transfer can cause the yield of the PCR process to differ from sample vial to sample vial. To perform the PCR process successfully and efficiently and to enable specialized applications (such as quantitative PCR), these temperature errors must be minimized as much as possible. The problems of minimizing non-uniformity in temperature at various points on the sample block become particularly acute when the size of the region containing samples becomes large as in a standard 8 by 12 microtiter plate.

SUMMARY

[0006] Apparatuses, systems, and methods for providing thermal uniformity throughout a thermocycler sample block are disclosed.

[0007] In one aspect, a thermal block assembly including a sample block and two or more thermoelectric devices, is disclosed. The sample block has a top surface configured to receive a plurality of reaction vessels and an opposing bottom surface. The thermoelectric devices are operably coupled to the sample block, wherein each thermoelectric device includes a housing for a thermal sensor and a thermal control interface with a controller. Each thermoelectric device is further configured to operate independently from each other to provide a substantially uniform temperature profile throughout the sample block. Each of the thermoelectric devices further comprises a top surface in thermal contact with the bottom surface of the sample block and an opposing bottom surface facing away from the sample block. The housing is a groove carved out of a surface of each thermoelectric device from an edge of said surface.

[0008] In another aspect, a thermoelectric device including a first thermal conducting layer, a second thermal conducting layer, a plurality of Peltier elements and an open channel, is disclosed. The Peltier elements are comprised of a semiconductor material and are sandwiched in between the first and the second thermal conducting layers. The open channel is carved out of the first thermal conducting layer from an edge of the first thermal conducting layer, wherein the open channel is configured to house a thermal sensor.

[0009] In another aspect, a thermoelectric device including a first thermal conducting layer, a second thermal conducting layer, a plurality of Peltier elements and an open channel, is disclosed. The first and second thermal conducting layers have inner and outer surfaces. The plurality of Peltier elements comprised of semiconductor material that are adjacent to the inner

surface of the first and second thermal conducting layers. The open channel is carved out of the first thermal conducting layer and the plurality of Peltier elements exposing the inner surface of the second thermal conducting layer. The open channel is configured to contain a thermal sensor.

[0010] In another aspect, a method for controlling sample block temperature is disclosed. A block assembly with a sample block and two or more thermoelectric devices in thermal communication with the sample block, is provided. Each of the thermoelectric devices comprises a top surface in thermal contact with the bottom surface of the sample block and an opposing bottom surface facing away from the sample block. Each of the thermoelectric devices houses a unique thermal sensor in a groove carved out of a surface of said thermoelectric device from an edge of said surface. Each of thermoelectric devices is paired to their respective unique thermal sensors to form a thermal unit. The temperature of each of the thermal units is independently controlled with a controller to provide a substantially uniform temperature profile throughout the sample block.

[0011] In another aspect, a thermal cycler system with a sample block assembly and controller, is disclosed. The sample block assembly includes a sample block configured to receive a plurality of reaction vessels and two or more thermoelectric devices in thermal communication with the sample block, wherein each thermoelectric device houses a unique thermal sensor. The controller includes a computer processing unit with machine executable instructions and two or more communication ports. Each port is operably connected to one of the two or more thermoelectric devices and their respective thermal sensor. The machine executable instructions are configured to individually adjust the temperature of each thermoelectric device based on the temperature measurements from their respective thermal sensor to provide a substantially uniform temperature profile throughout the sample block. Each of the thermoelectric devices further comprises a top surface in thermal contact with the bottom surface of the sample block and an opposing bottom surface facing away from the sample block. The thermal sensor is housed in a groove carved out of a surface of each thermoelectric device from an edge of said surface.

[0012] In another aspect, a thermal block assembly with two or more sample blocks, two or more sets of thermoelectric devices, a thermal control interface, and a controller, is disclosed. Each sample block has a top surface configured to receive a plurality of reaction vessels and an

opposing bottom surface. Each set of thermoelectric devices is operably coupled to each sample block. The thermal control interface is in communications with the controller. Each of the thermoelectric devices includes a top surface in thermal contact with the bottom surface of the respective sample block and an opposing bottom surface facing away from the respective sample block. Each of the thermoelectric devices further includes housing for a thermal sensor, the housing comprising a groove carved out of a surface of said thermoelectric device from an edge of said surface.

[0013] In another aspect, a thermal block assembly with at least one sample block, at least one set of thermoelectric devices, a thermal control interface and a controller, is disclosed. Each sample block has a top surface configured to receive a plurality of reaction vessels and an opposing bottom surface. The at least one set of thermoelectric devices is operable coupled to each sample block. The thermal control interface is in communications with the controller. Each of the thermoelectric devices includes a top surface in thermal contact with the bottom surface of the respective sample block and an opposing bottom surface facing away from the respective sample block. Each of the thermoelectric devices further includes housing for a thermal sensor, the housing comprising a groove carved out of a surface of said thermoelectric device from an edge of said surface.

[0014] These and other features are provided herein.

CLAIMS

1. A thermal block assembly, comprising:

a sample block with a top surface configured to receive a plurality of reaction vessels and an opposing bottom surface; and

two or more thermoelectric devices operably coupled to the sample block, wherein each thermoelectric device includes a housing for a thermal sensor and a thermal control interface in communications with a controller, wherein each thermoelectric device is configured to operate independently from each other to provide a substantially uniform temperature profile throughout the sample block,

wherein each of the thermoelectric devices further comprises a top surface in thermal contact with the bottom surface of the sample block and an opposing bottom surface facing away from the sample block; and

wherein the housing is a groove carved out of a surface of each thermoelectric device from an edge of said surface.

2. The thermal block assembly of claim 1, wherein the top surface comprises the groove.

3. The thermal block assembly of claim 1, wherein the bottom surface comprises the groove.

4. The thermal block assembly of claim 1, wherein the thermal sensor is selected from the group consisting of thermocouples, thermistors, platinum resistance thermometers and silicon bandgap temperature sensors.

5. The thermal block assembly of claim 1, wherein the thermal sensor is operably connected to the sample block.

6. The thermal block assembly of claim 1, wherein the controller is configured to provide two or more control channels.

7. The thermal block assembly of claim 6, wherein each control channel is associated with one of the thermoelectric devices on the thermal block assembly.

8. The thermal block assembly of claim 7, wherein each control channel is capable of controlling one of the thermoelectric devices and communicating with the thermal sensor associated with the thermoelectric device.

9. The thermal block assembly of claim 1, wherein the controller comprises two or more independent controllers.

10. The thermal block assembly of claim 9, wherein each independent controller comprises a computer processor.

11. The thermal block assembly of claim 10, wherein the computer processor is configured to control one of the two or more thermoelectric devices and to communicate with the thermal sensor associated with the thermoelectric device.

12. The thermal block assembly of claim 1, wherein the controller comprises two or more sub-controller elements.

13. The thermal block assembly of claim 12, wherein each of the two or more sub-controllers are operably connected to one of the thermoelectric devices.

14. The thermal block assembly of claim 1, further comprising a heat sink, wherein the heat sink comprises a baseplate and fins, wherein the baseplate comprises a top surface and an opposing bottom surface, wherein the top surface is in thermal contact with the opposing bottom surface of the thermoelectric devices, and the fins are pendant the opposing second surface.

15. A thermoelectric device, comprising:

a first thermal conducting layer;

a second thermal conducting layer;

a plurality of Peltier elements comprised of semiconductor material sandwiched in between the first and the second thermal conducting layers; and

an open channel carved out of the first thermal conducting layer from an edge of the first thermal conducting layer, wherein the open channel is configured to house a thermal sensor.

16. The thermoelectric device of claim 15, wherein the semiconductor material includes bismuth telluride.

17. The thermoelectric device of claim 15, wherein the first thermal conducting layer and the second thermal conducting layer comprise alumina.

18. A thermoelectric device, comprising:

a first thermal conducting layer with an inner surface and an outer surface;

a second thermal conducting layer with an inner surface and an outer surface;

a plurality of Peltier elements comprised of semiconductor material that are adjacent to the inner surface of the first thermal conducting layer and the inner surface of the second thermal conducting layer; and

an open channel carved out of the first thermal conducting layer and the plurality of Peltier elements exposing the inner surface of the second thermal conducting layer, wherein the open channel is configured to contain a thermal sensor.

19. The thermoelectric device of claim 18, wherein the semiconductor material includes bismuth telluride.

20. The thermoelectric device of claim 18, wherein the first thermal conducting layer and the second thermal conducting layer comprise alumina.

21. A method for controlling sample block temperature, comprising:

providing a block assembly including,

a sample block;

two or more thermoelectric devices in thermal communication with the sample block,

wherein each of the thermoelectric devices comprises a top surface in thermal contact with the bottom surface of the sample block and an opposing bottom surface facing away from the sample block, and each of the thermoelectric devices houses a unique thermal sensor in a groove carved out of a surface of said thermoelectric device from an edge of said surface;

pairing each of the thermoelectric devices with their respective unique thermal sensors to form a thermal unit; and

independently controlling the temperature of each of the thermal units with a controller to maintain a substantially uniform temperature throughout the sample block.

22. The method of claim 21, wherein the controller is configured to minimize temperature differences measured by the thermal sensor of each thermal unit.

23. The method of claim 22, wherein each thermal sensor is configured to measure temperature of a sample block region that is proximate to each respective thermal sensor.

24. The method of claim 21, wherein the controller is comprised of 2 or more sub-controllers.

25. The method of claim 24, wherein each of the sub-controllers is operably connected to one of the thermal units.

26. A thermocycler system, comprising:

a sample block assembly including,

a sample block configured to receive a plurality of reaction vessels; and

two or more thermoelectric devices in thermal communication with the sample block, wherein each thermoelectric device houses a unique thermal sensor; and

a controller including a computer processing unit with machine executable instructions and two or more communication ports, each port operably connected to one of the two or more thermoelectric devices and their respective thermal

sensor, wherein the machine executable instructions are configured to individually adjust the temperature of each thermoelectric device based on temperature measurements from their respective thermal sensor to provide a substantially uniform temperature profile throughout the sample block,

wherein each of the thermoelectric devices further comprises a top surface in thermal contact with the bottom surface of the sample block and an opposing bottom surface facing away from the sample block; and

wherein the thermal sensor is housed in a groove carved out of a surface of each thermoelectric device from an edge of said surface.

27. The thermocycler system of claim 26, wherein the top surface comprises the groove.

28. The thermocycler system of claim 26, wherein the bottom surface comprises the groove.

29. The thermocycler system of claim 26, further comprising a heat sink, wherein the heat sink comprises a baseplate and fins, wherein the baseplate comprises a top surface and an opposing bottom surface, wherein the top surface is in thermal contact with the opposing bottom surface of the thermoelectric devices, and the fins are pendant the opposing second surface.

30. A thermal block assembly, comprising:

two or more sample blocks, each sample block with a top surface configured to receive a plurality of reaction vessels and an opposing bottom surface; and

two or more sets of thermoelectric devices operably coupled to each sample block and a thermal control interface in communications with a controller,

wherein each of the thermoelectric devices includes a top surface in thermal contact with the bottom surface of the respective sample block and an opposing bottom surface facing away from the respective sample block; and

wherein each of the thermoelectric devices further includes housing for a thermal sensor, the housing comprising a groove carved out of a surface of said thermoelectric device from an edge of said surface.

31. The thermal block assembly of claim 30, further comprising two or more heat sinks, wherein each heat sink comprises a baseplate and fins, wherein the baseplate comprises a top surface and an opposing bottom surface, wherein the top surface is in thermal contact with the

opposing bottom surface of the thermoelectric devices, and the fins are pendant the opposing second surface.

32. The thermal block assembly of claim 30, wherein the controller comprises two or more independent controllers, wherein each independent controller comprises a

computer processor and is configured to control one of the two or more sample blocks and sets of thermoelectric devices.

33. The thermal block assembly of claim 30, wherein the controller comprises a computer processor and two or more channels, wherein the processor is configured to control each of the two or more channels.

34. The thermal electric assembly of claim 30, wherein each of the sets of thermoelectric devices comprises at least one thermoelectric device.

35. A thermal block assembly, comprising:

at least one sample block, each sample block with a top surface configured to receive a plurality of reaction vessels and an opposing bottom surface; and

at least one set of thermoelectric devices operably coupled to each sample block and a thermal control interface in communications with a controller,

wherein each of the thermoelectric devices includes a top surface in thermal contact with the bottom surface of the respective sample block and an opposing bottom surface facing away from the respective sample block; and

wherein each of the thermoelectric devices further includes housing for a thermal sensor, the housing comprising a groove carved out of a surface of said thermoelectric device from an edge of said surface.

36. The thermal block assembly of claim 35, further comprising at least one heat sink, wherein each heat sink comprises a baseplate and fins, wherein the baseplate comprises a top surface and an opposing bottom surface, wherein the top surface is in thermal contact with the opposing bottom surface of the thermoelectric devices, and the fins are pendant the opposing second surface.

37. The thermal block assembly of claim 35, wherein the controller comprises at least one independent controller, wherein each independent controller comprises a computer processor and is configured to control one of the at least one sample block and set of thermoelectric devices.

38. The thermal block assembly of claim 35, wherein the controller comprises a computer processor and at least one channel, wherein the processor is configured to control each of the at least one channel.

39. The thermal electric assembly of claim 35, wherein each of the at least one set of thermoelectric devices comprises at least one thermoelectric device.