WHAT IS CLAIMED IS:

1. An ionizing radiation detection system comprising:
    a self-quenching sensing element having a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:
        an ionizing gas to ionize in response to receiving a particle of ionizing radiation;
        a halogen quenching gas; and
        an oxygen-containing gas in an amount of at least approximately 3 % by pressure of a total pressure of the plurality of gases, wherein the oxygen-containing gas includes air, substantially pure diatomic oxygen, or ozone.

2. An ionizing radiation detection system comprising:
    a plurality of self-quenching Geiger-Mueller sensing elements, each sensing element having a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:
        an inert ionizing gas to ionize in response to receiving a particle of ionizing radiation;
        a halogen quenching gas; and
        an oxygen-containing gas in an amount of at least approximately 3 % by pressure of a total pressure of the plurality of gases, wherein the oxygen-containing gas includes air, substantially pure diatomic oxygen, or ozone,
    wherein the plurality of Geiger-Mueller sensing elements have a mean time before failure of at least approximately 95 hours at a temperature of approximately 100°C and a bias voltage of approximately 1050 V DC.

3. The ionizing radiation detection system of claim 2, wherein the Geiger-Mueller sensing elements have a mean time before failure of at least approximately 95 hours at a temperature of approximately 185°C and a bias voltage of approximately 1050 V DC.

4. A method of using an ionizing radiation detection system comprising:
    evacuating an enclosure for a Geiger-Mueller sensing element having an enclosure;

adding a plurality of gases to the enclosure, the plurality of gases including an ionizing gas, a halogen quenching gas and an oxygen-containing gas including air, substantially pure diatomic oxygen, or ozone, wherein the oxygen-containing gas is present in an amount of at least approximately 3 % by pressure of a total pressure of the ionizing gas, the quenching gas, and the oxygen-containing gas.

5. The method of claim 4, further comprising, before adding the ionizing gas and the quenching gas, substantially coating an inner surface of the enclosure with a cathode material.

6. The method of claim 4 or 5, further comprising, before adding the ionizing gas and the quenching gas, providing an anode within the enclosure, wherein the anode is electrically isolated from the inner surface.

7. The method of claim 4, 5, or 6, further comprising pre-mixing the ionizing gas and the quenching gas and adding the pre-mixed ionizing and quenching gases to the enclosure before adding the oxygen-containing gas to the enclosure.

8. The ionizing radiation detection system or method of any of the preceding claims, wherein any self-quenching sensing element or the Geiger-Mueller sensing element further comprises an anode including a material that oxidizes in the presence of the oxygen-containing gas.

9. The ionizing radiation detection system or method of any of the preceding claims, wherein:
the oxygen-containing gas including substantially pure diatomic oxygen, or ozone is present in an amount of at least approximately 5 % by pressure of a total pressure of the plurality of gases; or
the oxygen-containing gas includes air in an amount at least approximately 10 % by pressure of the total pressure of the plurality of gases.

10. An ionizing radiation detection system comprising:
a self-quenching sensing element having:

a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:

an ionizing gas to ionize in response to receiving a particle of ionizing radiation; and

a halogen quenching gas; and

an anode comprising a noble metal, nickel, or any combination thereof.

11. The ionizing radiation detection system of claim 10, wherein the plurality of gases is substantially free of an oxygen-containing gas.

12. The ionizing radiation detection system of claim 10 or 11, wherein the anode comprises platinum, palladium, gold, ruthenium, rhenium, iridium, osmium, a nickel alloy, such as a refractory metal-nickel alloy, such as a Ni-Ti alloy.

13. The ionizing radiation detection system of claim 10 or 11, wherein the anode comprises an iron-containing wire and a material surrounding the wire, wherein the material comprises the noble metal, nickel, or any combination thereof, or wherein the anode comprises a nickel-containing wire and a material surrounding the wire, wherein the material comprises the noble metal.

14. The ionizing radiation detection system or method of any of the preceding claims, wherein the ionizing gas includes a Penning mixture.

15. The ionizing radiation detection system or method of claim 14, wherein the ionizing gas includes a first noble gas and a second noble gas having a lower ionization potential than the first noble gas, wherein the second noble gas is present in an amount of at least approximately 0.1 % by pressure of the total pressure.

WHAT IS CLAIMED IS:

1. An ionizing radiation detection system comprising:

a self-quenching sensing element having a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:

an ionizing gas to ionize in response to receiving a particle of ionizing radiation;

a halogen quenching gas; and

an oxygen-containing gas in an amount of at least approximately 3 % by pressure of a total pressure of the plurality of gases, wherein the oxygen-containing gas includes substantially pure oxygen or ozone; or

an oxygen-containing gas including air in an amount of at least approximately 10% by pressure of a total pressure of the plurality of gases.

2. The ionizing radiation detection system of claim 1, comprising:

a plurality of the self-quenching sensing elements, each sensing element having a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:

an inert ionizing gas to ionize in response to receiving a particle of ionizing radiation;

a halogen quenching gas; and

an oxygen-containing gas in an amount of at least approximately 3 % by pressure of a total pressure of the plurality of gases, wherein the oxygen-containing gas includes substantially pure oxygen or ozone; or

an oxygen-containing gas including air in an amount of at least approximately 10 % by pressure of a total pressure of the plurality of gases.

wherein the plurality of sensing elements are Geiger-Mueller sensing elements and have a mean time before failure of at least approximately 95 hours at a temperature of approximately 100°C and a bias voltage of approximately 1050 V DC.

3. The ionizing radiation detection system of claim 1, comprising:

a plurality of the self-quenching sensing elements, each sensing element having a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:

an inert ionizing gas to ionize in response to receiving a particle of ionizing radiation;

a halogen quenching gas; and

an oxygen-containing gas in an amount of at least approximately 3 % by pressure of a total pressure of the plurality of gases, wherein the oxygen-containing gas includes substantially pure oxygen or ozone; or

an oxygen-containing gas including air in an amount of at least approximately 10 % by pressure of a total pressure of the plurality of gases,

wherein the plurality of sensing elements are Geiger-Mueller sensing elements and have a mean time before failure of at least approximately 95 hours at a temperature of approximately 185°C and a bias voltage of approximately 1050 V DC.

4. A method of using an ionizing radiation detection system comprising:

evacuating an enclosure for a sensing element having an enclosure, wherein the sensing element is Geiger-Mueller sensing element;

adding a plurality of gases to the enclosure, the plurality of gases including an ionizing gas, a halogen quenching gas and an oxygen-containing gas, wherein:

the oxygen containing gas including air in an amount of at least approximately 10 % by pressure of a total pressure of the ionizing gas, the quenching gas, and the oxygen-containing gas; or

the oxygen containing gas including substantially pure oxygen or ozone is present in an amount of approximately at least approximately 3 % by pressure of the ionizing gas, the quenching gas, and the oxygen-containing gas.

5. The method of claim 4, further comprising, before adding the ionizing gas and the quenching gas, substantially coating an inner surface of the enclosure with a cathode material.

6. The method of claim 4 or 5, further comprising, before adding the ionizing gas and the quenching gas, providing an anode within the enclosure, wherein the anode is electrically isolated from the inner surface.

7. The method of claim 4, 5, or 6, further comprising pre-mixing the ionizing gas and the quenching gas and adding the pre-mixed ionizing and quenching gases to the enclosure before adding the oxygen-containing gas to the enclosure.

8. The ionizing radiation detection system or method of any of the preceding claims, wherein any self-quenching sensing element or the Geiger-Mueller sensing element further comprises an anode including a material that oxidizes in the presence of the oxygen-containing gas.

9. The ionizing radiation detection system or method of any of the preceding claims, wherein:
   the oxygen-containing gas including substantially pure oxygen, or ozone is present in an amount of at least approximately 5 % by pressure of a total pressure of the plurality of gases; or
   the oxygen-containing gas includes air in an amount at least approximately 12.5 % by pressure of the total pressure of the plurality of gases.

10. An ionizing radiation detection system comprising:
    a self-quenching sensing element having:
    a substantially sealed enclosure containing a plurality of gases, the plurality of gases including:
    an ionizing gas to ionize in response to receiving a particle of ionizing radiation; and
    a halogen quenching gas; and
    an anode comprising a noble metal, nickel, or any combination thereof.

11. The ionizing radiation detection system of claim 10, wherein the plurality of gases is substantially free of an oxygen-containing gas.

12. The ionizing radiation detection system of claim 10 or 11, wherein the anode comprises platinum, palladium, gold, ruthenium, rhenium, iridium, osmium, a nickel alloy, such as a refractory metal-nickel alloy, such as a Ni-Ti alloy.

13. The ionizing radiation detection system of claim 10 or 11, wherein the anode comprises an iron-containing wire and a material surrounding the wire, wherein the material comprises the noble metal, nickel, or any combination thereof, or wherein the anode comprises a nickel-containing wire and a material surrounding the wire, wherein the material comprises the noble metal.

14. The ionizing radiation detection system or method of any of the preceding claims, wherein the ionizing gas includes a Penning mixture.

15. The ionizing radiation detection system or method of claim 14, wherein the ionizing gas includes a first noble gas and a second noble gas having a lower ionization potential than the first noble gas, wherein the second noble gas is present in an amount of at least approximately 0.1 % by pressure of the total pressure.