SAND2013-9559P

Advanced Digital Microfluidic Interface for Sample Prep Automation
168507

Year 1 of 1
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Project Purpose:

The R&D100-winning Digital Microfluidic (DMF) Hub offers the potential to be a critical capability multiplier across a range of Sandia activities (see YouTube.com "Sandia Digital Microfluidic Hub"). In particular, by providing a means to modularize, interface, and automate complex sample preparation workflows at an unprecedented scale, the DMF Hub has been instrumental in establishing a toehold for Sandia in the promising new business area of DNA forensics. However, both the underlying phenomenology of digital microfluidics and the limitations of our preliminary design pose fundamental challenges which must be addressed through science-based engineering before DMF can truly become a robust and broadly applicable capability for Sandia. Accordingly, advanced development is needed to fully capitalize on the promise offered by this technology and to maintain Sandias relevance in the burgeoning field of automated sample preparation. Three key areas for improvement have been identified: 1) increased scale for higher throughput, 2) closed-loop control for reliable automated operation, and 3) expanded interface options for increased flexibility.

Long explored in academia, DMF technology is only now entering the mainstream for bioscience and sample preparation applications. Our early successes combined with our DMF Hub intellectual property have uniquely positioned Sandia as a key player in this emerging field at just the right time. This effort will provide not just a better-engineered version of a technical curiosity, but rather the first concrete application of DMF technology in an integrated and automated context to solve real world problems in a robust, flexible, and modular (rather than self-contained) fashion. This approach is both timely and crucial to the future of automated sample preparation, and the work represented by this LDRD proposal will enable Sandia to continue to push the technological envelope at this critical juncture in ways that neither academia nor industry have attempted.

Summary of Accomplishments:

We constructed a self-contained, portable, and integrated demonstration system designed to allow us to effectively showcase Sandia digital microfluidic and laboratory automation technologies to potential sponsors and customers. We designed and fabricated a new generation of printed circuit board-based digital microfluidic devices offering significant improvements to scale and operational flexibility over first generation microfabricated designs. We developed an alternative fluidic interface concept as a lower-cost alternative to the more highly-engineered digitial microfluidic hub and initiated testing of this interface. We performed initial explorations and achieved initial proof of concept for machine vision-based closed loop control of digital microfluidic droplet manipulations. We capitalized upon work performed under this LDRD to advance Sandia's licensing and commercialization strategies for intellectual property related to both microfluidic hub technology and the complementary rotary zone thermal cycler, gaining significant traction with a number of interested industry collaborators including Agilent, Roche, Beckman-Coulter, and Perkin-Elmer.

Significance:

This work has expanded upon microfluidic assay and sample manipulation architectures unique to Sandia which both provide novel methods for addressing critical national security needs in the chem/bio detection realm and offer potentially game-changing benefits for the laboratory automation field writ large. We have taken what was once an academic curiosity, digital microfluidics, and leveraged it into a broadly applicable technological capability with potential to address a wide range of needs in the areas of clinical diagnostics, personalized medicine, next generation sequencing, environmental monitoring, and deployable sensing.

Refereed Communications:

Sinha, A., M. J. Jebrail, H. Kim, K. D. Patel and S. S. Branda (2013). "A Versatile Automated Platform for Micro-scale Cell Stimulation Experiments." Journal of Visualized Experiments(78): e50597.