Burner Element

Field

The present invention provides a burner element for treating an effluent gas stream from a manufacturing process tool. The present invention also provides an abatement apparatus. The present invention also provides a method for treating an effluent gas stream from a manufacturing process tool.

Background

Radiant burners are known and are typically used for treating an effluent gas stream from a manufacturing processing tool used in, for example, the semiconductor or flat panel display manufacturing industry. During such manufacturing, residual compounds exist in the effluent gas stream pumped from the process tool.

Known radiant burners use combustion to remove the compounds from the effluent gas stream. A fuel gas is mixed with the effluent gas stream and that gas stream mixture is conveyed into a combustion chamber that is laterally surrounded by the exit surface of a burner. Fuel gas and air are simultaneously supplied to the burner to effect flameless combustion at the exit surface, with the amount of air passing through the foraminous burner liner being sufficient to consume not only the fuel gas supply to the burner, but also all the combustibles in the gas stream mixture injected into the combustion chamber.

Typically, the fuel gas may be a hydrocarbon fuel. There is, however, a desire to move away from the use of said hydrocarbon fuels. The present invention addresses at least in part these and other issues with the prior art.

Summary

In an aspect, the present invention provides a burner element for treating an effluent gas stream from a manufacturing process tool. The burner element comprises a porous sleeve at least partially defining a treatment chamber. The porous sleeve is configured to allow a first gaseous composition to pass through towards said treatment chamber. The burner element further comprises an

array of inlets arranged about the porous sleeve such that each inlet is embedded in said porous sleeve. Each inlet is configured to inject a second gaseous composition towards the treatment chamber.

The burner element may form part of an abatement apparatus. The abatement apparatus comprises a treatment chamber. Preferably, the treatment chamber is a combustion chamber. Said abatement apparatus may be, by way of example, an iAtlas as produced by Edwards Limited. The burner element may form part of the abatement apparatus which may be connected to a manufacturing process tool during use. Preferably, said manufacturing process tool may be a semiconductor or flat panel display manufacturing process tool.

The porous sleeve may be configured to disperse gases passing therethrough. Preferably, the porous sleeve may have a pore diameter of from about 200 μm to about 1200 μm. Preferably, the porous sleeve may be configured to disperse the first gaseous composition as it passes through said porous sleeve to enter the treatment chamber.

The porous sleeve may be optically opaque when viewed externally in any radially inward direction normal to the outermost surface of the porous sleeve. In other words, the porous sleeve may be configured such that there is no linear radially inward path from the outermost surface of the porous sleeve to the innermost surface of the porous sleeve that is not blocked (i.e. intersected) by a portion of the porous sleeve. The porous sleeve may comprise a material having a thermal conductivity of from about 0.1 W/mK to about 10 W/mK.

The porous sleeve at least partially defines the treatment chamber. The treatment chamber may be the portion of the burner in which the abatement of effluent gas stream occurs. In other words, the porous sleeve provides at least a portion of the surface defining the treatment chamber.

In some cases, the porous sleeve may define substantially the entirety of the treatment chamber. Preferably, the innermost surface of the porous sleeve may at least partially define the treatment chamber. Said innermost surface may be the surface closest to a central axis of the treatment chamber. As an

example, the treatment chamber may be substantially cylindrical or frustoconical. In such cases, the porous sleeve may provide a portion or the entirety of the curved sidewalls defining the treatment chamber.

The treatment chamber may further comprise an effluent gas stream inlet configured to convey the effluent gas stream into the treatment chamber. The treatment chamber may further comprise an outlet configured to convey the treated gas stream out of the treatment chamber. Preferably the effluent gas stream inlet and the outlet may be arranged at opposite ends of the treatment chamber. Preferably, the effluent gas stream may not pass through the porous sleeve during treatment.

The array of inlets may comprise from about 2 inlets to about 1000 inlets. Preferably, the array of inlets may comprise from about 100 to about 900 inlets. For example, the array of inlets may comprise 810 inlets. It will be appreciated that the number of inlets may depend on, for example, the dimensions of the burner, the spacing of the inlets, and the compositions of the first and second gaseous compositions. The array of inlets may be provided such that, when in use, a combustion front is provided at or immediately adjacent substantially the entirety of the surface of the porous sleeve defining the treatment chamber.

Each inlet is embedded in the porous sleeve. In other words, the position at which the second gaseous composition exits the inlet is embedded within the porous sleeve. In other words, the position at which the second gaseous composition exits the inlet may be arranged between the innermost and the outermost surfaces of the porous sleeve. Preferably, said innermost and outermost surfaces may refer to their radial position relative to a central axis of the porous sleeve. During use, the second gaseous composition may be separated from the first gaseous composition until it has exited the inlet, at which point the first and second gaseous compositions may mix. Accordingly, by embedding the inlet(s) in the porous sleeve, the position at which the first gaseous composition and second gaseous composition mix can be relatively close to the combustion front in comparison to burner elements of the prior art.

During use, the first gaseous composition may be conveyed through the porous sleeve towards the treatment chamber. The second gaseous composition may be conveyed through the inlets towards the treatment chamber. The first gaseous composition and the second gaseous composition may mix in the regions surrounding the inlets towards the treatment chamber to form a flammable fuel gas mixture (i.e. gaseous mixture). Upon ignition, a combustion front may be formed. The position of the combustion front may be an equilibrium between the burning velocity of the gaseous mixture and the forward gas velocity towards the treatment chamber of the gases (i.e. the gaseous mixture, first gaseous composition, and second gaseous composition).

In burners of the prior art, a premixed fuel, typically comprising a hydrocarbon, is ignited to provide the combustion front within the treatment chamber. The premixed fuel (i.e. fuel and oxidant) is mixed prior to introduction to the burner. Such systems operate well with hydrocarbon fuels, as they provide a stable combustion front that anchors to the internal surface of the burner sleeve. Additionally, the combustion of hydrocarbon fuels provides appropriate temperatures for the treatment of the effluent gas stream. However, for environmental reasons there is a desire to eliminate the use of hydrocarbon fuels in burner elements.

Providing a fuel gas mixture having an appropriate burning velocity is critical in enabling the formation of a stable combustion front. The burning velocity of a gas may be defined as the speed at which the flame front propagates relative to the unburnt fuel. If the burning velocity is too high, this can result in flame flashback and an unstable combustion front. The burning velocity of a fuel gas mixture can be reduced by using a relatively fuel-lean mixture, i.e. by decreasing the proportion of fuel relative to oxidant in the fuel gas mixture. However, if the mixture is too fuel-lean, then the combustion may not provide high enough temperatures for use in a burner element for treatment of an effluent gas stream. Therefore, a balance must be struck between controlling the burning velocity and the temperature of the combustion.

The present invention provides a burner element wherein the first gaseous composition and the second gaseous composition are prevented from mixing until the second gaseous composition has exited the array of inlets. Therefore, the mixing to provide the fuel gas mixture may occur closer to the combustion front than in burner elements of the prior art. This may ensure that a combustible fuel gas mixture is only present at or near the desired location of the combustion front, reducing the likelihood of flame flashback. Additionally, the flow rate of the first gaseous composition and that of the second gaseous composition may differ. This may enable improved control over their mixing, and thereby over the position of the combustion front.

Advantageously, the burner element of the present invention may allow the use of first and/or second gaseous compositions that combine to provide a fuel gas mixture that would have a burning velocity that is higher than would be suitable for use in burner elements of the prior art. Without wishing to be bound by theory, as the mixing of the first and second gaseous compositions occurs within the porous sleeve of the burner element of the present invention, this allows for greater control over the position combustion front.

If such a fuel gas mixture were used in a burner element of the prior art (i.e. wherein the fuel gas mixture is premixed prior to entering the burner element), then flame flashback would most likely occur as the burning velocity is too high to provide a stable combustion front.

For the avoidance of doubt, the first gaseous composition and the second gaseous composition may have different compositions. Preferably, the first or second gaseous composition may comprise a fuel, and the other may comprise an oxidant. In some embodiments, the first and/or the second gaseous compositions may not be able to provide a stable combustion front alone. Examples of the first and second gaseous compositions may be as set out elsewhere herein.

Typically, each inlet may be embedded by a depth of from about 10% to about 90% through the thickness of the porous sleeve in a radial direction. Preferably, said radial direction may be a radially inward direction. The radial direction may

be towards a central axis of the treatment chamber. By way of illustrative example, if the porous sleeve has a thickness in a radial direction of 10 mm (i.e. distance between the outermost surface and innermost surface), each inlet may be embedded by a depth of from about 1 mm to about 9 mm from the outermost surface. It will be appreciated that the outermost surface may be defined by the region of the outermost surface immediately adjacent to the inlet, rather than the concave region in which the inlet is embedded.

Preferably each inlet may be embedded by a depth of from about 20% to about 80% through the thickness of the porous sleeve in a radial direction. For example, each inlet may be embedded by a depth of from about 33%, about 50% or about 66% through the thickness of the porous sleeve in a radial direction. Preferably, each inlet may be embedded by substantially the same depth. Substantially the same depth may be within ±20% through the thickness of the porous sleeve in a radial direction, preferably within ±10%, more preferably within ±5%.

Typically, the porous sleeve may have a substantially uniform thickness in a radial direction. In some embodiments, the porous sleeve may have a thickness of from about 1 mm to about 10 mm, preferably from about 2 mm to about 6 mm. Preferably, the porosity of the porous sleeve may be substantially uniform throughout. Advantageously, this may aid in evenly dispersing the first gaseous composition as it passes through the porous sleeve.

In some embodiments, the porous sleeve may be generally tubular.

Typically, the porous sleeve may have an axial length of from about 50 mm to about 500 mm, more preferably from about 60 mm to about 200 mm, about 75 mm and about 150 mm being examples. The inside diameter of the porous sleeve may be from about 50 mm to about 250 mm, preferably from about 100 mm to about 200 mm, about 150 mm and about 175 mm being examples.

Typically, the array of inlets may be regularly arranged about the exterior of the porous sleeve. Preferably, the inlets may be arranged in a substantially evenly spaced array. In other words, the distance between each inlet and each of its

nearest neighbouring inlets may be substantially the same. Preferably, the distance between each inlet and each of its nearest neighbouring inlets may be from about 5 mm to about 10 mm. The inlets of the array may be arranged in substantially regularly spaced rows and/or columns. Advantageously, the arrangement of the array of inlets may improve the uniformity of the combustion front during use.

The array of inlets may be, for example, a triangular array, a square array, or a hexagonal array. Preferably, the array may be a square array. It will be understood that the array may be mapped to the shape of a portion of the outer surface of the porous sleeve. In embodiments wherein the array is a square array, the inlets may be arranged in circumferentially extending rows, and longitudinally extending columns. The distance between each inlet and its nearest neighbouring inlets within a row may be from about 5 mm to about 10 mm. The distance between each inlet and its nearest neighbouring inlets within a column may be from about 5 mm to about 10 mm. Preferably, said circumferential separation and said longitudinal separation may substantially match. By way of example, the array of inlets may comprise 54 columns of inlets and 15 rows of inlets. Said array of inlets may be a square array comprising 810 inlets.

Typically, the burner element may further comprise a perforated wall surrounding the porous sleeve. The perforated wall may be configured to allow the first gaseous composition to pass therethrough towards the treatment chamber. In some embodiments, the porous sleeve may be connected to the perforated wall. Preferably, the perforated wall may comprise a plurality of apertures (i.e. perforations) that are configured to enable the first gaseous composition to pass therethrough.

The perforated wall may be arranged radially outwardly of the porous sleeve. The perforated wall may be metallic. In embodiments, the apertures may be arranged in the gaps between the inlets. The apertures may be arranged in an array that substantially matches the spacing of the array of inlets. The apertures may be substantially evenly distributed on the perforated wall. It will be

appreciated that the size and/or distribution of the apertures may depend on the preferred flow distribution of the first gaseous composition.

The perforated wall may be substantially surrounded by an outer wall. The perforated wall and the outer wall may be separated by a plenum (i.e. a gap). In use, the first gaseous composition may flow from the plenum, through the perforated wall, and through the porous sleeve towards the treatment chamber. In some embodiments, the ratio of the number of inlets in the array to the number of apertures in the outer wall may be from about 1:2 to about 2:1. Preferably, the number of inlets in the array may be within ±10% of the number of apertures in the perforated wall. In some embodiments, the number of inlets in the array may be equal to the number of apertures in the perforated wall.

Typically, the array of inlets may be connected to a manifold configured to divide a flow of the second gaseous composition between the inlets. Preferably, the manifold may be configured to divide said flow of the second gaseous composition substantially evenly between the inlets. The flow may be characterised as a volumetric flow. In embodiments, the entire array of inlets may be connected to a single manifold. Alternatively, a plurality of manifolds may be present and sub-groups of inlets may be connected to each manifold. Advantageously, substantially evenly dividing the flow of the second gaseous composition between the inlets may provide more even mixing with the first gaseous composition upon exiting the inlets, and therefore a more consistent and stable combustion front.

Preferably, the manifold comprises a plurality of hollow staves. Each hollow stave is connected to a sub-group of the array of inlets. In embodiments, the hollow staves are substantially evenly spaced about the external surface of the porous sleeve. The hollow staves may be fluidly connected to each other. Each sub-group of the array of inlets may comprise from about 2 to about 50 inlets, preferably from about 10 to about 25 inlets, for example 15 inlets. The inlets of each sub-group may be substantially evenly spaced along the length of the stave.

The manifold may comprise from about 2 to about 200 hollow staves, preferably from about 30 to about 100 hollow staves, for example 60 hollow staves. Each of the staves may be connected to a supply of the second gaseous composition.

In embodiments, the staves and the perforated wall may be a single, unitary component. In said embodiments, the staves and perforated wall may be a generally tubular structure. Each stave may be connected to the nearest neighbouring staves by a portion of said perforated wall.

Preferably, the porous sleeve may be connected to the perforated wall. The porous sleeve may be detachably connected to the perforated wall.

Typically, the volumetric flow rate of the first gaseous composition through each of the apertures of the perforated wall may be from about 50 cm^3min^{-1} to about 110 cm^3min^{-1}, preferably from about 70 cm^3min^{-1} to about 90 cm^3min^{-1}. For example, the volumetric flow rate of the first gaseous composition through each of the apertures of the perforated wall may be about 80 cm^3min^{-1}. Typically, volumetric flow rate of the second gaseous composition through each of the inlets of the array may be from about 10 cm^3min^{-1} to about 30 cm^3min^{-1}, preferably from about 15 cm^3min^{-1} to about 25 cm^3min^{-1}. For example, the volumetric flow rate of the second gaseous composition through each of the inlets of the array may be about 20 cm^3min^{-1}.

Advantageously, the present invention may allow the use of fuel gas mixtures (i.e. the first gaseous composition and the second gaseous composition) with higher burning velocities than would have been feasible for use in burner elements of the prior art. This may enable a departure from fuel gas mixtures comprising hydrocarbon fuels.

The first gaseous composition may comprise air. In some embodiments, the first gaseous composition may comprise air and hydrogen, wherein the hydrogen is present at less than about 10 %v/v, preferably less than about 5 %v/v. Preferably, the first gaseous composition may consist essentially of air.

The second gaseous composition may be selected from the list comprising hydrogen, carbon monoxide, hydrogen and carbon monoxide, or ammonia.

Preferably, the second gaseous composition may consist essentially of hydrogen.

In alternative embodiments, the first gaseous composition may be selected from the list comprising hydrogen, carbon monoxide, hydrogen and carbon monoxide, or ammonia. In such embodiments, the second gaseous composition may comprise air.

Preferably, the first gaseous composition and/or the second gaseous composition may not comprise a hydrocarbon fuel.

Typically, the internal surface of the porous sleeve may define a substantially frustoconical treatment chamber. Said treatment chamber may have a larger cross-sectional area proximal to the outlet and a smaller cross-sectional area proximal to the effluent gas stream inlet. The cross-sectional area of the treatment chamber may increase between the effluent gas stream inlet and the outlet. The rate of said increase may be substantially continuous (i.e. a continuous expansion). Preferably, the shape of said cross-sectional area may remain constant, for example, a circle.

Alternatively, the increase in cross-sectional area may be at a first rate for a first portion of the treatment chamber, than at a second rate for a second portion of the treatment chamber. In other words, the first portion of the treatment chamber may be cylindrical or a first frustoconical portion, and the second portion of the treatment chamber may be a second frustoconical portion. Advantageously, such an arrangement may exhibit reduced particle deposition in comparison to cylindrical treatment chambers.

Typically, the porous sleeve may comprise one of an optically opaque mesh, an un-sintered ceramic-metal fibre composite, or a sintered metal. In some embodiments, the porous sleeve may comprise a plurality of interconnected, concentrically arranged layers.

In a further aspect, the present invention provides an abatement apparatus comprising a burner element according to any preceding claim. The abatement

apparatus may comprise one or more further mechanisms configured to treat the effluent gas flow, arranged prior to and/or after the burner element.

In a further aspect, the present invention provides a method for treating an effluent gas stream from a manufacturing process tool. The method comprises the step of providing an abatement apparatus comprising the burner element according to any embodiment of an aspect described herein.

The method further comprises the step of flowing a first gaseous composition through the porous sleeve towards the treatment chamber, and a second gaseous composition through the array of inlets towards the treatment chamber. Preferably, the first gaseous composition may comprise air. In some embodiments, the first gaseous composition may comprise air and hydrogen, wherein the hydrogen is present at less than about 10 %v/v, preferably less than about 5 %v/v. Preferably, the first gaseous composition may consist essentially of air. Preferably, the volumetric flow rate of the first gaseous composition through each aperture of the perforated wall may be from about 50 cm^3min^{-1} to about 110 cm^3min^{-1}, preferably from about 70 cm^3min^{-1} to about 90 cm^3min^{-1}, for example 80 cm^3min^{-1}.

Preferably, the second gaseous composition may comprise hydrogen, carbon monoxide, hydrogen and carbon monoxide, or ammonia. Preferably, the second gaseous composition may consist essentially of hydrogen, carbon monoxide, hydrogen and carbon monoxide, or ammonia. Preferably, the volumetric flow rate of the second gaseous composition through each inlet may be from about 10 cm^3min^{-1} to about 30 cm^3min^{-1}, preferably from about 15 cm^3min^{-1} to about 25 cm^3min^{-1}, for example 20 cm^3min^{-1}. Preferably, the volumetric flow rate of the second gaseous composition through each inlet may be substantially the same.

The method further comprises the step of igniting the mixture of the first and second gaseous compositions to provide a combustion front. It will be appreciated that in the regions surrounding each inlet, the first and second gaseous compositions will mix to provide a combustible fuel gas mixture. Said mixing may be shear mixing. This may result in a compositional gradient around

each inlet between the flow of the first gaseous composition and the second gaseous composition. The combustion front may anchor within said compositional gradient between the first and second gaseous compositions at an equilibrium position where the shear mixing (i.e. fuel gas composition), burning velocity, and gas flow rate characteristics are balanced to support a combustion front.

As the burning velocity may be relatively high, this may produce a combustion front having peaks proximal to each inlet, and troughs arranged between the peaks. In other words, the combustion front may have an “egg-box” structure. In some instances, the fuel gas composition may support a substantially planar combustion front.

Typically, the face velocity of the first gaseous composition at the exit surface (i.e. the internal surface) of the porous sleeve may be from about 0.05 ms^{-1} to about 0.2 ms^{-1}, for example about 0.075 ms^{-1}. The face velocity of the second gaseous composition at each inlet may be from about 0.25 ms^{-1} to about 1 ms^{-1}, for example about 0.6 ms^{-1}.

Typically, the face velocity of the second gaseous composition exiting through each inlet may be from about 3 times to about 10 times greater than the face velocity of the first gaseous composition at the exit surface of the porous sleeve. Preferably, the face velocity of the second gaseous composition exiting through each inlet may be from about 4 times to about 8 times greater than the face velocity of the first gaseous composition at the exit surface of the porous sleeve.

Typically, the volumetric flow rate of the first gaseous composition through each of the apertures of the perforated wall may be from about 50 cm^3min^{-1} to about 110 cm^3min^{-1}, preferably from about 70 cm^3min^{-1} to about 90 cm^3min^{-1}. For example, the volumetric flow rate of the first gaseous composition through each of the apertures of the perforated wall may be about 80 cm^3min^{-1}. Typically, volumetric flow rate of the second gaseous composition through each of the inlets of the array may be from about 10 cm^3min^{-1} to about 30 cm^3min^{-1}, preferably from about 15 cm^3min^{-1} to about 25 cm^3min^{-1}. For example, the

volumetric flow rate of the second gaseous composition through each of the inlets of the array may be about 20 cm^3min^{-1}.

The method further comprises the step of flowing an effluent gas stream into the treatment chamber for treatment. The effluent gas stream may be the exhaust gases from a manufacturing process tool. Said manufacturing process tool may be a semiconductor or flat panel display manufacturing process tool. Preferably the effluent gas stream may be conveyed into the treatment chamber through an effluent gas inlet. Following treatment, the treated gas may be conveyed out of the treatment chamber through an outlet. The inlet may be arranged at a first end of the treatment chamber. The outlet may be arranged at a second end of the treatment chamber, opposite the first end.

For the avoidance of doubt, all aspects and embodiments described herein may be combined, *mutatis mutandis*.

Brief Description of Figures

Preferred embodiments of the present invention will now be described, with reference to the following figures, in which:

Figure 1 shows a cross-sectional view of a portion of a burner element of the prior art;

Figure 2 shows a cross-sectional view of a portion of a burner element in accordance with an embodiment of the present invention;

Figure 3 shows a cross-sectional view of a hollow stave as may be present in an embodiment of the present invention;

Figure 4 shows an example of a component of a burner element in accordance with an embodiment of the present invention;

Figure 5 shows a flow diagram of a method in accordance with an embodiment of the present invention.

Detailed Description

Figure 1 illustrates a cross-sectional view of a portion of a burner element of the prior art. A cross-section of a porous component (1) of the burner element is shown, when in use. A premixed gaseous fuel (G_p) comprising a hydrocarbon is provided. Said premixed gaseous fuel (G_p) flows from a first side of the burner element, through the porous component (1) to the treatment chamber (3). The premixed gaseous fuel (G_p) is ignited to provide a combustion front (2). The combustion front (2) is located within the treatment chamber (3). The combustion front (2) is anchored to the internal surface (4) of the porous component (1) that defines the treatment chamber (3).

The premixed gaseous fuel (G_p) has undergone mixing upstream of the burner element. In some cases, the premixed gaseous fuel (G_p) comprises a hydrocarbon and an oxidant. As a result of the burning velocity of the premixed gaseous fuel (G_p), it readily forms a stable combustion front (2) that anchors to the internal surface (4) of the porous component (1).

Figure 2 shows a cross-sectional view of a portion of a burner element (5) in accordance with an embodiment of the present invention. The burner element (5) comprises a porous sleeve (6) at least partially defining a treatment chamber (7).

The porous sleeve (6) is configured to allow a first gaseous composition (G_1) to pass through towards the treatment chamber (7). The porous sleeve (6) is configured to disperse gases passing therethrough. An internal surface (8) of the porous sleeve (6) at least partially defines the treatment chamber (7).

The burner element (5) further comprises an array of inlets (9) arranged such that each inlet is embedded in said porous sleeve. Further inlets of the array are arranged elsewhere about the porous sleeve, but are not visible in this figure as it is a cross-sectional view.

Each of the inlets (9) is embedded in the porous sleeve (6). The porous sleeve (6) has a thickness (L). The thickness (L) extends from the external surface (10) to the internal surface (8) of the porous sleeve (6). Each inlet (9) is embedded in the porous sleeve (6) by a distance (D). In this embodiment, each of the inlets

(9) is embedded in the porous sleeve by a substantially uniform distance (D). In this instance, the inlets (9) are embedded by from about 30% to about 50% of the distance through the thickness (L) of the porous sleeve (6) in an inward direction (i.e. towards the treatment chamber).

The inlets (9) viewed in figure 2 are arranged in a column. The inlets (9) are connected to a manifold. In this embodiment, the manifold is a hollow stave (11). Further features of the hollow stave (11) will be described in reference to figure 3. The hollow stave (11) is configured to divide a supply of second gaseous composition (G_2) between the inlets (9). Each inlet (9) is configured to inject said second gaseous composition (G_2) towards the treatment chamber (7).

For the avoidance of doubt, in this two-dimensional representation the dashed line portion of the first gaseous composition (G_1) may be representative of the first gaseous composition (G_1) passing around the hollow stave (11). In this embodiment the first gaseous composition (G_1) does not pass through the hollow stave. The second gaseous composition (G_2) is prevented from mixing with the first gaseous composition (G_1) until the second gaseous composition (G_2) has exited the inlets (9).

In this embodiment, the first gaseous composition (G_1) may comprise an oxidant, and the second gaseous composition (G_2) may comprise hydrogen. In the regions surrounding the inlets (9), the first gaseous composition (G_1) and the second gaseous composition (G_2) may mix via shear mixing as they are conveyed towards the treatment chamber (7). This may result in a compositional gradient around each inlet (9) between the flow of the first gaseous composition (G_1) and the second gaseous composition (G_2).

Upon entering the treatment chamber (7), the mixture of the first gaseous composition (G_1) and the second gaseous composition (G_2) is ignited and forms a combustion front (12). The combustion front (12) may be within said compositional gradient between the first (G_1) and second (G_2) gaseous compositions at an equilibrium position where the shear mixing (i.e. fuel gas composition), burning velocity, and gas flow rate characteristics are balanced

to support a combustion front (12). Accordingly, as shown in two-dimensions, this may result in a combustion front of peaks and troughs.

In some embodiments, the combustion front (12) may be at least partially located within the porous structure. For example, the “troughs” of the combustion front may be located within the porous structure, and the “peaks” of the combustion front may be located within the treatment chamber (7).

Figure 3 illustrates a cross-sectional view of a hollow stave (11) as may be present in an embodiment of the present invention. In this embodiment, the hollow stave (11) comprises fifteen inlets (9). The stave (11) is connected to a supply of the second gaseous composition (G_2). The stave (11) acts as a manifold to substantially evenly divide the supply of the second gaseous composition (G_2) between the inlets (9). Preferably, the stave (11) may be arranged such that during use there is a substantially equal volumetric flow rate of the second gaseous composition (G_2) through each inlet (9). Said volumetric flow rate of second gaseous composition through each inlet may be about 20 cm^3min^{-1}.

The stave (11) may be coupled to other staves. The stave (11) may comprise a conduit (13) through which the second gaseous composition (G_2) is supplied to the stave (11).

The second gaseous composition (G_2) may be hydrogen.

Figure 4 illustrates an example of a component (14) of a burner element in accordance with an embodiment of the present invention. (Does not include the matrix).

The component (14) comprises a plurality of hollow staves (11) as described elsewhere herein. Each hollow stave (11) is be connected to a supply of the second gaseous composition (G_2), for example hydrogen. The supply of the second gaseous composition (G_2) is provided to the hollow staves (11) via a conduit (13). The supply of said second gaseous composition (G_2) enters the conduit (13) through ports (15). Said ports (15) are arranged on the exterior of the component (14).

The hollow staves (11) may be arranged in parallel. The hollow staves (11) are arranged about the treatment chamber when in use. Each hollow stave (11) is connected to its nearest neighbouring hollow staves (11) by a perforated wall (16). As shown, the perforated wall (16) comprises a plurality of apertures (17). Each of the apertures (17) is configured to allow the first gaseous composition (G_1) to pass through the perforated wall (16) during use. The first gaseous composition may be air.

On the inside of the component (14), the array of inlets (9) can be seen. Additionally, the apertures (17) are arranged in an array spaced between the array of inlets (9). Each of the inlets (9) protrudes radially inwardly from the internal wall (18). The apertures (17), in contrast, do not protrude radially inwardly. For the avoidance of doubt, during use, a porous sleeve (not shown) is arranged within the internal wall (18) of the component (13), such that the inlets (9) are embedded therein.

Figure 5 shows a flow diagram of a method in accordance with an embodiment of the present invention.

The method comprises the step (19) of providing an abatement apparatus comprising the burner element according to any embodiment of an aspect described herein.

The method further comprises the step (20) of flowing a first gaseous composition through the porous sleeve towards the treatment chamber, and a second gaseous composition through the array of inlets towards the treatment chamber. Preferably, the first gaseous composition may comprise air. Preferably, the volumetric flow rate of the first gaseous composition through each aperture of the perforated wall is from about 50 cm^3min^{-1} to about 110 cm^3min^{-1}.

Preferably, the second gaseous composition may comprise hydrogen. Preferably, the volumetric flow rate of the second gaseous composition through each inlet may be from about 10 cm^3min^{-1} to about 30 cm^3min^{-1}, preferably from about 15 cm^3min^{-1} to about 25 cm^3min^{-1}. Preferably, the volumetric flow rate of

the second gaseous composition through each inlet may be substantially uniform.

The method further comprises the step (21) of igniting the mixture of the first and second gaseous compositions to provide a combustion front.

The method further comprises the step (22) of flowing an effluent gas stream into the treatment chamber for treatment. The effluent gas stream may be the exhaust gases from a manufacturing process tool. Said manufacturing process tool may be a semiconductor or flat panel display manufacturing process tool. Preferably the effluent gas stream may be conveyed into the treatment chamber through an effluent gas inlet. Following treatment, the treated gas may be conveyed out of the treatment chamber through an outlet. The inlet may be arranged at a first end of the treatment chamber. The outlet may be arranged at a second end of the treatment chamber, opposite the first end.

Reference Key

1. Porous component (prior art)
2. Combustion front (prior art)
3. Treatment chamber (prior art)
4. Internal surface of burner element (prior art)
5. Burner element
6. Porous sleeve
7. Treatment chamber
8. Internal surface
9. Inlets
10. External surface
11. Stave
12. Combustion front
13. Conduit
14. Component
15. Port
16. Perforated wall
17. Aperture
18. Internal wall
19. Method step
20. Method step
21. Method step
22. Method step

Claims

1. A burner element for treating an effluent gas stream from a manufacturing process tool, comprising:
a porous sleeve at least partially defining a treatment chamber, said porous sleeve being configured to allow a first gaseous composition to pass through towards said treatment chamber,
an array of inlets arranged about the porous sleeve such that each inlet is embedded in said porous sleeve, and wherein each inlet is configured to inject a second gaseous composition towards the treatment chamber.

2. The burner element of claim 1, wherein each inlet is embedded to a depth of from about 10% to about 90% of the thickness of the porous sleeve in a radial direction, preferably by from about 20% to about 80%, for example about 33%, about 50% or about 66%.

3. The burner element of claim 1 or claim 2, wherein the porous sleeve is generally tubular.

4. The burner element of claim 1 or 2, wherein the internal surface of the porous sleeve defines a substantially frusto-conical treatment chamber.

5. The burner element of any preceding claim, wherein the array of inlets are regularly arranged about the exterior of the porous sleeve, preferably wherein the inlets are in a substantially evenly spaced array.

6. The burner element of any preceding claim, further comprising a perforated wall surrounding the porous sleeve and configured to allow the first gaseous composition to pass therethrough towards the treatment chamber, preferably wherein the perforated wall comprises a plurality of apertures configured to enable the first gaseous composition to pass therethrough.

7. The burner element of any preceding claim, wherein the array of inlets are connected to a manifold configured to divide a flow of the second gaseous composition between the inlets, preferably to divide said flow substantially evenly between the inlets.

8. The burner element of claim 7, wherein the manifold comprises a plurality of hollow staves, each stave being connected to a sub-group of the array of inlets, preferably wherein the staves are arranged substantially evenly about the external surface of the porous sleeve.

9. The burner element of claim 8, wherein the staves and perforated wall are a single, unitary component.

10. The burner element of any of claims 6 to 9, wherein the porous sleeve is connected to the perforated wall.

11. The burner element of any preceding claim, wherein the porous sleeve comprises one of an optically opaque mesh, an un-sintered ceramic-metal fibre composite, or a sintered metal.

12. An abatement apparatus comprising a burner element according to any preceding claim.

13. A method for treating an effluent gas stream from a manufacturing process tool, comprising the steps of:
    a. providing an abatement apparatus comprising the burner element according to any of claims 1 to 11;
    b. flowing a first gaseous composition through the porous sleeve towards the treatment chamber, and a second gaseous composition through the array of inlets towards the treatment chamber;
    c. igniting the mixture of the first and second gas compositions to provide a combustion front;

d. flowing an effluent gas stream into the treatment chamber for treatment.

14. The method according to claim 13, wherein the face velocity of the second gaseous composition exiting through each inlet may be from about 3 times to about 10 times greater than the face velocity of the first gaseous composition at the exit surface of the porous sleeve.

15. The method according to claim 13 or 14 when dependent on claim 6, wherein the volumetric flow rate of the first gaseous composition through each aperture of the perforated wall is from about 50 cm^3min^{-1} to about 110 cm^3min^{-1}, and/or wherein the volumetric flow rate of the second gaseous composition through each inlet is from about 10 cm^3min^{-1} to about 30 cm^3min^{-1}.