US008940147B1

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

(10) **Patent No.: US 8,940,147 B1**
(45) **Date of Patent: Jan. 27, 2015**

(54) **MICROFLUIDIC HUBS, SYSTEMS, AND METHODS FOR INTERFACE FLUIDIC MODULES**

(75) Inventors: **Michael S. Bartsch**, Menlo Park, CA (US); **Mark R. Claudnic**, Livermore, CA (US); **Hanyoup Kim**, Rockville, MD (US); **Kamlesh D. Patel**, Dublin, CA (US); **Ronald F. Renzi**, Tracy, CA (US); **James L. Van De Vreugde**, Livermore, 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 393 days.

(21) Appl. No.: **13/456,135**

(22) Filed: **Apr. 25, 2012**

Related U.S. Application Data

(60) Provisional application No. 61/478,641, filed on Apr. 25, 2011.

(51) **Int. Cl.**
G01N 27/447 (2006.01)

(52) **U.S. Cl.**
USPC **204/601**; 422/502; 422/504

(58) **Field of Classification Search**
USPC 204/451, 601; 422/502, 504
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,989,234 B2 1/2006 Kolar et al.
7,329,545 B2 2/2008 Pamula et al.
7,439,014 B2 10/2008 Pamula et al.
7,569,129 B2 8/2009 Pamula et al.
7,727,723 B2 6/2010 Pollack et al.
7,763,471 B2 7/2010 Pamula et al.
7,815,871 B2 10/2010 Pamula et al.
7,816,121 B2 10/2010 Pollack et al.
7,822,510 B2 10/2010 Paik et al.
7,851,184 B2 12/2010 Pollack et al.

FOREIGN PATENT DOCUMENTS

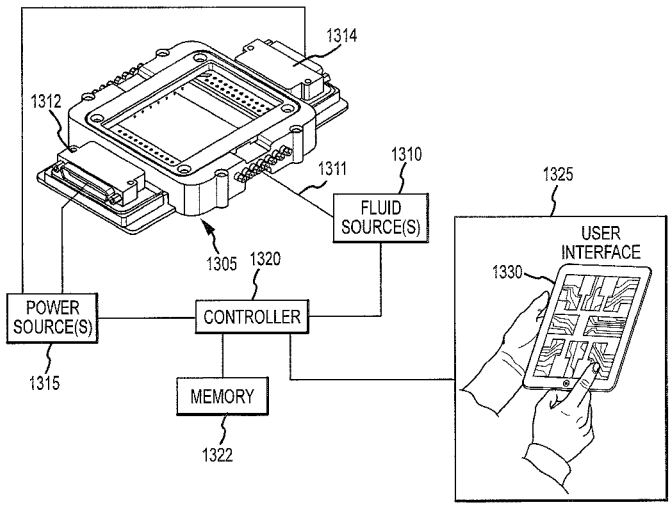
WO WO 2012/040227 A1 * 4/2010

OTHER PUBLICATIONS

Abdelgawad, M. et al., "All-terrain droplet actuation", Lab on a Chip, 2008. 8(5): p. 672-677.
Abdelgawad, M. et al., "The Digital Revolution: A New Paradigm for Microfluidics", Advanced Materials, 2009. 21(8): p. 920-925.
Barbulovic-Nad, I. S. et al., "A microfluidic platform for complete mammalian cell culture", Lab on a Chip, 2010. 10(12): p. 1536-1542.
(Continued)

Primary Examiner — J. Christopher Ball
(74) *Attorney, Agent, or Firm* — Helen S. Baca

(57) **ABSTRACT**

Embodiments of microfluidic hubs and systems are described that may be used to connect fluidic modules. A space between surfaces may be set by fixtures described herein. In some examples a fixture may set substrate-to-substrate spacing based on a distance between registration surfaces on which the respective substrates rest. Fluidic interfaces are described, including examples where fluid conduits (e.g. capillaries) extend into the fixture to the space between surfaces. Droplets of fluid may be introduced to and/or removed from microfluidic hubs described herein, and fluid actuators may be used to move droplets within the space between surfaces. Continuous flow modules may be integrated with the hubs in some examples.

21 Claims, 17 Drawing Sheets