

AN APPARATUS AND METHOD FOR CLEANING GLASS SUBSTRATES USING A COOL HYDROGEN FLAME

FIELD OF THE INVENTION

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The present invention relates in general to the surface cleaning of glass substrates for Flat Panel Displays. More particularly, the present invention relates to an apparatus and method for using a cool hydrogen flame for surface cleaning of glass substrates for manufacturing of Flat Panel

10 Displays

BACKGROUND OF THE INVENTION

15 Flat panel displays (FPDs) are well known devices commonly used in industrial and consumer devices. The most common FPDs are the Liquid Crystal Displays (LCDs) and the Plasma Display Panels (PDPs). The FPDs have relatively small footprints as compared to Cathode Ray Tube (CRT) displays. They consume less energy. The images produced are not
20 distorted at the edges. FPDs are currently used in almost every field of technology that requires a graphic display. They are fast replacing CRT monitors as the de facto output peripheral for personal computers. FPDs are also displacing the conventional CRT television sets.

25 One of the important elements of the FPDs is the glass substrates which are used to make the viewable screen of the displays. The quality requirements of such glass substrates are very high. They have to be of high clarity, high degree of flatness, uniform thickness and free from contaminants. These glass substrates are now manufactured in large
30 pieces measuring about 890 mm by 680 mm with a thickness of about 0.7 mm. They are later cut into smaller pieces for their various applications.

FPD manufacturers often rely on service providers to perform the cleaning task and to deliver the ready-to-use glass substrates according to their requirements to reduce their overhead costs. The typical standard of cleanliness that is required of glass substrates of the size 890 mm by 680 mm is approximately 15,000 particles of size 0.3 micron.

In a glass substrate cleaning plant, the manufactured glass substrates are delivered in packages of 10-12, held together by four slotted angles made from urethane foam in order to protect each glass substrate from another. The surface of these glass substrates at this stage is highly contaminated. The contaminants range from small general particulate matter like dust to other organic compounds and protein matter. Some of these organic compounds and protein matter can be attributed to human handling and can include natural oils from the skin or simply put "fingerprints".

The washing or cleaning of glass substrates in the manufacturing of FPDs is crucial. It ensures that the surfaces of the glass substrates are free from contaminants. This is necessary for the proper coating requirements according to the different types of FPDs. The importance of cleaning the glass substrates is basically to ensure the clarity of the images produced when the FPDs are finally assembled. Contaminants present on the surfaces of the glass substrates prevent proper coating and causes distortion.

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Some of the possible approaches or methods used in cleaning glass substrates are : high temperature de-ionized water, the Radiance Process®, High Power Ultrasonic cleaning and Plasma cleaning.

The currently most practiced method of cleaning glass substrates is to first wash them with high temperature de-ionized (DI) water, followed by vacuum drying. The glass substrates are then conveyed directly into a clean

room environment for packaging. This method though somewhat effective, consumes several million cubic meters of DI water for a typical production process. The use of vacuum drying also increases costs, as power requirements are also very high. Studies have indicated that a plant cleaning
5 5000 FPD parts a day would require about 1.44 cubic meters of DI water per FPD part. This washing method also becomes less effective when the particulate size approaches 0.3 microns.

The Radiance Process® makes use of a laser and a continuous
10 laminar flow of an inert gas to remove contaminants. The laser breaks the bonds holding the contaminants to the glass substrate and the inert gas carries the contaminants away. Recent demonstrations have shown that the total particulate counts were reduced dramatically. However, the Radiance Process® is highly dependent on maintaining the laminar flow of inert gases
15 over the glass substrate surface. The equipment to provide and carry out this Radiance Process® is presently not available at a low cost.

Another method used is High Power Ultrasonic cleaning. The technology itself is not new. Ultrasonic cleaning has already been used with
20 Printed Circuit Boards. It has been applied here in the cleaning of glass substrates as well. However, the method is far from perfect. During the ultrasonic cleaning process, cavitation of the cleaning fluid results in formation of small bubbles impacting onto the surface of the glass substrates. This sometimes causes micro-fractures on the glass surface
25 and renders the glass substrate unusable.

Plasma Cleaning technology is performed in high vacuum systems by exposing the parts to be cleaned to energized plasmas. Though effective, plasma systems require high sources of energy to energize the plasmas and
30 to provide the high vacuum environments. Invariably, such a system might be too expensive to use merely on account of cleaning the surfaces of a glass substrate.

OBJECTIVE OF THE PRESENT INVENTION

5 It is therefore an object of the present invention to provide a novel, effective and economical method of removing of contaminants from surfaces of glass substrates.

 It is also an object of the invention to provide an apparatus for doing the same.

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SUMMARY OF THE INVENTION

 Contaminants from surfaces of temperature sensitive substrates, such as glass substrates are removed by exposing the surfaces to a hydrogen Surface-mixed diffusion flame for a predetermined duration of time. The predetermined duration of time being insufficient to heat up the surfaces substantially thereby causing damage to the temperature sensitive substrates.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a top elevation plan view of the layout of the apparatus according to the present invention.

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Fig. 2 shows a right side cross-sectional view of the Hydrogen Flame Chamber according to section A-A pf Fig.1.

Fig. 3 shows a block diagram illustrating the steps of cleaning the glass substrates according to the present invention.

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the Hydrogen cleaning chamber 20 is a vacuum chamber operating at about 3 psi, there is no opportunity for the gases to accumulate even if they are not used up.

5 Referring to Fig.1 and Fig.3, the steps of the process of cleaning a glass substrate 30 starts with the mounting 110 of the glass substrate 30 onto a jig 14. The glass substrate 30 is then conveyed to a DI water tank 16. The glass substrate 30 is lowered or dipped 115 into the DI water tank for an initial washing. Any soluble contaminants and loose particulate matter would
10 be removed here. The glass substrate 30 is then raised and conveyed to the drying chamber 18 for drying 120. Compressed air or dry steam is used to blow or displace any moisture on the glass substrate 30. This also aids in removal of other particulate matter. The glass substrate is then conveyed to the Hydrogen Flame chamber 20 for the final surface cleaning of the glass
15 substrate using Hydrogen Flame 125. Referring to Fig.2, the Hydrogen Burner Hubs 35a,35b are situated at a level near the top of the glass substrate 30 as it enters the Hydrogen Flame Chamber 20. The Hydrogen Burner Hubs 35a,35b have already been ignited. The Surface-mixed Diffusion Flame 40a, 40b are just in contact with the surfaces near the top of
20 the glass substrate 30. The jig 14 is then raised vertically allowing the flames to come into contact with the rest of the glass substrate 30. In effect, the flames are being gently swept over the entire surfaces of the glass substrate 30. The flames are "swept" over the surfaces at a rate of about 20 mm per second. This results in any contaminants being vaporized from the
25 surfaces of the glass substrate. At this rate, such a system could very well clean a single glass substrate in less than a minute, close to 1500 units in a single 24 hour day.

30 In this present system, it is the glass substrate that is being moved, while the burners remain stationery. It is also entirely possible, to have the glass substrate remain stationery while the burners are being articulated or

even having both being articulated in a manner to ensure that the entire surfaces of the glass substrate are "swept".

5 The cleaned glass substrate 30 is then immediately conveyed into a clean-room packaging facility 22. The glass substrate 30 is then packaged 130 in an inert gas to protect it from contamination and increase its electrical stability. A process which is also known as passivation. The glass substrates are now ready for delivery to the FPD manufacturers.

10 Using hydrogen flames for the clean vaporization of contaminants is by no means a new technology. However, the product to be cleaned is a 890 mm by 680 mm glass substrate with a thickness of about 0.7 mm. A conventional pre-mixed hydrogen flame would simply be too hot. The glass substrate of such a large area would simply warp and lose its flatness and
15 clarity. If a pre-mixed flame was kept at a further distance, it would simply not vaporized the contaminants. Only the Surface-mixed Diffusion flame is "cool" enough to be exposed directly to the glass substrate and yet still be able to vaporize the contaminants.

20 Furthermore, the well known properties of hydrogen flames is its clean-burning effect which does not produce soot or carbon particles like most hydrocarbon flames. The absence of soot during combustion also significantly reduces the radiative heat release by hydrogen flames thus making it a "cool" flame. In addition, the hydroxyl radicals produced during
25 hydrogen combustion are extremely reactive and will effectively destroy and remove organic contaminants quickly.

This method of using a Surface-mixed Diffusion flame advantageously overcomes the shortcomings of the other methods of cleaning. It uses much
30 less water, less power consumption and does not require expensive equipment. This method does not induce additional mechanical stress on the glass substrate and does not compromise the quality requirements of

the FPD manufacturers. The gases required are easily available and do not constitute a high cost. Some of the more stubborn contaminants like "fingerprints" comprising of natural oils and organic matter are easily removed compared to when using hot DI water.

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The above description according to one example of the invention does not in any way limit the scope of the invention.

It would be apparent to one skilled in the art that the present invention may be modified or used in or with other types of temperature sensitive
10 substrates without departing from the scope of the invention.



CLAIMS

1. A method for removing contaminants from surfaces of temperature sensitive substrates, said method comprising the steps :
 - 5 producing a hydrogen Surface-mixed diffusion flame; and
 - exposing said hydrogen Surface-mixed diffusion flame to said surfaces for a predetermined duration of time;
 - said predetermined duration of time being insufficient to heat up said surfaces substantially thereby causing damage to said temperature sensitive
 - 10 substrates.
2. A method according to claim 1, wherein said method is performed in a vacuum environment.
- 15 3. A method according to claim 1, wherein said temperature sensitive substrate comprises one or more of the following : glass substrates and semiconductor silicon-based substrates.
4. A method according to claim 1, wherein said hydrogen Surface-mixed
- 20 diffusion flame is produced by burning pure hydrogen in pure oxygen without pre-mixing.
5. A method according to claim 4, wherein said pure oxygen is at least 100% more than said pure hydrogen.
- 25 6. A process for cleaning surfaces of a glass substrate, said process comprising the steps:
 - washing said glass substrate with de-ionized water;
 - drying said glass substrate;
 - 30 producing a hydrogen Surface-mixed diffusion fame; and
 - exposing said hydrogen Surface-mixed diffusion flame to said surfaces for a predetermined duration of time;



said predetermined duration of time being insufficient to heat up said glass substrate substantially thereby causing damage to said glass substrate.

5 7. A process according to claim 6, wherein said glass substrate is for the manufacturing of Flat Panel Displays.

8. A process according to claim 6, wherein said step of exposing said hydrogen Surface-mixed diffusion flame to said surfaces is carried out in a vacuum chamber.

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9. A process according to claim 6, wherein said hydrogen Surface-mixed diffusion flame is produced by burning pure hydrogen in pure oxygen without pre-mixing.

15 10. A process according to claim 6, wherein said pure oxygen is at least 100% more than said pure hydrogen.

11. A system for cleaning surfaces of a glass substrate for manufacturing Flat Panel Displays, said system comprising :

20 a jig for securely holding said glass substrate;
a conveying means for transporting said jig;
a washing unit using de-ionized water for cleaning said glass substrate;
a drying unit; and
a cleaning chamber using Hydrogen surface-mixed diffusion flame,

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12. A system according to claim 11 wherein said cleaning chamber is a vacuum chamber.

30 13. A system according to claim 11 wherein said system further comprises a clean room for passivating and packaging said glass substrate.



14. A system according to claim 11 wherein the pressure within said cleaning chamber is about 0.2 bar.

5 15. A system according to claim 11 wherein said cleaning chamber comprises of a plurality of burner nozzles for producing a plurality of hydrogen Surface-mixed diffusion flames.

16. A system according to claim 11 wherein said plurality of burner nozzles are capable of controlled movement in a predetermined fashion.

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17. A system according to claim 11 wherein said hydrogen Surface-mixed diffusion flame is produced by burning pure hydrogen in pure oxygen without pre-mixing.

15 18. A system according to claim 15 wherein said plurality of burner nozzles are of the tube in orifice design.

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