Claims:

1. A method for processing a substrate within a processing chamber, comprising:

providing a precursor gas mixture into the processing chamber, wherein the precursor gas mixture comprises a deposition precursor gas and an etch precursor gas;

subjecting the precursor gas mixture to a thermal energy from a heat source to deposit a first material layer on a surface of the substrate, wherein the thermal energy is below the minimum required for pyrolysis of the etch precursor gas in the precursor gas mixture; and

after the first material layer is formed on the surface of the substrate, subjecting the precursor gas mixture to a photon energy from a radiation source, the photon energy having a wavelength and a power level selected to promote photolytic dissociation of the etch precursor gas over the deposition precursor gas and etch a portion of the first material layer from the surface of the substrate.

2. The method of claim 1, further comprising:

after the portion of the material layer is etched from the surface of the substrate, turning off the radiation source;

subjecting the precursor gas mixture to the thermal energy such that the deposition precursor gas is activated to deposit a second material layer on the surface of the substrate; and

after the second material layer is formed on the surface of the substrate, subjecting the precursor gas mixture to the photon energy such that the etch precursor gas is activated to etch a portion of the second material layer from the surface of the substrate.

3. The method of claim 2, wherein the photon energy has a wavelength that is sufficient to photolytically dissociate the etch precursor gas, or below the minimum required for photodissociation of the etch precursor gas

4. The method of claim 2, wherein the radiation source comprises a laser source, a bright light emitting diode (LED) source, or a thermal source.

5. The method of claim 4, wherein the laser source comprises a solid state laser, a fiber laser, an excimer laser, a carbon dioxide (CO_2) laser, or the like, and the laser source producing output in the ultraviolet (UV) wavelength range between about 10 nm and about 420 nm.

6. The method of claim 2, wherein the radiation source is configurable to deliver pulses of electromagnetic radiation having energy level between about 0.1 mJ/cm^2 and 1.0 J/cm^2 with duration between about 1 nsec and about 100 µsec.

7. A method for processing a substrate within a processing chamber, comprising:

flowing a deposition precursor gas and an etch precursor gas into the processing chamber;

maintaining the processing chamber at a temperature that is sufficient to thermally decompose substantially the deposition precursor gas, wherein the temperature of the processing chamber is below the minimum required for pyrolysis of the etch precursor gas;

directing a first electromagnetic radiation from a radiation source toward a surface of the substrate, the electromagnetic radiation having a first wavelength and a first power level selected to promote pyrolysic dissociation of the deposition precursor gas over the etch precursor gas to deposit a material layer on the surface of the substrate; and

directing a second electromagnetic radiation from the radiation source toward the surface of the substrate, the electromagnetic radiation having a second wavelength and a second power level selected to promote photolytic dissociation of the etch precursor gas over the deposition precursor gas.

8. The method of claim 7, wherein the radiation source comprises a laser source, a bright light emitting diode (LED) source, or a thermal source.

9. The method of claim 7, wherein the first wavelength and second wavelength are selected from a range between about 400 nm and about 1,000 nm or between about 190 nm and about 420 nm.

10. The method of claim 7, wherein the first electromagnetic radiation and second electromagnetic radiation are delivered in a plurality of pulses having energy level between about 0.1 mJ/cm^2 and 1.0 J/cm^2 with duration between about 1 nsec and about 100 μsec.

11. A substrate processing system, comprising:

a processing chamber having a substrate support for supporting a substrate;

a gas supply providing a precursor gas mixture from one or more gas sources into the processing chamber, wherein the precursor gas mixture comprises a deposition precursor gas and an etch precursor gas;

a heating module heating the substrate and maintaining the processing chamber at a temperature that is sufficient to thermally decompose substantially the deposition precursor gas to deposit a material layer on the surface of the substrate, wherein the temperature of the processing chamber is below the minimum required for pyrolysis of the etch precursor gas; and

a radiation source emitting an electromagnetic radiation to the precursor gas mixture at or near the surface of the substrate, the electromagnetic radiation having a wavelength and a power level selected to promote photolytic dissociation of the etch precursor gas over the deposition precursor gas and etch a portion of the material layer from the surface of the substrate.

12. The substrate processing system of claim 11, wherein the electromagnetic radiation has a wavelength that is sufficient to photolytically dissociate the etch precursor gas, or below the minimum required for photodissociation of the etch precursor gas.

13. The substrate processing system of claim 11, wherein the radiation source comprises a laser source, a bright light emitting diode (LED) source, or a thermal source.

14. The substrate processing system of claim 13, wherein the laser source comprises a solid state laser, a fiber laser, an excimer laser, a carbon dioxide (CO_2) laser, or the like, and the laser source producing output in the ultraviolet (UV) wavelength range between about 10 nm and about 420 nm.

15. The substrate processing system of claim 11, wherein the electromagnetic radiation is delivered in a plurality of pulses having energy level between about 0.1 mJ/cm^2 and 1.0 J/cm^2 with duration between about 1 nsec and about 100 μsec.

Claims

1. A method for processing a substrate within a processing chamber, comprising:

providing a precursor gas mixture into the processing chamber, wherein the precursor gas mixture comprises a deposition precursor gas and an etch precursor gas;

subjecting the precursor gas mixture to a thermal energy from a heat source to deposit a first material layer on a surface of the substrate, wherein the thermal energy is below the minimum required for pyrolysis of the etch precursor gas in the precursor gas mixture; and

after the first material layer is formed on the surface of the substrate, subjecting the precursor gas mixture to a photon energy from a radiation source, the photon energy and the thermal energy together result in at least photolytic dissociation of the etch precursor gas occurring faster than decomposition of the deposition precursor gas to etch a portion of the first material layer from the surface of the substrate.

2. The method of claim 1, further comprising:

after the portion of the material layer is etched from the surface of the substrate, turning off the radiation source;

subjecting the precursor gas mixture to the thermal energy to deposit a second material layer on the surface of the substrate, wherein the thermal energy is below a minimum energy required for pyrolysis of the etch precursor gas in the precursor gas mixture; and

after the second material layer is formed on the surface of the substrate, switching on the radiation source and subjecting the precursor gas mixture to the thermal energy and the photon energy from the radiation source to result in at least photolytic dissociation of the etch precursor gas occurring faster than decomposition of the deposition precursor gas to etch a portion of the second material layer from the surface of the substrate.

3. The method of claim 2, wherein the photon energy has a wavelength that is sufficient to photolytically dissociate the etch precursor gas, or below the minimum required for photodissociation of the etch precursor gas

4. The method of claim 2, wherein the radiation source comprises a laser source, a bright light emitting diode (LED) source, or a thermal source.

5. The method of claim 4, wherein the laser source comprises a solid state laser, a fiber laser, an excimer laser, a carbon dioxide (CO_2) laser, or the like, and the laser source producing output in the ultraviolet (UV) wavelength range between about 10 nm and about 420 nm.

6. The method of claim 2, wherein the radiation source delivers pulses of electromagnetic radiation having energy level between about 0.1 mJ/cm^2 and 1.0 J/cm^2 with duration between about 1 nsec and about 100 μsec.

7. A method for processing a substrate within a processing chamber, comprising:

flowing a deposition precursor gas and an etch precursor gas into the processing chamber;

maintaining the processing chamber at a temperature that is sufficient to thermally decompose substantially the deposition precursor gas, wherein the temperature of the processing chamber is below a minimum temperature required for pyrolysis of the etch precursor gas;

directing a first electromagnetic radiation from a radiation source toward a surface of the substrate, the electromagnetic radiation having a first wavelength and a first power level selected to promote pyrolytic dissociation of the deposition precursor gas over the etch precursor gas to deposit a material layer on the surface of the substrate; and

directing a second electromagnetic radiation from the radiation source toward the surface of the substrate, the electromagnetic radiation having a second wavelength and a second power level selected to promote photolytic dissociation of the etch precursor

gas over the deposition precursor gas, wherein the second wavelength and the second power level are different from the first wavelength and the first power level.

8. The method of claim 7, wherein the radiation source comprises a laser source, a bright light emitting diode (LED) source, or a thermal source.

9. The method of claim 7, wherein the first wavelength and second wavelength are selected from a range between about 400 nm and about 1,000 nm or between about 190 nm and about 420 nm.

10. The method of claim 7, wherein the first electromagnetic radiation and second electromagnetic radiation are delivered in a plurality of pulses having energy level between about 0.1 mJ/cm^2 and 1.0 J/cm^2 with duration between about 1 nsec and about 100 μsec.

11. A substrate processing system, comprising:

a processing chamber having a substrate support for supporting a substrate;

a gas supply providing a precursor gas mixture from one or more gas sources into the processing chamber, wherein the precursor gas mixture comprises a deposition precursor gas and an etch precursor gas;

a thermal heating module for coupling thermal energy to the precursor gas mixture and maintaining the processing chamber at a temperature that is sufficient to thermally decompose substantially the deposition precursor gas to deposit a material layer on the surface of the substrate, wherein the thermal energy is below the minimum energy required for pyrolysis of the etch precursor gas in the precursor gas mixture; and

a radiation source emitting ultraviolet (UV) radiation to the precursor gas mixture at or near the surface of the substrate, the UV radiation and the thermal energy together result in at least photolytic dissociation of the etch precursor gas occurring faster than decomposition of the deposition precursor gas to etch a portion of the material layer from the surface of the substrate.

12. The substrate processing system of claim 11, wherein the UV radiation has a wavelength that is sufficient to photolytically dissociate the etch precursor gas, or below the minimum required for photodissociation of the etch precursor gas.

13. The substrate processing system of claim 11, wherein the UV radiation has a wavelength range between about 10 nm and about 420 nm.

14. A method for processing a substrate within a processing chamber, comprising:

providing a precursor gas mixture into the processing chamber, wherein the precursor gas mixture comprises a deposition precursor gas and an etch precursor gas;

subjecting the precursor gas mixture to a thermal energy to deposit a first material layer on a surface of the substrate, wherein the thermal energy is below a minimum energy required for decomposition of the etch precursor gas in the precursor gas mixture;

after the first material layer is formed on the surface of the substrate, subjecting the precursor gas mixture to the thermal energy and a first photon energy from a radiation source to etch at least a portion of the first material layer from the surface of the substrate, wherein the first photon energy alone is below a minimum required for photolytic dissociation of the etch precursor gas, and combination of the first photon energy and the thermal energy results in at least photolytic dissociation of the etch precursor gas occurred faster than decomposition of the deposition precursor gas.

15. The method of claim 14, further comprising:

after at least the portion of the first material layer is etched from the surface of the substrate, turning off the radiation source;

subjecting the precursor gas mixture to the thermal energy to deposit a second material layer on the surface of the substrate, wherein the thermal energy is below the minimum energy required for pyrolysis of the etch precursor gas in the precursor gas mixture; and

after the second material layer is formed on the surface of the substrate, subjecting the precursor gas mixture to the thermal energy and a second photon energy

from the radiation source to etch at least a portion of the second material layer from the surface of the substrate, wherein the second photon energy alone is below the minimum required for photolytic dissociation of the etch precursor gas, and combination of the second photon energy and the thermal energy results in at least photolytic dissociation of the etch precursor gas occurred faster than decomposition of the deposition precursor gas.