complex and competitive binding complex include a detector agent bound within the complex. In one embodiment described here, the detector agent is an oxidizing enzyme.

As shown at block **3212**, in some embodiments, the reader generates a current, which heats or otherwise stimulates a first heating element, thereby causing heat to transfer to a first heat-actuated valve within the cartridge. In some embodiments, this causes the valve to melt or undergo another phase change, which allows liquid to flow out of the first reservoir into an analysis channel via capillary action. As the liquid flows, it transports the mixture with it, and the magnetic particles within the mixture, including magnetic particles within sandwich complexes and/or competitive binding complexes, localize over one or more magnetic fields within the analysis channel, forming one or more localized samples.

Optionally, at block **3214**, the reader generates a current, which heats or otherwise stimulates a second heating element such that a second valve within the cartridge undergoes a phase change and a wash solution flows out of a second reservoir into the analysis channel. In various embodiments, the wash solution removes, from the one or more localized samples, oxidizing enzymes (or other detector agents) that are not indirectly bound to magnetic particles.

At block **3216**, the reader generates a current, which heats or otherwise stimulates a third heating element such that a third valve within the cartridge undergoes a phase change and a solution of substrates flows out of a third reservoir into the analysis channel. In various embodiments, when the detector agent is an oxidizing enzyme, the oxidizing enzymes within the sandwich complexes and/or competitive binding complexes of each localized sample oxidize the substrate molecules present in the aqueous media used to transport said substrate molecules. In embodiments in which sandwich complexes are present, oxidation occurs at an electrochemical cell formed by an electrochemical sensor and the volume of liquid substantially over it and electrons flow from the working electrode of the electrochemical sensor to the volume substantially above said sensor in a quantity proportional to a quantity of target analyte present within the localized sample. In embodiments in which competitive binding complexes are present, oxidation occurs at an electrochemical cell formed by an electrochemical sensor and the volume of liquid substantially over said sensor and electrons flow from working electrode of the electrochemical sensor in a quantity inversely proportional to a quantity of target analyte present within the localized sample.

At block **3218**, the reader's processor receives from the reader's electric connector a first signal detected at the electrochemical sensor. In various embodiments, the signal is a voltage or current signal. At least a portion of the signal is caused by the oxidation of the substrate. At block **3220**, the reader's processor receives from the reader's electric connector a second signal detected by a reference sensor. At block **3222**, the reader's processor calculates a resultant signal by subtracting or applying another algorithm to remove the second signal from the first signal to account for and/or eliminate noise that may be present within the system. At block **3224**, the reader's processor processes and analyzes the resultant signal to identify the presence and/or quantity of a target analyte. Optionally, as shown at block **3226**, in some embodiments, the reader transmits signals indicative of a test result to a mobile computing device for further processing, storage, transmission to a server, and/or display of results to a user.

Although the foregoing has included detailed descriptions of some embodiments by way of illustration and example, it will be readily apparent to those of ordinary skill in the art in light of the teachings of these embodiments that numerous changes and modifications may be made without departing from the spirit or scope of the appended claims.

What is claimed is:

1. A microfluidic cartridge comprising:
- a fluid-holding reservoir comprising an outlet;
- a microfluidic channel configured to receive fluid from the fluid-holding reservoir through the outlet;
- a printed circuit board;
- a via positioned in the printed circuit board such that the via is positioned under, over, or adjacent to the outlet of the fluid-holding reservoir;
- a valve comprising a phase-changeable material, wherein:
  - in a first state, the phase-changeable material is deposited on the via and extends into the outlet, occluding an entire cross-section of the outlet, and
  - in a second state, the phase-changeable material does not occlude the entire cross-section of the outlet;
- a heating element configured to heat the via such that the via heats the phase-changeable material deposited on the via to transition the phase-changeable material from the first state to the second state to permit the fluid to flow from the fluid-holding reservoir through the outlet and into the microfluidic channel; and
- a cartridge housing configured to enclose the fluid-holding reservoir, the microfluidic channel, the printed circuit board, the via, the valve, and the heating element.

2. The microfluidic cartridge of claim **1**, wherein the valve is configured to irreversibly transition from the first state to the second state.

3. The microfluidic cartridge of claim **1**, wherein, in the first state, the phase-changeable material is in a solid or semi-solid state.

4. The microfluidic cartridge of claim **1**, wherein the phase-changeable material transitions from the first state to the second state at a temperature between 50 and 100 degrees Celsius.

5. The microfluidic cartridge of claim **1**, wherein the phase-changeable material has a minimum height necessary to occlude the entire cross-section of the outlet.

6. The microfluidic cartridge of claim **1**, wherein the phase-changeable material is a hydrophilic wax comprising at least one of hexadecanol and octodecanol.

7. The microfluidic cartridge of claim **6**, wherein an amount of hydrophilic wax deposited on the via is below 1 microliter in a liquid state.

8. The microfluidic cartridge of claim **1**, further comprising a spring-loaded contact providing effective contact between the heating element and the via.

9. The microfluidic cartridge of claim **1**, wherein the heating element is activated through a transistor.

10. The microfluidic cartridge of claim **1**, wherein the heating element is a resistive heating element.

11. The microfluidic cartridge of claim **10**, wherein the resistive heating element comprises a serpentine trace on the printed circuit board.

12. The microfluidic cartridge of claim **1**, wherein the heating element is coupled to a processor.

13. The microfluidic cartridge of claim **12**, wherein the processor is configured to execute instructions stored in a memory, and the instructions, when executed, cause the processor to activate the heating element at a programmed time.

14. The microfluidic cartridge of claim **1**, further comprising a feedback-and-control system to achieve a consistent thermal profile at the via.

15. The microfluidic cartridge of claim **1**, wherein the outlet is a semicircle with a boundary extension.