

WHAT IS CLAIMED is:

1. A method for measuring thermal resistance between a thermal component of an instrument and a consumable, comprising:

contacting a known consumable with a thermal component of an instrument to be tested;

driving the thermal component using a periodic sine wave input based on a predetermined interrogation frequency;

measuring a plurality of temperature outputs from a thermal sensor responsive to driving the thermal component using the periodic sine wave input;

multiplying the plurality of temperature outputs by a reference signal in phase with the periodic sine wave input and calculating the resultant direct current (DC) signal component to determine an in-phase component, X;

multiplying the plurality of temperature outputs by a 90° phase-shifted reference signal and calculating the resultant DC signal component to determine a quadrature, out-of-phase component, Y;

calculating a phase offset responsive to the periodic sine wave input based on $\tan^{-1}(Y/X)$ or $\text{atan2}(X,Y)$;

determining a resistance value for the thermal interface using a calibrated resistance-phase offset equation and the calculated phase offset; and

comparing the determined resistance value to a predetermined resistance threshold value.

2. The method of claim 1, the determined resistance value being above the predetermined resistance threshold value, the method further comprising determining the thermal component has a defect at the thermal interface surface based on the determined resistance value being above the predetermined resistance threshold value.

3. The method of claim 1, the determined resistance value being below the predetermined resistance threshold value, the method further comprising determining the thermal component is acceptable based on the determined resistance value being below the predetermined resistance threshold value.

4. The method of any of claims 1-3, wherein the thermal component comprises a thermoelectric cooler.

5. The method of any of claims 1-4, wherein the consumable comprises a flow cell.

6. The method of any of claims 1-5, wherein the predetermined interrogation frequency is determined based on an estimated RC corner value for the known consumable and the thermal component of the instrument.

7. A method for measuring thermal resistance between a thermal component of an instrument and a consumable, comprising:

contacting a consumable to be tested with a known thermal component of an instrument;

driving the thermal component using a periodic sine wave input based on a predetermined interrogation frequency;

measuring a plurality of temperature outputs from a thermal sensor responsive to driving the thermal component using the periodic sine wave input;

multiplying the plurality of temperature outputs by a reference signal in phase with the periodic sine wave input and calculating the resultant direct current (DC) signal component to determine an in-phase component, X;

multiplying the plurality of temperature outputs by a 90° phase-shifted reference signal and calculating the resultant DC signal component to determine a quadrature, out-of-phase component, Y;

calculating a phase offset responsive to the periodic sine wave input based on $\tan^{-1}(Y/X)$ or $\text{atan2}(X,Y)$;
determining a resistance value for the thermal interface using a calibrated resistance-phase offset equation and the calculated phase offset; and
comparing the determined resistance value to a predetermined resistance threshold value.

8. The method of claim 7, the determined resistance value being above the predetermined resistance threshold value, the method further comprising determining the consumable has a defect at the thermal interface surface based on the determined resistance value being above the predetermined resistance threshold value.

9. The method of claim 7, the determined resistance value being below the predetermined resistance threshold value, the method further comprising determining the consumable is acceptable based on the determined resistance value being below the predetermined resistance threshold value.

10. The method of any of claims 7-9, wherein the thermal component comprises a thermoelectric cooler.

11. The method of any of claims 7-10, wherein the consumable comprises a flow cell.

12. The method of any of claims 7-11, wherein the predetermined interrogation frequency is determined based on an estimated RC corner value for the consumable and the known thermal component of the instrument.

13. A method for measuring thermal resistance between a thermal component of an instrument and a consumable, comprising:
contacting a consumable with a thermal component of an instrument;
driving the thermal component using a periodic sine wave input based on a predetermined interrogation frequency;

measuring a plurality of temperature outputs from a thermal sensor responsive to driving the thermal component using the periodic sine wave input;

multiplying the plurality of temperature outputs by a reference signal in phase with the periodic sine wave input and calculating the resultant direct current (DC) signal component to determine an in-phase component, X;

multiplying the plurality of temperature outputs by a 90° phase-shifted reference signal and calculating the resultant DC signal component to determine a quadrature, out-of-phase component, Y;

calculating a phase offset responsive to the periodic sine wave input based on $\tan^{-1}(Y/X)$ or $\text{atan2}(X,Y)$;

determining a resistance value for the thermal interface using a calibrated resistance-phase offset equation and the calculated phase offset;

comparing the determined resistance value to a first predetermined resistance threshold value;

comparing the determined resistance value to a second predetermined resistance threshold value; and

determining a characteristic of the thermal interface based on the comparison of the determined resistance value to the first and second predetermined resistance threshold values.

14. The method of claim 13, the determined resistance value being above the second predetermined resistance threshold value, the method further comprising determining the consumable is not inserted in the instrument based on the determined resistance value being above the second predetermined resistance threshold value.

15. The method of claim 13, the determined resistance value being below the second predetermined resistance threshold value and above the first predetermined resistance threshold value, the method further comprising determining a defect or debris is at the thermal interface surface based on the determined resistance value being below

the second predetermined resistance threshold value and above the first predetermined resistance threshold value.

16. The method of any of claims 13-15, wherein the thermal component comprises a thermoelectric cooler.

17. The method of any of claims 13-16, wherein the consumable comprises a flow cell

18. The method of claim 17, wherein the flow cell is used for sequencing by synthesis.

19. The method of any of claims 13-18, wherein the predetermined interrogation frequency is determined based on an estimated RC corner value for the consumable and the known thermal component of the instrument.

20. A computer-readable medium having stored thereon a computer program comprising instructions to cause the instrument to execute the method of any of claims 13-19.