CLAIMS

What is claimed is:

1. A deposition chamber, comprising:

a reaction volume, wherein:

the reaction volume is in fluidic communication with a source of a process gas comprising hexafluoropropylene oxide vapor and a source of vacuum;

the reaction volume is configured to allow one-dimensional flow of the process gas therethrough;

the reaction volume is capable of being evacuated of air by the source of vacuum;

the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto;

the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the reaction volume is enclosed by a plurality of walls and a base;

at least one of the walls and the base is movable and/or comprises a movable portion; and

the size of the reaction volume is capable of being changed by moving one or more of the moveable walls, the moveable base, and/or one or more movable portions of one or more walls and/or the base.

2. A method, comprising:

moving at least a portion of a wall and/or a base enclosing a reaction volume, wherein:

the reaction volume is positioned in a deposition chamber;

the reaction volume is in fluidic communication with a source of a process gas comprising hexafluoropropylene oxide vapor and a source of vacuum;

the reaction volume is configured to allow one-dimensional flow of the process gas therethrough;

the reaction volume is capable of being evacuated of air by the source of vacuum;

the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto;

the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the reaction volume is enclosed by a plurality of walls and a base; and

moving the portion and/or the entirety of the wall and/or the base of the deposition chamber changes a size of the reaction volume.

3. A deposition chamber, comprising:

a reaction volume, wherein:

the reaction volume is in fluidic communication with a source of a process gas comprising hexafluoropropylene oxide vapor and a source of vacuum;

the reaction volume is configured to allow one-dimensional flow of the process gas therethrough;

the reaction volume is capable of being evacuated of air by the source of vacuum;

the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto;

the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the reaction volume is enclosed by a plurality of walls and a base; and

at least a portion of the base is rotatable.

4. A method, comprising:

rotating at least a portion of a base that, together with a plurality of walls, encloses a reaction volume, wherein:

the reaction volume is positioned in a deposition chamber;

the reaction volume is in fluidic communication with a source of a process gas comprising hexafluoropropylene oxide vapor and a source of vacuum;

the reaction volume is configured to allow one-dimensional flow of the process gas therethrough;

~~the reaction volume is capable of being evacuated of air by the source of vacuum;~~

~~the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto; and~~

~~the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose.~~

~~5.~~1. A method, comprising:

applying a voltage and a tensile force to a filament taking the form of a wire~~,~~ made of a material, wherein:

the wire is positioned in a reaction volume comprising at most 10 mTorr of air and comprising hexafluoropropylene oxide vapor;

the reaction volume is positioned in a deposition chamber;

the voltage causes the wire to increase in temperature;

the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose; ~~and~~

wherein the reaction volume has a total pressure of less than or equal to 100 Torr and greater than or equal to 1 mTorr;

wherein the temperature of the wire is greater than or equal to 150 °C and less than or equal to 1500 °C; and

wherein a ratio of the applied tensile force to a rated tensile strength of the material forming the wire is greater than or equal to 0.6 and less than or equal to 0.8 at ~~a~~the temperature of the ~~filament~~wire.

~~6. A system, comprising:~~

~~a deposition chamber comprising a reaction volume; and~~

~~a filament positioned at least partially inside the reaction volume, wherein:~~

~~the reaction volume is capable of comprising hexafluoropropylene oxide vapor and being evacuated of air by a source of vacuum;~~

~~the filament takes the form of a wire configured to increase in temperature upon the application of a voltage thereto;~~

the filament is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the filament is capable of being stably positioned at a first location;

the filament is capable of being stably positioned at a second location;

the second location is different from the first location; and

the filament is incapable of being stably positioned at a third location positioned between the first location and the second location.

7. A method, comprising:

passing a current through a filament taking the form of a wire to resistively heat the wire;

sensing a resistance of the wire; and

if the resistance of the wire is greater than or equal to 101% or less than or equal to 99% of a set point, adjusting a voltage applied to the wire, wherein:

the wire is positioned at least partially inside a reaction volume;

the reaction volume is positioned in a deposition chamber;

the reaction volume comprises at most 10 mTorr of air and comprises hexafluoropropylene oxide vapor; and

the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose.

8.2. AThe method of claim 1, further comprising:

sensing a resistance of a wire; and

if the resistance of the wire is greater than or equal to 101% or less than or equal to 99% of a set point, providing a warning, wherein:and

the wire is positioned at least partially inside a reaction volume;

the reaction volume is positioned in a deposition chamber;

the reaction volume comprises at most 10 mTorr of air and comprises hexafluoropropylene oxide vapor; and

~~the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose~~if the sensed resistance of the wire differs by greater than or equal to 0.1% of the set point or less than or equal to 5% of the set point,

adjusting the voltage applied to the wire in order to maintain the temperature of the wire within the temperature range of greater than or equal to 150 °C and less than or equal to 1500 °C; and optionally providing a warning, if the sensed resistance of the wire is greater than or equal to 101% or less than or equal to 99% of the set point.

3. The method of claim 1, wherein an amount of hexafluoropropylene oxide vapor in the reaction volume is greater than or equal to 1 mol % and less than or equal to 100 mol % of the gases present in the reaction volume;

optionally wherein the reaction volume further comprises one or more carrier gasses, optionally wherein the one or more carrier gasses are an inert gas; and

optionally wherein the one or more carrier gasses have a one-dimensional flow which occurs across at least the top 25% and no more than the top 95% of the reaction volume.

4. The method of claim 1, wherein the total pressure is greater than or equal to 1 mTorr and less than or equal to 10 Torr.

~~9. A system, comprising:~~

~~a deposition chamber comprising a reaction volume; and~~

~~a cooling element, wherein:~~

~~the reaction volume is capable of comprising hexafluoropropylene oxide vapor and being evacuated of air by a source of vacuum;~~

~~the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto;~~

~~the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;~~

~~a substrate is positioned in the reaction volume;~~

~~the cooling element is positioned around the substrate; and~~

the cooling element extends from a bottom of the substrate to the top of the substrate.

10. A system, comprising:

a deposition chamber comprising a reaction volume; and

a cooling element, wherein:

the reaction volume is capable of comprising hexafluoropropylene oxide vapor and being evacuated of air by a source of vacuum;

the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto;

the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;

a substrate is positioned in the reaction volume;

the cooling element is positioned around the substrate; and

the substrate is freely-movable with respect to the cooling element.

11. A method, comprising:

polymerizing hexafluoropropylene oxide to form a particle comprising poly(tetrafluoroethylene); and

depositing the particle comprising poly(tetrafluoroethylene) onto a surface, wherein:

the polymerization is performed in a reaction volume;

the reaction volume is positioned in a deposition chamber;

the reaction volume comprises at most 10 mTorr of air and comprises hexafluoropropylene oxide vapor;

the reaction volume comprises a filament taking the form of a resistively heated wire;

the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose; and

when the particle forms, it is surrounded by gas.

12. A method, comprising:

depositing a coating comprising poly(tetrafluoroethylene) on a substrate, wherein:

the substrate is positioned in a reaction volume;

the reaction volume is positioned in a deposition chamber;

the reaction volume comprises at most 10 mTorr of air and comprises hexafluoropropylene oxide vapor;

the reaction volume comprises a filament taking the form of a resistively heated wire;

the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the substrate outgasses one or more gases during the deposition of the coating; and

the one or more gases make up greater than or equal to 0.1 mol% and less than or equal to 10 mol% of the gases present in the reaction volume during the deposition of the coating.

13. A method, comprising:

removing contaminants from a surface of a substrate by immersing the substrate in a solvent; and

within 30 minutes after the contaminants are removed, depositing a coating comprising poly(tetrafluoroethylene) onto the surface of the substrate by chemical vapor deposition, wherein, during the deposition step:

the substrate is positioned in a reaction volume;

the reaction volume is positioned in a deposition chamber;

the reaction volume comprises at most 10 mTorr of air and comprises hexafluoropropylene oxide vapor;

the reaction volume comprises a filament taking the form of a resistively heated wire; and

the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose; and

wherein, after the deposition step, the coating has an adhesion to the substrate such that its adhesion score, as determined by the procedure described in ASTM D3359, is greater than or equal to 4.

14. The system, method, or deposition chamber of any preceding claim, wherein the portion of the base is configured to be rotated in one direction.

15. The system, method, or deposition chamber of any preceding claim, wherein the portion of the base is configured to be rotated continuously.

16. The system, method, or deposition chamber of any preceding claim, wherein a temperature of the wire is greater than or equal to 150 °C and less than or equal to 1500 °C.

17. The system, method, or deposition chamber of any preceding claim, wherein an amount of hexafluoropropylene oxide vapor in the reaction volume is greater than or equal to 1 mol% and less than or equal to 100 mol% of the gases present in the reaction volume.

18. The system, method, or deposition chamber of any preceding claim, wherein the reaction volume further comprises a carrier gas.

19. The system, method, or deposition chamber of any preceding claim, wherein a pressure of the reaction volume is greater than or equal to 1 mTorr and less than or equal to 100 Torr.

20. The system, method, or deposition chamber of any preceding claim, wherein a port is positioned between the source of the process gas and the reaction volume.

21. The system, method, or deposition chamber of any preceding claim, wherein the one-dimensional flow is parallel to the filament.

22. The system, method, or deposition chamber of any preceding claim, wherein the one-dimensional flow is perpendicular to the filament.

23. The system, method, or deposition chamber of any preceding claim, wherein the reaction volume comprises a plurality of filaments.

24. The system, method, or deposition chamber of any preceding claim, wherein the one-dimensional flow is present in at least the top 25% of the reaction volume and no more than the top 95% of the reaction volume.

25. The system, method, or deposition chamber of any preceding claim, wherein the base comprises two or more rotatable portions.

26. The system, method, or deposition chamber of any preceding claim, wherein the base is capable of rotating at a rate of greater than or equal to 0.1 rpm and less than or equal to 10 rpm.

27. The system, method, or deposition chamber of any preceding claim, wherein the base and/or one or more of the walls are removable.

28. The system, method, or deposition chamber of any preceding claim, wherein the base and/or one or more of the walls are capable of being cooled and/or heated.

29. The system, method, or deposition chamber of any preceding claim, wherein the base and the walls fluidically isolate the reaction volume from an environment external to the reaction volume.

30. The system, method, or deposition chamber of any preceding claim, wherein the coating is deposited prior to appreciable transport of contaminants from an interior of the substrate to a surface of the substrate.

31. The system, method, or deposition chamber of any preceding claim, wherein the carrier gas is an inert gas.

32.5. The system, method, or deposition chamber of any preceding claim of claim 1, wherein the reaction volume comprises a plurality of filaments taking the form of wires.;

33. The system, method, or deposition chamber of any preceding claim, wherein an average distance between the wires is greater than or equal to 0.1 inch and less than or equal to 2.5 inches; or.

34. The system, method, or deposition chamber of any preceding claim, wherein the average distance between the wires and the base of the reaction volume is greater than or equal to 0.1 inch and less than or equal to 24 inches; or.

35. The system, method, or deposition chamber of any preceding claim, wherein the average distance between the wires and the base of the reaction volume is greater than or equal to 0.25 inches and less than or equal to 5 inches.

6. The method of claim 3, wherein the voltage adjustment applied is made by a proportional-integral-derivative controller.

36. The system, method, or deposition chamber of any preceding claim, wherein the first and second stable locations are two stable locations within a plurality of stable locations.

37. The system, method, or deposition chamber of any preceding claim, wherein an average distance between the stable locations is greater than or equal to 0.1 mm and less than or equal to 100 mm.

~~38. The system, method, or deposition chamber of any preceding claim, wherein the average distance between the stable locations is greater than or equal to 2 mm and less than or equal to 10 mm.~~

~~39. The system, method, or deposition chamber of any preceding claim, further comprising turning off the filament if the resistance of the wire is greater than or equal to 101% or less than or equal to 99% of a set point.~~

~~40.~~7. The ~~system, method, or deposition chamber of any preceding claim~~of clam 1, wherein the ratio of the applied tensile force to the rated tensile strength of the material forming the wire is greater than or equal to 0.7 and less than or equal to 0.8 at a temperature of the filament.

8. A method for forming a coating on a substrate in a reaction volume, positioned in a deposition chamber; wherein:

the reaction volume is in fluidic communication with a source of a process gas comprising hexafluoropropylene oxide vapor and a source of vacuum;

the reaction volume is configured to allow one-dimensional flow of the process gas therethrough;

the reaction volume is capable of being evacuated of air by the source of vacuum;

the reaction volume comprises a filament taking the form of a wire configured to increase in temperature upon the application of a voltage thereto, wherein a temperature of the wire is selected to be greater than or equal to 150 °C and less than or equal to 1500 °C;

the wire is configured to heat the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the reaction volume is enclosed by a plurality of walls and a base; wherein the method comprises:

placing the substrate within the reaction volume;

moving a portion and/or the entirety of the plurality of the walls and/or the base enclosing the reaction volume to minimize the reaction volume size around the substrate; and

depositing a fluorinated polymer onto at least a portion of the substrate;

optionally rotating at least a portion of the base;

optionally wherein the reaction volume comprises a plurality of filaments which are optionally positioned at least partially inside the reaction volume; and

optionally wherein the one-dimensional flow is present in at least the top 25% of the reaction volume and no more than the top 95% of the reaction volume.

9. The method of claim 8, wherein the portion of the base is rotated in one direction or the portion of the base is rotated continuously; and

optionally rotating the base at a rate of greater than or equal to 0.1 rpm and less than or equal to 10 rpm.

10. The method of claim 8, wherein a port is positioned between the source of the process gas and the reaction volume.

11. The method of claim 8, wherein the one-dimensional flow is parallel to the filament or is perpendicular to the filament.

12. The method of claim 8, further comprising rotating two or more portions of the base, when the at least portion of the base is rotated.

13. The method of claim 8, further comprising removing the base and/or one or

more of the walls and/or further comprising cooling and/or heating the base and/or one or more of the walls.

14. The method of claim 8, wherein the base enclosing the reaction volume is a base of the deposition chamber.

15. A method, comprising:

depositing a coating comprising poly(tetrafluoroethylene) on a substrate, wherein:

the substrate is positioned in a reaction volume;

the reaction volume is positioned in a deposition chamber;

the reaction volume comprises at most 10 mTorr of air and comprises hexafluoropropylene oxide vapor;

the reaction volume comprises a filament taking the form of a resistively heated wire;

the wire heats the hexafluoropropylene oxide vapor, thereby causing it to decompose;

the substrate outgasses one or more gases during the deposition of the coating; and

the one or more gases make up greater than or equal to 0.1 mol% and less than or equal to 10 mol% of the gases present in the reaction volume during the deposition of the coating.

16. The method of claim 15, wherein a temperature of the wire is greater than or equal to 150° C and less than or equal to 1500° C.

17. The method of claim 15, wherein the reaction volume comprises a plurality of filaments taking the form of wires.

~~41. The system, method, or deposition chamber of any preceding claim, wherein greater than or equal to 90% of the polymerization reaction results in the production of particles surrounded by gas.~~

~~42.~~18. The ~~system, method, or deposition chamber of any preceding claim~~ of claim 15, wherein the substrate comprises an elastomer.

~~43. The system, method, or deposition chamber of any preceding claim, wherein the cooling element is cooled by the circulation of cooled fluid across and/or through the cooling element.~~

~~44. The system, method, or deposition chamber of any preceding claim, wherein the cooling element is positioned beneath the substrate.~~

~~45.~~19. The ~~system,~~ method~~, or deposition chamber of any preceding claim~~ of claim 15, wherein the poly(tetrafluoroethylene) is particulate, and wherein the particles ~~has~~have an average diameter of greater than or equal to 0.5 nm and less than or equal to 50 microns~~.~~; or

~~46. The system, method, or deposition chamber of any preceding claim,~~ wherein the particles ~~has~~have an average diameter of greater than or equal to 1 nm and less than or equal to 1 micron.

20. The method of claim 8 or claim 15, wherein the hexafluoropropylene oxide vapor is present in the reaction volume in an amount that is greater than or equal to 1 mol % and less than or equal to 100 mol % of the gases present in the reaction volume.

21. The method of claim 8 or claim 15, wherein the reaction volume further comprises a carrier gas.

22. The method of claim 8 or claim 15, wherein a pressure of the reaction volume is greater than or equal to 1 mTorr and less than or equal to 100 Torr.

~~47. The system, method, or deposition chamber of any preceding claim, wherein the gases outgassed by the substrate comprise water and/or air.~~

~~48. The system, method, or deposition chamber of any preceding claim, wherein the contaminants comprise small molecules, oligomers, low molecular weight polymers, processing aids, and/or chemicals compounded with the substrate.~~