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**Burns et al.**

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(54) **THERMAL MICRO-VALVES FOR MICRO-INTEGRATED DEVICES**

(58) **Field of Classification Search** ..... 137/828,  
137/827, 251.1  
See application file for complete search history.

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(56) **References Cited**

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U.S. PATENT DOCUMENTS

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 273 days.

6,575,188 B2\* 6/2003 Parunak ..... 137/251.1  
6,679,279 B1\* 1/2004 Liu et al. .... 137/13  
2002/0143437 A1\* 10/2002 Handique et al. .... 700/266  
2004/0007275 A1\* 1/2004 Liu et al. .... 137/828

\* cited by examiner

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(57) **ABSTRACT**

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**Related U.S. Application Data**

The movement and mixing of microdroplets through microchannels is described employing silicon-based microscale devices, comprising microdroplet transport channels, reaction regions, electrophoresis modules, and radiation detectors. The discrete droplets are differentially heated and propelled through etched channels. Electronic components are fabricated on the same substrate material, allowing sensors and controlling circuitry to be incorporated in the same device.

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(51) **Int. Cl.**  
**F15C 1/04** (2006.01)  
**F16K 13/10** (2006.01)

(52) **U.S. Cl.** ..... 137/828; 137/251.1

**11 Claims, 31 Drawing Sheets**

