A Microfluidic Toolbox for Biomedical Applications

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Complete lab-on-a chip or micro total analysis systems (μ-TAS) require a wide variety of microfluidic components for the completion of complex and challenging medical and biological assays. These components fall into 3 broad categories: sample preparation, sample separation or analysis, and detection. All three areas must be well developed for a complete system. Unfortunately, the challenges for integrating all of the various components can be daunting, especially when multiple physical processes are required, such as: fluidics, electronics, optics, chemistry, and biology. To minimize the challenge, simple solutions that combine processes into one structure must be developed. This presentation will focus on how simple microfluidic platforms can be used to solve complex problems by combining a series of simple, yet powerful, processes. As part of this work, each area of a lab-on-a-chip system will be explored for how component demands can be reduced and how simple techniques can be used to combine functions into one structure. Finally, a discussion of how to multiplex these technologies in highly parallel ways will be provided. The presentation will explore a few technologies in particular: rapid, highly multiplexed DNA analysis, DNA and RNA extraction chips¸ and microarray platforms for protein and DNA analysis using both SPR and electrochemical detection. Specific applications of the technology include: quantifying circulating tumor cells using digital PCR (Figure 1) [1], detecting bacteria in environmental water sources (Figure 2) [2], detection of animal viruses, and printing of protein microarrays (Figure 3) [3].

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1. Scott Sundberg, Carl Wittwer, Chao Gao, and Bruce Gale, "Spinning Disc Platform for Microfluidic Digital PCR," *Anal. Chem*, in press.

2. Jungkyu Kim, Michael A. Johnson, Parker Hill, and Bruce K. Gale, "A microfluidic nucleic acid extraction system with both disposable and reusable components," *Biomed. Microdev.* submitted.

3. Mark A. Eddings, Josh W. Eckman, Carlos A. Arana, John E. Connolly, Bruce K. Gale, and David G. Myszka, "Spot-and-Hop Interspot Referencing for Surface Plasmon Resonance Imaging Using a Three-Dimensional Microfluidic Flow Cell Array," *Anal. Biochem*., Vol. 385, No. 2, pp. 309-313, 2009

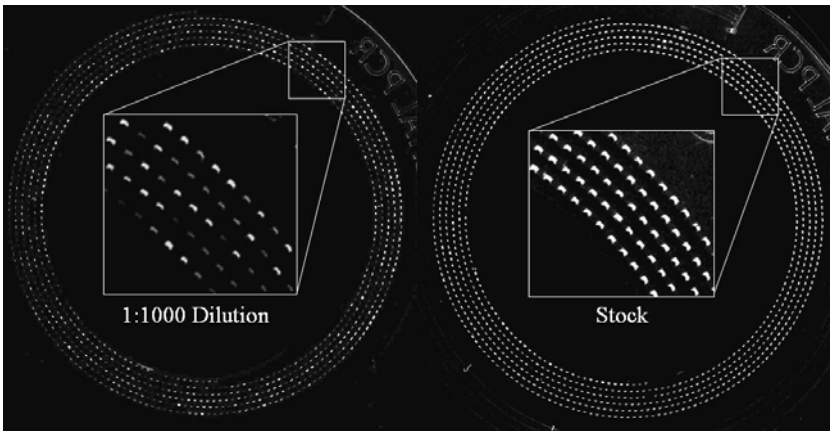

Figure 1. Two fluorescent images of the digital PCR disc are shown. On the left, 'stock' DNA is diluted a thousand fold and shows 'bright' and 'dark' wells for the digital signal. On the right, 'stock' DNA is amplified as a positive control.

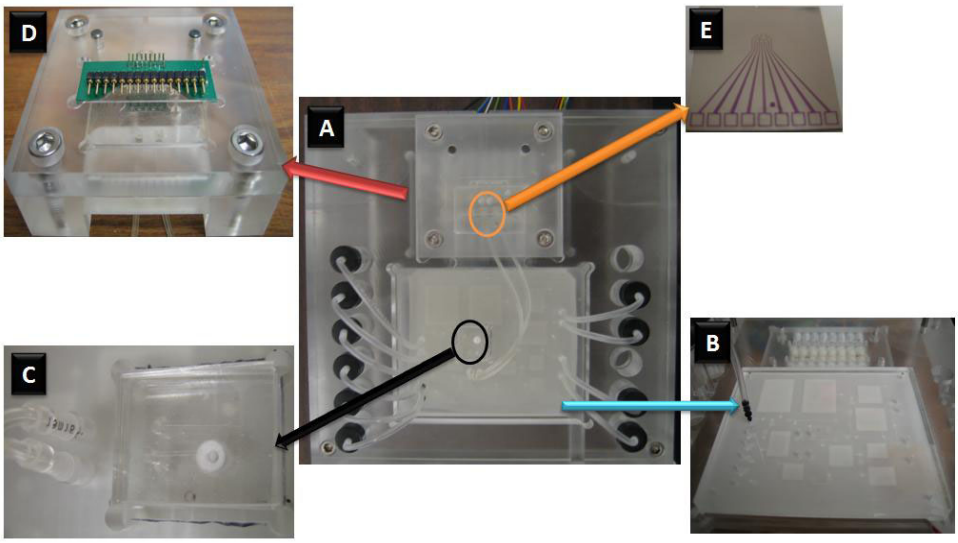

Figure 2. (A) A nanobiosensor integrated with microfluidic sample preparation components. (B) Microfluidic system for controlling microvalves and pumps (C) Microfluidic silica cartridge for RNA extraction (D) Electrochemical sensing platform. (E) MWCNT-EC chip

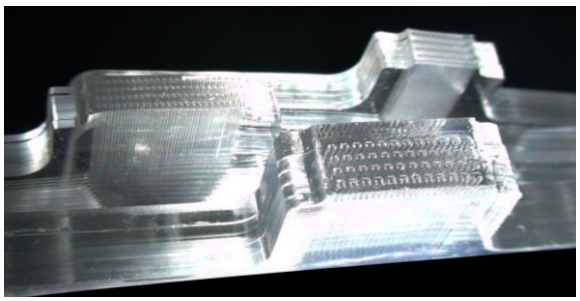

Figure 3. (A) Close up of the tips of microfluidic protein printing devices. The devices can be used to print 48 or 96 spots simultaneously.