CLAIMS

1. A sensor for detecting contamination of a cryogenic refrigerant in a cryogenic refrigeration system, said sensor comprising:

an inlet for coupling to a cryogenic refrigerant flow path in said cryogenic refrigeration system;

a thermal conductivity detector in fluid communication with said inlet, said thermal conductivity detector being configured to generate a signal indicative of a detected thermal conductivity of said cryogenic refrigerant received from said cryogenic refrigeration system when said sensor is coupled thereto;

circuitry configured to convert said thermal conductivity signal to an indication of contamination of said cryogenic refrigerant; and

an output configured to output said indication of contamination of said cryogenic refrigerant,

said sensor further comprising control circuity, said control circuitry comprising an input for receiving at least one signal indicative of a current state of said refrigeration system, said control circuitry being configured to control operation of said thermal conductivity detector in dependence upon said at least one received signal;

said control circuitry being configured to initiate said thermal conductivity detector to perform a thermal conductivity detection in response to determining said received signal indicating that said cryogenic vacuum pump is in a regeneration phase.

2. A sensor according to claim 1, said sensor further comprising at least one valve arranged to control flow of said cryogenic refrigerant to and from said sensor.

3. A sensor according to claim 2, said control circuitry being configured to control operation of said at least one valve.

4. A sensor according to any one of claim 1, said control circuitry being configured in response to determining that said cryogenic refrigeration system is below 200K and said contaminants are frozen within said cryogenic refrigeration system to initiate said thermal conductivity detector to perform said thermal conductivity detection to provide a baseline thermal conductivity detection.

5. A sensor according to any one of claim 4, said control circuitry being configured in response to determining that said refrigeration system is above 220K to control said thermal conductivity detector to initiate said thermal conductivity detector to perform said thermal conductivity detection to provide a contamination thermal conductivity detection.

6. A sensor according to claim 5, said circuitry being configured to convert said thermal conductivity signal to an indication of contamination of said cryogenic refrigerant in dependence upon both said baseline thermal conductivity detection and said contamination thermal conductivity detection.

7. A sensor according to claim 1, wherein said thermal conductivity detector comprises a filament thermal conductivity detector.

8. A sensor according to claim 7, comprising a further reference filament thermal conductivity detector, said further reference filament thermal conductivity detector being isolated from said refrigeration system and comprising refrigerant of a predetermined purity, said circuitry being configured to convert said thermal conductivity signal to an indication of contamination of said cryogenic refrigerant in dependence upon a comparison of said thermal conductivity detection of said further reference filament thermal conductivity detector and said filament thermal conductivity detector.

9. A sensor according to claim 1, wherein said thermal conductivity detector comprises a microelectromechanical system (MEMS) device.

10. A sensor according to claim 1, wherein said circuitry is configured to receive signals indicative of at least one of temperature and pressure of said refrigerant and to convert said thermal conductivity signal to said indication of contamination in dependence upon said at least one temperature and pressure.

11. A cryogenic refrigeration system comprising a cryogenic refrigerant and a sensor for determining contamination of said cryogenic refrigerant according to claim 1.

12. A cryogenic refrigeration system according to claim 11, further comprising at least one compressor for compressing said cryogenic refrigerant, at least one pump, and a controller for controlling operation of said cryogenic refrigeration system, said controller being configured to control a mixing cycle by triggering operation of said compressor and said at least one pump for a predetermined time prior to transmitting a signal to said sensor for initiating detection of said contamination of said cryogenic refrigerant.