CLAIMS

What is claimed is:

1. A system for monitoring radical particles which, when assembled, comprises:

a test chamber configured to be coupled to a flow channel adapted to transmit a gas, the test chamber defining an aperture connecting the test chamber and the flow channel, the aperture configured to permit a subset of the gas to enter the test chamber from the flow channel;

an ionizer positioned within the test chamber, the ionizer configured to generate radical ions from radical particles of the subset of the gas; and

a mass spectrometer configured to measure a quantity of the radical ions.

2. The system of claim 1, wherein the mass spectrometer is a residual gas analyzer (RGA).

3. The system of claim 1, wherein the test chamber is configured to maintain a gas pressure lower than a gas pressure at the flow channel.

4. The system of claim 3, wherein the gas pressure in the test chamber is less than 1e-2 Torr, and the gas pressure in the flow channel is greater than 0.01 Torr.

5. The system of claim 1, wherein the ionizer is positioned within 4 inches of the aperture.

6. The system of claim 1, wherein the ionizer is configured to operate at a low-energy state to generate the radical ions and minimize generation of non-radical ions, the low-energy state being lower than an energy state associated with the generation of the non-radical ions.

7. The system of claim 1, wherein the ionizer is configured to operate at a plurality of low-energy states, each of the plurality of low-energy states corresponding to a respective radical particle.

8. The system of claim 1, wherein the ionizer is configured to operate at a high-energy state to enable acquisition of a reference signal based on non-radical particles of the subset of the gas.

9. The system of claim 1, wherein the aperture has a diameter of less than 1 millimeter.

10. The system of claim 1, wherein the aperture permits passage, to the test chamber, a ratio of radical particles to non-radical particles that is greater than 0.1% of the ratio present in the gas within the flow channel.

11. The system of claim 1, further comprising a protrusion of the test chamber extending into the flow channel and encompassing a volume of the test chamber, the aperture being positioned at the protrusion.

12. The system of claim 11, wherein the protrusion exhibits a substantially conical shape, the aperture being positioned at a point of the conical shape.

13. The system of claim 12, wherein the ionizer is positioned to generate radical ions within a volume defined by the conical shape.

14. The system of claim 13, wherein the conical shape is configured as an electrostatic element of the ionizer.

15. The system of claim 13, further comprising an electrostatic lens configured to direct the radical ions as a beam towards the mass spectrometer.

16. The system of claim 1, further comprising a controller configured to control operation of a radical particle source based on the quantity of the radical ions measured by the mass spectrometer.

17. The system of claim 16, wherein controlling the operation of the radical particle source includes controlling at least one of 1) quantity of radical particle generation over a given time and 2) a time period in which the radical particles are generated.

18. The system of claim 16, wherein controlling the operation of the radical particle source includes controlling at least one of power, gas flow, gas pressure, and temperature of a wetted path of the flow channel.

19. The system of claim 1, further comprising a stopper configured to selectively seal the aperture.

20. The system of claim 1, wherein a surface encompassing the aperture is non-metal and exhibits a reactivity and recombination coefficient for the radical particles that is lower than that of a metal surface.

21. The system of claim 1, wherein a surface encompassing the aperture is metallic and exhibits low reactivity with the radical particles.

22. The system of claim 1, wherein the flow channel is a conduit extending from a radical source to a process chamber.

23. The system of claim 1, wherein the flow channel is a region down-stream of a reaction zone in a process chamber.

24. The system of claim 1, wherein the flow channel is a conduit down-stream of a process chamber.