CLAIMS

1. An apparatus configured to pre-treat a substrate for epitaxial growth of a crystalline material thereon, comprising:

a chamber comprising an opening to receive the substrate for housing therein;

a gas inlet which directs a gaseous precursor into the chamber, wherein the gaseous precursor comprises oxygen; and

a light source externally coupled to the chamber, wherein the light source and the chamber are configured to have the light source project ultraviolet radiation into the chamber to ionize oxygen therein into ozone for passivating the substrate, wherein the ultraviolet radiation comprises a wavelength which is sufficient to ionize the oxygen into ozone, wherein the wavelength ranges from 200 nm to 280 nm.

2. The apparatus of claim 1, wherein the chamber comprises a door coupled to the opening, wherein the door is operably adjustable to close the opening after receiving the substrate and/or allow the substrate to be conveyed into the chamber through the opening.

3. The apparatus of claim 1 or 2, wherein the chamber comprises a movable arm therein to place the substrate received on a chuck in the chamber.

4. The apparatus of any one of claims 1 to 3, wherein the chamber comprises the gas inlet and a gas outlet, wherein the gas inlet is connected to an inlet pump to direct the gaseous precursor into the chamber and the gas outlet is connected to an outlet pump to deliver any gas out of the chamber.

5. The apparatus of claim 2, wherein the chamber comprises an exit opening coupled with an exit door for the substrate to be conveyed out of chamber, wherein the exit door is operably adjustable to close the exit opening after the substrate is conveyed out of the chamber and/or allow the substrate to be conveyed out of the chamber through the exit opening.

6. The apparatus of claim 5, wherein the door and the exit door are operably adjustable to have the chamber configured as a closed chamber for pre-treating the substrate.

7. The apparatus of any one of claims 1 to 6, wherein the light source is arranged at a distance from where the substrate is housed in the chamber.

8. The apparatus of any one of claims 1 to 7, wherein the chamber has a transparent portion proximal to the light source, wherein the light source is arranged to project light downward onto where the substrate is housed in the chamber through the transparent portion.

9. The apparatus of any one of claims 1 to 8, wherein the light source is coupled to a surface defining a wall of the chamber, wherein the surface is transparent.

10. The apparatus of any one of claims 1 to 9, wherein the chamber is operable at atmospheric pressure for passivating the substrate.

11. The apparatus of any one of claims 1 to 10, wherein the crystalline material comprises a transition metal dichalcogenide.

12. The apparatus of claim 11, wherein the transition metal dichalcogenide comprises tungsten disulfide, tungsten diselenide, tungsten ditelluride, molybdenum disulfide, molybdenum diselenide, or molybdenum ditelluride.

13. The apparatus of any one of claims 1 to 12, wherein the substrate is a sapphire substrate.

14. A system operable to have epitaxial growth of a crystalline material on a pre-treated substrate, comprising:

an apparatus of any one of claims 1 to 13 operable to provide a pre-treated substrate; and

a growth chamber arranged downstream of the apparatus to receive the pre-treated substrate directly from the apparatus, wherein the growth chamber is operable for epitaxial growth of a crystalline material on the pre-treated substrate.

15. The system of claim 14, wherein the pre-treated substrate is a sapphire substrate.

16. The system of claim 14 or 15, wherein the apparatus comprises a chamber with an exit opening for the pre-treated substrate to be conveyed out therefrom and the growth chamber comprises an entrance opening to receive the pre-treated substrate, wherein the exit opening and the entrance opening are connected with a closed channel in which the pre-treated substrate is conveyed through.

17. The system of any one of claims 14 to 16, wherein the growth chamber comprises a chemical vapor deposition chamber, metal-organic chemical vapor deposition chamber, or an atomic layer deposition chamber.