The excess air supplied to the burner was 61 % more than the stoichiometric requirement of the natural gas simultaneously supplied to the burner. The combustion product gas contained 11.3% by volume of residual oxygen. Analysis of this product gas revealed that only 56% of the C₂F₆ injected into the furnace had been destroyed.

[0035] However, another test was carried out without making any changes in the foregoing operation except that 12% by volume (2.4 l per minute) of natural gas was mixed with the nitrogen stream containing C₂F₆. In this case, the excess air supplied to the burner also burned the natural gas admixed with the nitrogen stream so that the residual oxygen in the combustion product gas dropped to 7.4% by volume. Analysis of the product gas showed that 99% of the C₂F₆ had been destroyed.

[0036] In another pair of tests, the burner was fired at the rate of 11.93kg-cal (44,000 BTU) per hour per

square centimetre (foot) with 61% excess air and the flow of nitrogen containing 4% by volume of C₂F₆ was doubled to 40 l per minute. In one test, natural gas was added to the waste nitrogen stream at the rate of 2.4 l per minute (6% by volume). The combustion product gas contained 7.1% by volume of residual oxygen. Only 60% of the C₂F₆ was destroyed. Merely by increasing the addition of natural gas to 4.7 l per minute (11.8% by volume) the destruction of C₂F₆ rose to 96% which is considered satisfactory when compared with current commercial processes that are more cumbersome and expensive. The residual oxygen in the combustion product gas dropped to 4.4% by volume.

[0037] In still another test, the supply of nitrogen containing 2% by volume of C₂F₆ was quadrupled to 80 l per minute and the burner was fired at the rate of 15.73kg-cal (58,000 BTU) per hour per square centimetre (foot) with 61% excess air. Natural gas added to the nitrogen stream was 8.9% by volume (previous test 12%). The combustion product gas contained only 3.5% by volume of residual oxygen. The destruction of 99% of the C₂F₆ was achieved.

[0038] The first two tests demonstrate the critical need of supplying fuel gas admixed with the waste stream injected into the destructive combustion zone. The second pair of tests shows that increasing the amount of fuel gas mixed with the waste stream increased the combustive destruction of the halogenated compound. The last cited test makes it clear that even though a waste stream with a low concentration (2% by volume) of C₂F₆ was passed through the combustion zone at a rapid rate (80 l per minute), 99% of the fluorocarbon was still destroyed. The several tests demonstrate the broad range of flow rates of waste stream with varying C₂F₆ concentrations that can be successfully processed in a combustion zone surrounded by the radiant surface of a foraminous gas burner.

[0039] The foregoing tests were carried out with C₂F₆ free of particulate-forming matter such as silane and arsine to facilitate the analysis of the combustion product gas to determine the percentage of C₂F₆ destruction achieved in each test. To establish what happens when silane enters the destructive combustion zone, a test was conducted in which silane was added to a nitrogen stream injected into the combustion zone at the rate of 40 l per minute. The silane addition was 0.22 l per minute for 1.5 hours and then increased to 0.31 l per minute for another 1.5 hours. The addition of natural gas to the waste stream containing silane was at the rate of 4.7 l per minute. As in other tests, the foraminous burner was fired at the rate of 11.93kg-cal (44,000 BTU) per hour per square centimetre (foot) with 61% excess air. The silane was completely destroyed and the resulting silica particles did not accumulate in the destructive combustion zone.

[0040] Additional tests were carried out on waste streams containing CF₄ alone and mixed with C₂F₆ and silane. The desired destruction of the fluorocarbons and

silane was again accomplished. The efficacy of the combustive destruction of halogenated compounds and/or particulate-forming matter has been established and shown to be attainable by simple adjustments in the amounts of fuel gas fed to the foraminous burner and added to the waste stream containing troublesome substances even when the injection rate is varied over a wide range.

[0041] Simple tests have also provided guidelines for selecting for any waste stream the conditions that will yield in excess of 95% destruction of halogenated compounds which are resistant to breakdown. The fuel gas supplied to the foraminous burner should generally be at a rate of at least about 6.78kg-cal (25,000 BTU) per house per square centimetre (foot) of burner surface. Combustion air is supplied solely to the burner in an amount that exceeds the stoichiometric requirement of both the fuel gas supplied to the burner and all the combustibles injected into the destructive combustion zone; a large air excess of at least about 50% relative to the fuel gas supplied to the foraminous burner is a good starting level in seeking the optimum conditions for any particular waste stream.

[0042] The amount of fuel gas on a kg-cal (BTU) basis supplied to the foraminous burner is always greater than that admixed with the waste stream. The ratio of burner fuel gas to waste stream fuel gas is usually in the range of about 2:1 to 5:1, high ratios being generally applicable to low rates of waste stream treatment and low ratios being generally applicable to high rates of waste stream treatment. These guidelines facilitate both the selection of the initial conditions for treating a particular waste stream and then the adjustment of these initial conditions to attain a desired high level of destruction such as 99%.

[0043] The invention is noteworthy for the simplicity and compactness of the furnace as well as for the simplicity of operation and low fuel consumption to easily effect 99% destruction of halogenated compounds and/or particulate-forming matter such as silane and arsine, while avoiding the troublesome deposition and accumulation of particulates such as SiO_2 and As_2O_3 within the combustion zone.

Claims

1. A process for the combustive destruction of noxious substances, by injecting a gas stream containing at least one noxious substance in to a combustion zone (21, 31) that is laterally surrounded by the exit surface (15, 39) of a foraminous gas burner, **characterised in that** fuel gas and air are simultaneously supplied to the foraminous gas burner (10, 35) to effect combustion at the exit surface and fuel gas is admixed with the gas stream prior to injection in to the combustion zone (21, 31), the amount of the fuel gas supplied to the foraminous gas burner is, on a

kg-cal (BTU) basis, greater than that of the admixed fuel gas, and the amount of the air supplied to the foraminous gas burner is in excess of the stoichiometric requirement of all the combustibles entering the combustion zone, and the resulting combustion product stream is discharged from the combustion zone.

2. A process according to Claim 1 in which the fuel gas is natural gas and the amount of air supplied to the foraminous gas burner (10, 35) is at least about 50% in excess of the stoichiometric requirement of said natural gas supplied to the foraminous gas burner.
3. A process according to Claim 1 or Claim 2 in which the ratio of the amount of fuel gas supplied to the foraminous gas burner (10, 35) to the amount of fuel gas injected into the combustion zone (21.31) is in the range of about 2:1 to 5:1.
4. A process according to any preceding claim in which the gas stream is nitrogen containing at least one fluorocarbon and/or a hydride discharged as a waste stream from the manufacture of semiconductors.
5. A process according to any preceding claim in which the foraminous gas burner (10, 35) has a porous layer (15, 39) of ceramic and/or metal fibres.
6. A process according to any preceding claim in which the combustion product stream is discharged downwardly from the combustion zone (31) directly into a column (50) while cooling water flows down the inner surface of the column.
7. A process according to any one of Claims 1 to 6 in which at least one noxious substance is a halogenated compound and/or particulate-forming matter, the fuel gas supplied to the foraminous gas burner (10, 35) yields at least 6.78kg-cal (25,000 BTU) per hour per square centimetre (foot) of the exit surface (15, 39) of the foraminous gas burner (10, 35), and the ratio of the amount of the fuel gas supplied to the foraminous gas burner (10, 35) to the amount of the fuel gas admixed with the injected gas stream is controlled in the range of about 2:1 to 5:1 to achieve the combustive destruction of at least about 95% of the content of the halogenated compound and/or particulate-forming matter.
8. A process according to Claim 7 in which the combustion product stream is discharged downwardly from the combustion zone (31) directly in to a column (50) while cooling water flows down the inner surface of the walls of the column (50).

9. Apparatus for the combustive destruction of noxious substances, which comprises a combustion chamber (31) laterally surrounded by the exit surface (39) of a foraminous gas burner (35), and means (42) for injecting a gas stream containing at least one noxious substance and means (40) for supplying fuel gas and air directly in to the combustion chamber, **characterised in that** means (44) are provided to inject fuel gas in to the waste stream prior to injection in to the combustion chamber mixed with the gas stream, a cooling column (50) is below and in flow-communication with the combustion chamber, the column having means (51,52) for maintaining a flow of water down the inner surface of the walls of the column, and a gas-liquid separator (54) is connected to the bottom of the column.

10. Apparatus according to Claim 9 in which the foraminous gas burner (35) has a porous layer (39) of ceramic and/or metal fibres.

11. Apparatus according to Claims 9 or Claim 10 in which the top of the combustion chamber (31) has a ceiling formed by the exit surface of a foraminous gas burner (36).

Patentansprüche

1. Verfahren zum Vernichten von Schadstoffen durch Verbrennung, wobei ein Gasstrom, der mindestens einen Schadstoff enthält, in einen Verbrennungsbereich (21, 31) eingeleitet wird, der seitlich von Austrittsflächen (15, 39) eines perforierten oder mit Löchern versehenen Gasbrenners umschlossen ist, **dadurch gekennzeichnet, daß**

dem perforierten Gasbrenner (10, 35) ein Brenngas und Luft gleichzeitig zugeführt werden, um an der Austrittsfläche eine Verbrennung zu bewirken, wobei dem Gasstrom Brenngas beigemischt wird, bevor er in den Verbrennungsbereich (21, 31) eingeleitet wird, wobei die Menge des dem perforierten Gasbrenner zugeführten Brenngases auf einer kg-cal- (BTU-) Basis größer ist als diejenige des beigemischten Brenngases, und wobei die Menge der dem perforierten Gasbrenner zugeführten Luft größer ist als für alle in den Verbrennungsbereich eintretende Brennstoffe stöchiometrisch erforderlich, und wobei der erhaltene Verbrennungsproduktstrom vom Verbrennungsbereich abgeleitet wird.

2. Verfahren nach Anspruch 1, wobei das Brenngas ein Erdoder Naturgas ist und die dem perforierten Gasbrenner (10, 35) zugeführte Luftmenge mindestens 50% größer ist als für das dem perforierten Gasbrenner zugeführte Naturgas stöchiometrisch erforderlich.

3. Verfahren nach Anspruch 1 oder 2, wobei das Verhältnis der dem perforierten Gasbrenner (10, 35) zugeführten Brenngasmenge zur in den Verbrennungsbereich (21, 31) eingeleiteten Brenngasmenge im Bereich von 2:1 bis 5:1 liegt.

4. Verfahren nach einem der vorangehenden Ansprüche, wobei der Gasstrom ein Stickstoffgasstrom ist, der mindestens einen Fluorkohlenstoff und/oder ein Hydrid enthält, der/das als Abgasstrom bei der Halbleiterfertigung abgeleitet wird.

5. Verfahren nach einem der vorangehenden Ansprüche, wobei der perforierte Gasbrenner (10, 35) eine poröse Schicht (15, 39) aus Keramik- und/oder Metallfasern aufweist.

6. Verfahren nach einem der vorangehenden Ansprüche, wobei der Verbrennungsproduktstrom vom Verbrennungsbereich (31) nach unten direkt in eine Säule (50) abgeleitet wird, während entlang der Innenfläche der Säule Kühlwasser nach unten fließt.

7. Verfahren nach einem der Ansprüche 1 bis 6, wobei mindestens ein Schadstoff eine halogenhaltige Verbindung und/oder eine aus Partikeln bestehende Substanz ist, durch das dem perforierten Gasbrenner (10, 35) zugeführte Brenngas eine Energie von mindestens 6,78 kg-cal (25000 BTU; pro Stunde pro Quadratcentimeter (Quadratfuß) der Austrittsfläche (15, 39) des perforierten Gasbrenners (10, 35) freigesetzt wird und das Verhältnis der dem perforierten Gasbrenner (10, 35) zugeführten Brenngasmenge zur Menge des dem eingeleiteten Gasstrom beigemischten Brenngases im Bereich von etwa 2:1 bis 5:1 geregelt wird, um zu erreichen, daß mindestens 95% des Anteils der halogenhaltigen Verbindung und/oder der aus Partikeln bestehenden Substanz durch Verbrennung vernichtet werden.

8. Verfahren nach Anspruch 7, wobei der Verbrennungsproduktstrom vom Verbrennungsbereich (31) nach unten direkt in eine Säule (50) abgeleitet wird, während entlang der Innenfläche der Wände der Säule (50) Kühlwasser nach unten fließt.

9. Vorrichtung zum Vernichten von Schadstoffen durch Verbrennung mit:

einer Verbrennungskammer (31), die seitlich von der Austrittsfläche (39) eines perforierten Gasbrenners (35) umgeben ist, Einrichtungen (42) zum Einleiten eines Gasstroms, der mindestens einen Schadstoff enthält, und einer Einrichtung (40) zum direkten Zuführen

eines Brenngases und von Luft in die Verbrennungskammer,

dadurch gekennzeichnet, daß

Einrichtungen (44) vorgesehen sind, die ein Brenngas in den mit dem Gasstrom gemischten Abgasstrom einleiten, bevor er in die Verbrennungskammer eingeleitet wird, eine Kühle säule (50) unter der Verbrennungskammer angeordnet ist und mit ihr in Strömungsverbindung steht, wobei die Säule eine Einrichtung (51, 52) aufweist, die dazu dient, eine Wasserströmung entlang der Innenfläche der Wände der Säule nach unten aufrechtzuerhalten, und wobei ein Gas-Flüssigkeit-Separator (54) mit der Unterseite der Säule verbunden ist.

10. Vorrichtung nach Anspruch 9, wobei der perforierte Gasbrenner (35) eine poröse Schicht (39) aus Keramik und/oder Metallfasern aufweist.

11. Vorrichtung nach Anspruch 9 oder 10, wobei die Oberseite der Verbrennungskammer (31) eine durch eine Austrittsfläche eines perforierten Gasbrenners (36) gebildete Decke aufweist.

Revendications

1. Procédé pour la destruction par combustion de substances toxiques, par injection d'un courant gazeux contenant au moins une substance toxique dans une zone de combustion (21,31) qui est entourée latéralement de la surface de sortie (15,39) d'un brûleur à gaz foraminé, **caractérisé en ce que** du gaz combustible et de l'air sont amenés simultanément au brûleur à gaz foraminé (10,35) pour effectuer la combustion à la surface de sortie et du gaz combustible est ajouté et mélangé au courant gazeux avant l'injection dans la zone de combustion (21,31), la quantité du gaz combustible amenée au brûleur à gaz foraminé est, sur une base kg-cal (BTU), supérieure à celle du gaz combustible ajouté et mélangé et la quantité d'air amenée au brûleur à gaz foraminé est en excédent des exigences stoechiométriques de tous les combustibles entrant dans la zone de combustion et le courant du produit de combustion résultant est évacué de la zone de combustion.

2. Procédé selon la revendication 1, dans lequel le gaz combustible est du gaz naturel et la quantité d'air amenée au brûleur à gaz foraminé (10,35) est d'au moins environ 50% en excédent des exigences stoechiométriques dudit gaz naturel amené au brûleur à gaz foraminé.

3. Procédé selon la revendication 1 ou 2, dans lequel le rapport entre la quantité de gaz combustible amené au brûleur à gaz foraminé (10,35) et la quantité de gaz combustible injecté dans la zone de combustion (21,31) se situe dans la plage d'environ 2:1 à 5:1.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel le courant gazeux est de l'azote contenant au moins un fluorocarbure et/ou un hydrure évacué en tant que courant de déchets provenant de la fabrication de semi-conducteurs.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel le brûleur à gaz foraminé (10,35) comporte une couche poreuse (15,39) de céramique et/ou de fibres métalliques.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel le courant du produit de combustion est évacué vers le bas depuis la zone de combustion (31) directement dans une colonne (50) tandis que de l'eau de refroidissement s'écoule vers le bas sur la surface intérieure de la colonne.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel au moins une substance toxique est un composé halogéné et/ou une matière de formation particulaire, le gaz combustible amené au brûleur à gaz foraminé (10,35) cède au moins 6,78kg-cal (25000 BTU) par heure par centimètre carré (pied) de la surface de sortie (15,39) du brûleur à gaz foraminé (10,35) et le rapport entre la quantité de gaz combustible amenée au brûleur à gaz foraminé (10,35) et la quantité de gaz combustible ajoutée et mélangée au courant gazeux est régulée dans la plage d'environ 2:1 à 5:1 pour obtenir la destruction par combustion d'au moins environ 95% de la teneur en composé halogéné et/ou en matière de formation particulaire.

8. Procédé selon la revendication 7, dans lequel le courant de produit de combustion est évacué vers le bas depuis la zone de combustion (31) directement dans une colonne (50) tandis que de l'eau de refroidissement s'écoule vers le bas sur la surface intérieure des parois de la colonne (50).

9. Appareil pour la destruction par combustion de substances toxiques qui comprend une chambre de combustion (31) entourée latéralement de la surface de sortie (39) d'un brûleur à gaz foraminé (35) et de moyens (42) pour injecter un courant gazeux contenant au moins une substance toxique et des moyens (40) pour alimenter du gaz combustible et de l'air directement dans la chambre de combustion, **caractérisé en ce que** des moyens (44) sont pré-

vus pour injecter le gaz combustible dans le courant de déchets avant l'injection dans la chambre de combustion mélangé avec le courant gazeux, une colonne de refroidissement (50) se situe au-dessous et se trouve en communication de fluide avec la chambre de combustion, la colonne comportant des moyens (51,52) pour maintenir un écoulement d'eau vers le bas sur la surface intérieure des parois de la colonne, et un séparateur gaz -liquide (54) est raccordé au fond de la colonne.

10. Appareil selon la revendication 9, dans lequel le brûleur à gaz foraminé (35) comporte une couche poreuse (39) de céramique et/ ou de fibres métalliques.

11. Appareil selon la revendication 9 ou la revendication 10, dans lequel le dessus de la chambre de combustion (31) comporte un plafond formé par la surface de sortie d'un brûleur à gaz foraminé (36).

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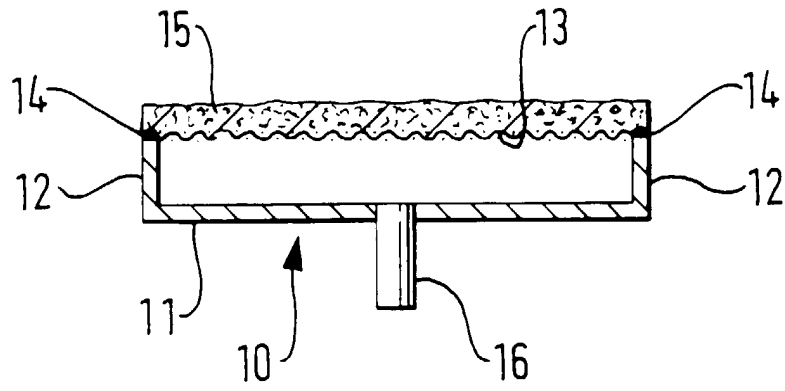


FIG. 1

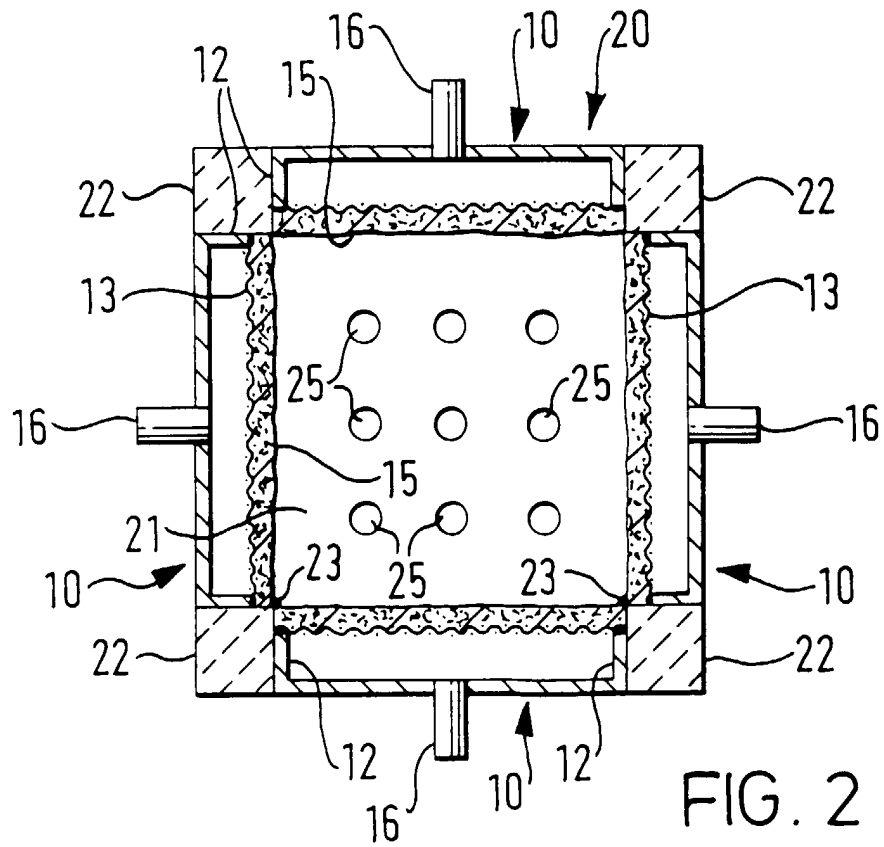


FIG. 2

