



US009186668B1

(12) **United States Patent**  
**Schaff et al.**

(10) **Patent No.:** **US 9,186,668 B1**  
(45) **Date of Patent:** **Nov. 17, 2015**

(54) **MICROFLUIDIC DEVICES, SYSTEMS, AND METHODS FOR QUANTIFYING PARTICLES USING CENTRIFUGAL FORCE**

(75) Inventors: **Ulrich Y. Schaff**, Davis, CA (US);  
**Gregory J. Sommer**, Livermore, CA (US); **Anup K. Singh**, Danville, CA (US)

(73) Assignee: **Sandia Corporation**, Albuquerque, NM (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 409 days.

(21) Appl. No.: **12/891,956**

(22) Filed: **Sep. 28, 2010**

**Related U.S. Application Data**

(60) Provisional application No. 61/351,458, filed on Jun. 4, 2010.

(51) **Int. Cl.**  
**C12Q 1/68** (2006.01)  
**C12M 1/34** (2006.01)  
**G01N 33/53** (2006.01)  
**B01L 3/02** (2006.01)  
**B01L 3/00** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **B01L 3/502** (2013.01); **B01L 3/0275** (2013.01)

(58) **Field of Classification Search**  
CPC ..... B01L 2400/0409; B01L 3/5027; C12Q 1/6883  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,555,284 A 1/1971 Anderson  
3,744,974 A 7/1973 Maddox  
4,125,375 A 11/1978 Hunter

4,156,570 A 5/1979 Wardlaw ..... 356/36  
4,656,143 A 4/1987 Baker et al.  
4,683,579 A 7/1987 Wardlaw ..... 377/11  
4,844,818 A 7/1989 Smith  
5,279,936 A 1/1994 Vorpahl  
5,635,362 A 6/1997 Levine et al.  
5,705,628 A 1/1998 Hawkins

(Continued)

**FOREIGN PATENT DOCUMENTS**

WO WO-2008/143578 11/2008  
WO WO 2008/143578 \* 11/2008  
WO WO-2009/098237 8/2009

**OTHER PUBLICATIONS**

Amersham, "Percoll: Methodology and Applications", 2001, pp. 1-84.\*

(Continued)

*Primary Examiner* — Betty Forman

(74) *Attorney, Agent, or Firm* — Dorsey & Whitney, LLP

(57) **ABSTRACT**

Embodiments of the present invention are directed toward microfluidic systems, apparatus, and methods for measuring a quantity of cells in a fluid. Examples include a differential white blood cell measurement using a centrifugal microfluidic system. A method may include introducing a fluid sample containing a quantity of cells into a microfluidic channel defined in part by a substrate. The quantity of cells may be transported toward a detection region defined in part by the substrate, wherein the detection region contains a density media, and wherein the density media has a density lower than a density of the cells and higher than a density of the fluid sample. The substrate may be spun such that at least a portion of the quantity of cells are transported through the density media. Signals may be detected from label moieties affixed to the cells.

**19 Claims, 10 Drawing Sheets**

