CLAIMS

1. A method of forming a coated powder composition, comprising:

positioning a plurality of powder particles within a processing region of a processing chamber, wherein each of the powder particles comprises an organic material; and

coating the plurality of powder particles with a metal oxide coating to form a plurality of coated particles during a cyclic vapor coating process, wherein the metal oxide coating comprises aluminum oxide, zinc oxide, or aluminum zinc oxide, and wherein the cyclic vapor coating process comprises one or more deposition cycles, and each of the deposition cycles comprises:

introducing a pulse of a metal precursor into the processing region via a first mass flow control valve;

exposing the plurality of powder particles to the metal precursor;

infiltrating the plurality of powder particles with the metal precursor via spaces between the powder particles; then

introducing two or more pulses of a purge gas into the processing region via a second mass flow control valve;

exposing the plurality of powder particles to the purge gas during a first purge process; then

introducing two or more pulses of an oxidizing agent into the processing region via a third mass flow control valve;

exposing the plurality of powder particles to the oxidizing agent;

infiltrating the plurality of powder particles with the oxidizing agent via spaces between the powder particles to produce the metal oxide coating disposed on outer surfaces of each of the powder particles; then

introducing two or more pulses of the purge gas via the second mass flow control valve; and

exposing the plurality of powder particles to the purge gas during a second purge process.

2. The method of claim 1, wherein each of the pulses of the metal precursor is introduced into the processing region for about 30 seconds to about 60 seconds, each of the pulses of the oxidizing agent is introduced into the processing region for about 30

seconds to about 60 seconds, and each of the pulses of the purge gas is introduced into the processing region for about 30 seconds to about 60 seconds.

3. The method of claim 1, wherein each of the deposition cycles comprises introducing from 3 pulses of the metal precursor to about 100 pulses of the metal precursor into the processing region, wherein each of the deposition cycles comprises introducing from 3 pulses of the oxidizing agent to about 100 pulses of the oxidizing agent into the processing region, and wherein each of the deposition cycles comprises introducing from 3 pulses of the purge gas to about 100 pulses of the purge gas into the processing region for each of the first and second purge processes.

4. The method of claim 1, wherein the deposition cycle is repeated from 2 times to about 20 times.

5. The method of claim 1, wherein each of the metal precursor and the oxidizing agent is independently introduced into the processing region having a stagnate atmosphere at a pressure of less than 760 Torr, and wherein each of the first, second, and third mass flow control valves independently contains an orifice with a diameter having in a range from about 0.062 inches to about 0.113 inches.

6. The method of claim 1, wherein each of the first, second, and third mass flow control valves independently contains an orifice with a diameter having in a range from about 0.050 inches to about 0.150 inches.

7. The method of claim 1, wherein the plurality of powder particles are maintained at a temperature in a range from about 15°C to about 25°C during the cyclic vapor coating process.

8. The method of claim 1, wherein the metal oxide coating consists essential of aluminum oxide, zinc oxide, or aluminum zinc oxide.

9. The method of claim 1, wherein the metal precursor comprises trimethyl aluminum, dimethyl aluminum hydride, triethyl aluminum, diethyl aluminum hydride,

tripropyl aluminum, dipropyl aluminum hydride, tributyl aluminum, dibutyl aluminum hydride, isomers thereof, salts thereof, of any combination thereof.

10. The method of claim 1, wherein the metal precursor comprises dimethyl zinc, diethyl zinc, dipropyl zinc, dibutyl zinc, isomers thereof, salts thereof, of any combination thereof.

11. The method of claim 1, wherein the metal precursor is at a temperature of about -20°C to about 20°C and at a pressure of about 0.01 Torr to about 20 Torr when being introduced into the first mass flow control valve.

12. The method of claim 1, wherein the oxidizing agent comprises water, oxygen (O_2), hydrogen peroxide, inorganic peroxide, ozone, atomic oxygen, oxygen plasma, or any combination thereof, and wherein the purge gas comprises argon, helium, nitrogen (N_2), or any combination thereof.

13. The method of claim 1, wherein the organic material contained in the powder particles comprises one or more active pharmaceutical ingredients (APIs), one or more pharmaceutically acceptable excipients (PAEs), or any combination thereof.

14. The method of claim 1, wherein the plurality of powder particles has an average particle size of about 0.1 μm to about 1,000 μm, and wherein the metal oxide coating has a thickness of about 1 nm to about 100 nm.

15. A method of forming a coated powder composition, comprising:

positioning a plurality of powder particles within a processing region of a processing chamber; and

coating the plurality of powder particles with a metal oxide coating to form a plurality of coated particles during a cyclic vapor coating process, wherein the metal oxide coating comprises aluminum oxide, and wherein the cyclic vapor coating process comprises one or more deposition cycles, and each of the deposition cycles comprises:

introducing two or more pulses of a first metal precursor into the processing region via a first mass flow control valve;

exposing the plurality of powder particles to the first metal precursor;

infiltrating the plurality of powder particles with the first metal precursor via spaces between the powder particles; then

introducing two or more pulses of a purge gas into the processing region via a second mass flow control valve;

exposing the plurality of powder particles to the purge gas during a first purge process; then

introducing two or more pulses of an oxidizing agent into the processing region via a third mass flow control valve;

exposing the plurality of powder particles to the oxidizing agent;

infiltrating the plurality of powder particles with the oxidizing agent via spaces between the powder particles to produce a first metal oxide layer disposed on outer surfaces of each of the powder particles; then

introducing two or more pulses of the purge gas via the second mass flow control valve;

exposing the plurality of powder particles to the purge gas during a second purge process;

introducing two or more pulses of a second metal precursor into the processing region via a fourth mass flow control valve;

exposing the plurality of powder particles to the second metal precursor;

infiltrating the plurality of powder particles with the second metal precursor via spaces between the powder particles; then

introducing two or more pulses of the purge gas into the processing region via the second mass flow control valve;

exposing the plurality of powder particles to the purge gas during a third purge process; then

introducing two or more pulses of the oxidizing agent into the processing region via the third mass flow control valve;

exposing the plurality of powder particles to the oxidizing agent;

infiltrating the plurality of powder particles with the oxidizing agent via spaces between the powder particles to produce a second metal

oxide layer disposed on the first metal oxide layer disposed on the outer surfaces of each of the powder particles; then

introducing two or more pulses of the purge gas via the second mass flow control valve; and

exposing the plurality of powder particles to the purge gas during a fourth purge process;

wherein the first and second metal precursors are different from each other;

wherein the metal oxide coating comprises the first metal oxide layer and the second metal oxide layer; and

wherein the first metal oxide layer comprises aluminum oxide, then the second metal oxide layer comprises zinc oxide, or alternatively, the first metal oxide layer comprises zinc oxide, then the second metal oxide layer comprises aluminum oxide.

16. The method of claim 15, wherein the deposition cycle is repeated from 2 times to about 20 times.

17. The method of claim 16, wherein each of the first, second, third, and fourth mass flow control valves independently contains an orifice with a diameter having in a range from about 0.062 inches to about 0.113 inches.

18. The method of claim 15, wherein each of the powder particles comprises an organic material.

19. The method of claim 15, wherein each of the powder particles comprises an inorganic material.

20. A method of forming a coated powder composition, comprising:

positioning a plurality of powder particles within a processing region of a processing chamber, wherein each of the powder particles comprises an inorganic material; and

coating the plurality of powder particles with a metal oxide coating to form a plurality of coated particles during a cyclic vapor coating process, wherein the metal oxide

coating comprises aluminum oxide, zinc oxide, or aluminum zinc oxide, and wherein the cyclic vapor coating process comprises one or more deposition cycles, and each of the deposition cycles comprises:

introducing two or more pulses of a metal precursor into the processing region via a first mass flow control valve;

exposing the plurality of powder particles to the metal precursor;

infiltrating the plurality of powder particles with the metal precursor via spaces between the powder particles; then

introducing two or more pulses of a purge gas into the processing region via a second mass flow control valve;

exposing the plurality of powder particles to the purge gas during a first purge process; then

introducing two or more pulses of an oxidizing agent into the processing region via a third mass flow control valve;

exposing the plurality of powder particles to the oxidizing agent;

infiltrating the plurality of powder particles with the oxidizing agent via spaces between the powder particles to produce the metal oxide coating disposed on outer surfaces of each of the powder particles; then

introducing two or more pulses of the purge gas via the second mass flow control valve; and

exposing the plurality of powder particles to the purge gas during a second purge process.

21. The method of claim 20, wherein the inorganic material contained in the powder particles comprises aluminum oxide, titanium dioxide, iron oxide, gallium oxide, magnesium oxide, zinc oxide, niobium oxide, hafnium oxide, tantalum oxide, lanthanum oxide, zirconium dioxide, silicon oxide, silicates thereof, nitrides thereof, or any combination thereof.