Claims

1. An apparatus for temperature-regulated radio frequency management in a mass spectrometer, the mass spectrometer having one or more radio frequency components disposed in a vacuum environment, said apparatus comprising:
   a radio frequency voltage detection circuit configured to provide feedback signal indicative of a radio frequency signal in one or more of said radio frequency components; and
   a temperature regulation apparatus disposed in said vacuum environment and configured to reduce temperature-induced variations in said radio frequency detection circuit, wherein said temperature regulation system is disposed on a radio frequency detection board disposed at least partially in said vacuum environment.

2. The apparatus of claim 1, wherein said radio frequency voltage detection circuit is disposed on said radio frequency detection board.

3. The apparatus of claims 1 or 2, wherein said feedback signal is applied to a radio frequency voltage source configured to supply a radio frequency voltage to said one or more radio frequency components to thereby control said supply.

4. The apparatus of any one of claims 1 to 3, wherein said temperature regulation circuit includes one or more heating elements that are selectively activated to raise a temperature of components of said radio frequency voltage detection circuit.

5. A mass spectrometer comprising:
   a vacuum chamber having a vacuum feed-through;
   a radio frequency component within said vacuum chamber; and
   a radio frequency voltage detection apparatus coupled with said radio frequency component, said radio frequency voltage detection apparatus disposed at least partially in said vacuum feed-through and having a capacitor for detecting the radio frequency voltage.

6. The mass spectrometer of claim 5, wherein said radio frequency voltage detection apparatus includes a board configured to fit at least a portion of said board inside said vacuum feed-through.

7. The mass spectrometer of claim 6, wherein said radio frequency voltage detection apparatus further includes a radio frequency detector positioned on said board, said radio frequency detector configured to generate a detect signal upon detection of a radio frequency signal.

8. The mass spectrometer of claim 7, wherein said radio frequency voltage detection apparatus further includes a rectifier positioned on said board, said rectifier coupled with said radio frequency detector, said rectifier configured to generate a rectified signal corresponding to said detect signal.

9. The mass spectrometer of claim 8, wherein said radio frequency voltage detection system further includes a heating element positioned on said board, configured to generate a heat flow.

10. The mass spectrometer of claim 9, wherein said radio frequency voltage detection apparatus further includes a temperature regulator coupled with said heating element, said temperature regulator configured to measure a temperature of said board and configured to adjust said heat flow generated by said heating element to maintain a predetermined temperature.

11. A radio frequency voltage detection apparatus for a mass spectrometer, said radio frequency voltage detection apparatus comprising:
a board configured to fit at least a portion of said board inside a vacuum feed-through of a vacuum chamber of said mass spectrometer;
a radio frequency detector positioned on said board, said radio frequency detector configured to generate a detect signal upon detection of a radio frequency signal;
a rectifier positioned on said board, said rectifier coupled with said radio frequency detector, said rectifier configured to generate a rectified signal corresponding to said detect signal;
a heating element positioned on said board, configured to generate a heat flow; and
a temperature regulator coupled with said heating element, said temperature regulator configured to measure a temperature of said board and configured to adjust said heat flow generated by said heating element to maintain a predetermined temperature.

12. The radio frequency voltage detection apparatus of claim 11 further comprising a mould formed around a portion of said board.

13. The radio frequency voltage detection apparatus of claim 12, wherein said mould formed around a portion of said board is configured to fit inside said vacuum feed-through.

14. The radio frequency voltage detection apparatus of any one of claims 11 to 13, wherein said radio frequency detector is a capacitor.

15. The radio frequency voltage detection apparatus of claim 14, wherein said capacitor is a ceramic capacitor.

16. The radio frequency voltage detection apparatus of any one of claims 11 to 15, wherein said board includes a metal layer and said heating element is configured to generate said heat flow in said metal layer.

17. The radio frequency voltage detection apparatus of any one of claims 11 to 16 is configured to provide a feedback signal corresponding to said radio frequency voltage to a feedback system for maintaining said radio frequency voltage at a predetermined voltage.

18. A method to detect a radio frequency signal applied to a radio frequency component of a mass spectrometer:
detecting a radio frequency voltage of said radio frequency signal applied to said radio frequency component of said mass spectrometer using a radio frequency voltage detection apparatus, said radio frequency detection apparatus configured to reside inside a vacuum feed-through of a vacuum chamber of said mass spectrometer;
generating a voltage corresponding to said detected radio frequency voltage of said radio frequency signal generated by said radio frequency component; and
regulating a temperature of said radio frequency voltage detection apparatus.

19. The method of claim 18, wherein detecting the radio frequency voltage of said radio frequency signal applied to said radio frequency component of said mass spectrometer using said radio frequency voltage detection apparatus includes detecting a voltage of a quadrupole mass filter.

20. The method of claims 18 or 19, wherein said radio frequency voltage detection apparatus includes a ceramic capacitor.

21. The method of any one of claims 18 to 20, wherein regulating said temperature of said radio frequency detection apparatus includes sensing said temperature of said radio frequency voltage detection system and maintaining said temperature at a predetermined temperature.

Claims

1. A radio frequency voltage detection system for a mass spectrometer, said radio frequency voltage detection system comprising:
a board configured to fit at least a portion of said board inside a vacuum feed-through of a vacuum chamber of said mass spectrometer;
a radio frequency detector positioned on said board, said radio frequency detector configured to generate a detect signal upon detection of a radio frequency signal;
a rectifier positioned on said board, said rectifier coupled with said radio frequency detector, said rectifier configured to generate a rectified signal corresponding to said detect signal;
a heating element positioned on said board, configured to generate a heat flow; and
a temperature regulator coupled with said heating element, said temperature regulator configured to measure a temperature of said board and configured to adjust said heat flow generated by said heating element to maintain a predetermined temperature.

2. The radio frequency voltage detection system of claim 1 further comprising a mold formed around a portion of said board.

3. The radio frequency voltage detection system of claim 2, wherein said mold formed around a portion of said board is configured to fit inside said vacuum feed-through.

4. The radio frequency voltage detection system of claim 1, wherein said radio frequency detector is a capacitor.

5. The radio frequency voltage detection system of claim 4, wherein said capacitor is a ceramic capacitor.

6. The radio frequency voltage detection system of claim 1, wherein said board includes a metal layer and said heating element is configured to generate said heat flow in said metal layer.

7. The radio frequency voltage detection system of claim 1 is configured to provide a feedback signal corresponding to said radio frequency voltage to a feedback system for maintaining said radio frequency voltage at a predetermined voltage.