Supplementary Material (ESI) for Lab on a Chip

Electronic Supplementary Material

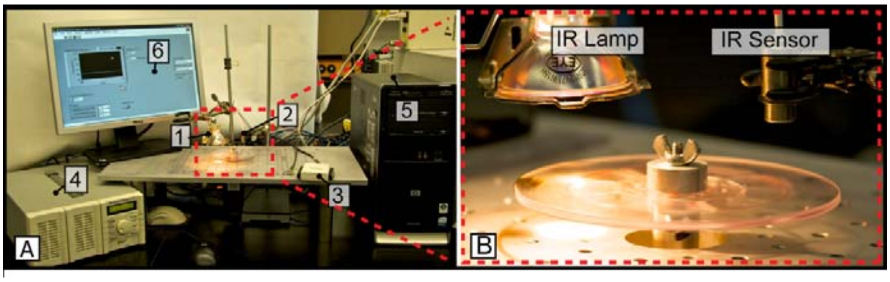

Fig. S1 (A) Photo of the IR heating system with a dashed red box highlighting the microfluidic disk. (1) IR lamp (2) IR temperature sensor (3) Data Acquisition (DAQ) Device (4) IR Lamp power supply (5) Computer control system (6) Control program (LabVIEW). (B) Insert - Close-up picture of controlled heating of a spinning microfluidic disc showing the IR lamp and IR temperature sensor.

Validation of Heating Platform

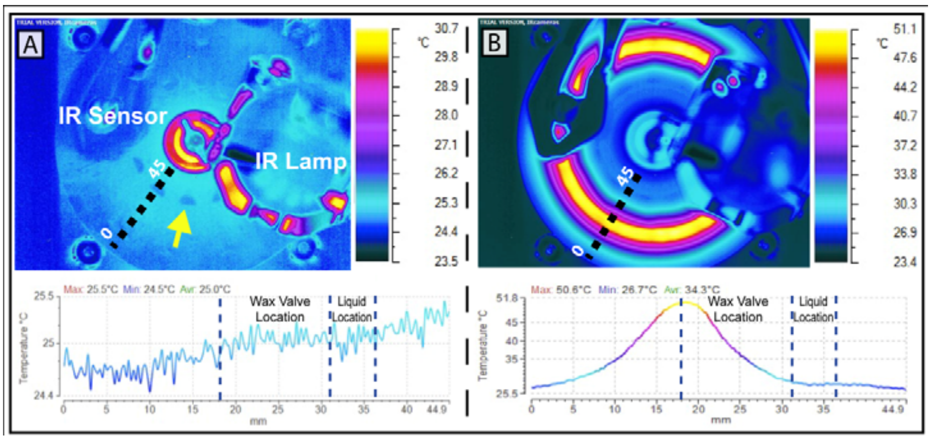

Fig. S2 Infrared (IR) photography of microfluidic disc. (A) Image of the stationary disc taken before infrared heating. Yellow arrow indicates fluids (dark patches) held back by closed wax valves (B) Image of rotating disc taken precisely before wax valve opening (T_m = 51.6 - 57.2 °C). Thermal gradient plots taken along black dotted line of respective images are shown below each condition. IR images confirmed correct temperature monitoring, key to the performance of the IR heating platform, and also confirmed elevated temperatures on the disc with a peak corresponding to the focal point of the IR lamp. Heat was applied to the end of the wax-plugged microchannel that was furthest away from the liquid sample. Even while heating in this asymmetric fashion, thermal energy is delivered to open the entire wax plug. Thermal analysis demonstrates minor heat transfer during this process to the liquid sample as shown by the similar temperatures in the region (see Liquid Location on the temperature profile).

In order to examine thermal distribution on the CD, a thermal camera (VarioCAM, JENOPTIK, Germany) was used to visualize heating on the disc. Using specialized software (Thermography Suite, IRcameras, Inc., MA, USA), detailed thermal analysis could be performed on the recorded information. Figure S2 shows thermal analysis of our system: (A) shows the system at rest (i.e., disc is not spinning and no heat is being applied), and (B) shows the thermal spectrum during rotation with maximum heating (i.e., immediately before wax valve opening). IR images confirmed elevated temperatures on the disc with a peak corresponding to the focal point of the IR lamp.

To minimally heat the liquid sample, heat was applied to the end of the wax-plugged microchannel that was furthest away from the liquid. Even while heating in this asymmetric fashion, thermal energy is delivered to open the entire wax valve. Subsequent thermal analysis demonstrated that there was minor heat transfer to the liquid sample during this process (thermal gradient plots, Figure S2). Finally, the melting temperature of the wax in question was confirmed to be near the low end of the manufacture's specified melting temperature (T_m = 51.6 - 57.2 °C). Overall, the temperatures obtained from the IR images and the IR sensor, were very similar when examining temperatures at a particular radii; thus, validating reliable temperature analysis via the IR heating platform.

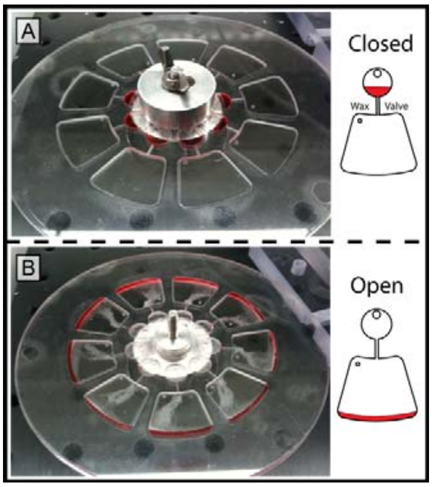

Fig. S3 Images and corresponding illustrations of wax valving on a centrifugal microfluidic disc. (A) Red dyed water is introduced into loading chambers and held back by wax plugs. (B) After wax valves have been actuated, via IR energy, and the disc is spun to an appropriate speed, liquid samples pass into their respective collection chambers. Note the minor design change from the microfluidic disc in Figure S2; this was implemented to replicate real use conditions where liquid storage typically takes place near the disc's center.