cartridge of FIG. **12**. Other configurations of inlets though not explicitly described or depicted are compatible with the technology described herein.

[0094] FIG. **13** shows, in close up, an exemplary spacing of valves and channels in adjacent lanes of a multi-sample microfluidic cartridge, for example as shown in FIG. **9**.

[0095] FIGS. **14** and **15** show close-ups of, respectively, heater arrays compatible with, and inlets on the exemplary cartridge shown in FIG. **9**.

[0096] FIGS. **16**A and **16**B show various views of an embodiment of a radially-configured highly-multiplexed cartridge, having a number of inlets, microfluidic lanes, valves and PCR reaction chambers. FIG. **16**C shows an array of heater elements compatible with the cartridge layout of FIG. **16**A.

[0097] The various embodiments shown in FIGS. **11**-**16**C are compatible with liquid dispensers, receiving bays, and detectors that are configured differently from the other specific examples described herein.

Use of Cutaways in Cartridge and Substrate to Improve Rate of Cooling During PCR Cycling

[0098] During a PCR amplification of a nucleotide sample, a number of thermal cycles are carried out. For improved efficiency, the cooling between each application of heat is preferably as rapid as possible. Improved rate of cooling can be achieved with various modifications to the heating substrate, as shown in FIGS. **17**A-**17**C.

[0099] One way to achieve rapid cooling is to cutaway portions of the microfluidic cartridge substrate, as shown in FIG. **17**A. The upper panel of FIG. **17**A is a cross-section of an exemplary microfluidic cartridge taken along the dashed line A-A' as marked on the lower panel of FIG. **17**A. PCR reaction chamber **901**, and representative heaters **1003** are shown. Also shown are two cutaway portions, one of which labeled **1201**, that are situated alongside the heaters that are positioned along the long side of the PCR reaction chamber. Cutaway portions such as **1201** reduce the thermal mass of the cartridge, and also permit air to circulate within the cutaway portions. Both of these aspects permit heat to be conducted away quickly from the immediate vicinity of the PCR reaction chamber. Other configurations of cutouts, such as in shape, position, and number, are consistent with the present technology.

[0100] Another way to achieve rapid cooling is to cutaway portions of the heater substrate, as shown in FIG. **17**B. The lower panel of FIG. **17**B is a cross-section of an exemplary microfluidic cartridge and heater substrate taken along the dashed line A-A' as marked on the upper panel of FIG. **17**B. PCR reaction chamber **901**, and representative heaters **1003** are shown. Also shown are four cutaway portions, one of which labeled **1205**, that are situated alongside the heaters that are situated along the long side of the PCR reaction chamber. Cutaway portions such as **1205** reduce the thermal mass of the heater substrate, and also permit air to circulate within the cutaway portions. Both of these aspects permit heat to be conducted away quickly from the immediate vicinity of the PCR reaction chamber. Four separate cutaway portions are shown in FIG. **17**B so that control circuitry to the various heaters is not disrupted. Other configurations of cutouts, such as in shape, position, and number, are consistent with the present technology. These cutouts may be created by a method selected from: selective etching using wet etching processes, deep reactive ion etching, selective etching using CO_2 laser or femtosecond laser (to prevent surface cracks or stress near the surface), selective mechanical drilling, selective ultrasonic drilling, or selective abrasive particle blasting. Care has to be taken to maintain mechanically integrity of the heater while reducing as much material as possible.

[0101] FIG. **17**C shows a combination of cutouts and use of ambient air cooling to increase the cooling rate during the cooling stage of thermocycling. A substantial amount of cooling happens by convective loss from the bottom surface of the heater surface to ambient air. The driving force for this convective loss is the differential in temperatures between the glass surface and the air temperature. By decreasing the ambient air temperature by use of, for example, a peltier cooler, the rate of cooling can be increased. The convective heat loss may also be increased by keeping the air at a velocity higher than zero.

[0102] An example of thermal cycling performance obtained with a configuration as described herein, is shown in FIG. **18** for a protocol that is set to heat up to 92° C., and stay there for 1 second, then cool to 62° C., and stay for 10 seconds. Cycle time is about 29 seconds, with 8 seconds required to heat from 62° C. and stabilize at 92° C., and 10 seconds required to cool from 92° C., and stabilize at 62° C.

Heater Multiplexing under software control

[0103] Another aspect of the heater unit described herein, relates to a control of heat within the system and its components. The method leads to a greater energy efficiency of the apparatus described herein, because not all heaters are heating at the same time, and a given heater is receiving current for only part of the time.

[0104] Generally, the heating of microfluidic components, such as a PCR reaction chamber, is controlled by passing currents through suitably configured microfabricated heaters. The heating can be further controlled by periodically turning the current on and off with varying pulse width modulation (PWM), wherein pulse width modulation refers to the on-time/off-time ratio for the current. The current can be supplied by connecting a microfabricated heater to a high voltage source (for example, 30 V), which can be gated by the PWM signal. In some embodiments, the device includes 48 PWM signal generators. Operation of a PWM generator includes generating a signal with a chosen, programmable, period (the end count) and a particular granularity. For instance, the signal can be 4000 μs (micro-seconds) with a granularity of 1 μs, in which case the PWM generator can maintain a counter beginning at zero and advancing in increments of 1 μs until it reaches 4000 μs, when it returns to zero. Thus, the amount of heat produced can be adjusted by adjusting the end count. A high end count corresponds to a greater length of time during which the microfabricated heater receives current and therefore a greater amount of heat produced. It would be understood that the granularity and signal width can take values other than those provided here without departing from the principles described herein.

Exemplary Electronics and Software

[0105] The heater unit described herein can be controlled by various electronics circuitry, itself operating on receipt of computer-controlled instructions. FIG. **18** illustrates exemplary electronics architecture modules for operating a heater unit and diagnostic apparatus. It would be understood by one of ordinary skill in the art that other configurations of electronics components are consistent with operation of the apparatus as described herein. In the exemplary embodiment, the