AUTOMATED MICROFLUIDIC CARTRIDGES FOR POINT-OF-CARE CELL COUNTING

S. Smith[1], P. Madzivhandila[1], R. Sewart[2], U. Govender[1], H. Becker[2], K. Land[1] and P. Roux[1]

[1]Council for Scientific and Industrial Research, SOUTH AFRICA and
[2]microfluidic ChipShop GmbH, GERMANY

ABSTRACT

This work presents microfluidic cartridges for automated blood cell counting towards a point-of-care (POC) full blood count (FBC). Total white blood cell count (WBC) and red blood cell count (RBC) tests were implemented using low-cost, disposable and mass producible microfluidic cartridges with automated sample introduction and processing steps for visual microscopy cell counting to be performed. Results across 10 WBC and 10 RBC cartridges compared well with gold standard FBC results and were within acceptable error ranges.

KEYWORDS: Microfluidic cartridges, Point-of-care diagnostics, Cell counting

INTRODUCTION

FBC tests are often the starting point in patient diagnosis and are thus of great benefit at the POC. Microfluidic-based developments have investigated POC blood cell counting or FBC tests, but often make use of impedance measurements or other complex techniques. Commercial systems such as HemoCue® are available, but require a separate instrument for each type of test. The need for a low-cost, integrated FBC at the POC remains, which this work begins to address through the development of low-cost microfluidic devices and compact, multi-purpose instrumentation.

EXPERIMENTAL

Modifications to an initial microfluidic cartridge design [1] were made to enable accurate blood sample and reagent dilutions and mixing to be achieved. Figure 1 shows an example of the injection molded microfluidic cartridge with blister pouches utilized for on-board reagent storage (a), as well as the portable set-up that was implemented for actuating the microfluidic cartridges (b).

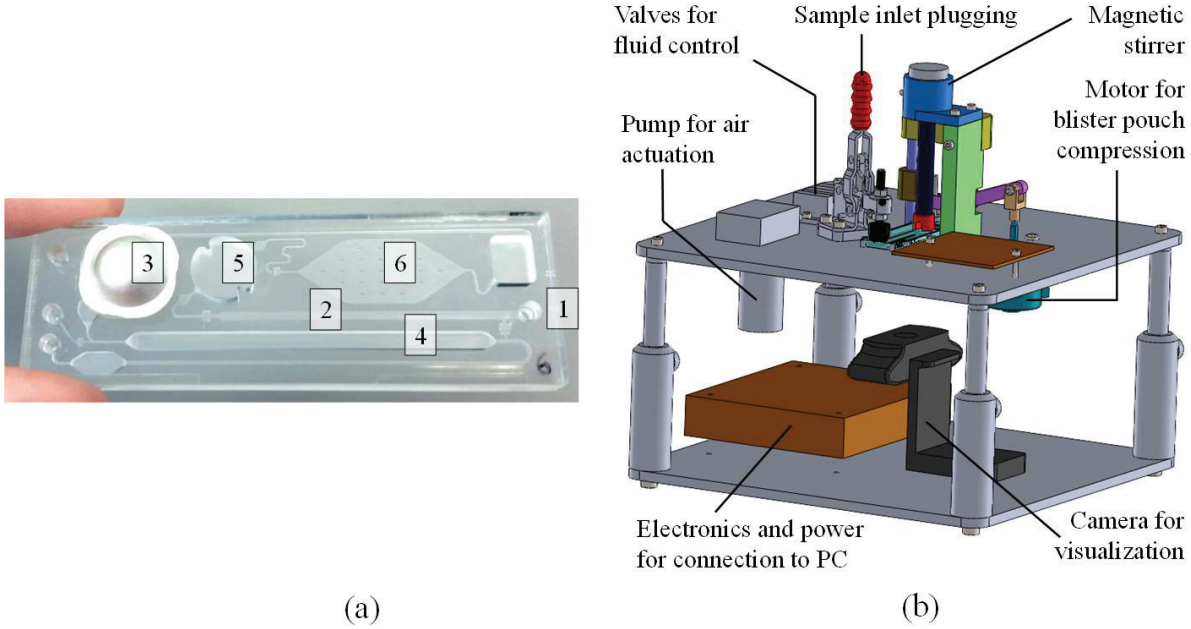

Figure 1: (a) Injection molded microfluidic cartridge for cell counting, showing 1) blood sample introduction and 2) blood sample metering, 3) blister pouch for on-board reagent storage and dispensing, 4) reagent metering, 5) mixing of sample and reagent, and 6) chamber for visualization and cell counting. Cartridge dimensions: 75.5 mm × 25.5 mm × 3mm. Cartridges and blister pouches were manufactured by microfluidic ChipShop GmbH. (b) Drawing of portable test set-up for control and testing of microfluidic cartridges.

Cell count estimates were obtained using automated microscopy analysis methods [2] for 10 WBC and 10 RBC cartridges and were compared to the widely accepted hemocytometer method for cell counting. A manual cartridge test was carried out using a pre-diluted and pre-mixed solution of blood and reagent dispensed into the cartridge to mimic a hemocytometer result. Comparisons were also made against gold standard FBC results obtained from a pathology laboratory, and WBC results were also compared to the HemoCue® WBC DIFF System.

RESULTS AND DISCUSSION

Results and comparisons are summarized in Figure 2, with internationally accepted performance limits indicated. These are based on values from the Clinical Laboratory Improvements Amendments (CLIA)-88. For WBC and RBC, error ranges of up to 15% and 6 % from the true value or FBC result are acceptable, respectively [3]. The average automated cartridge results for WBC lie just outside this range (15.8%), while the average RBC results lie well within the range (2.6 %).

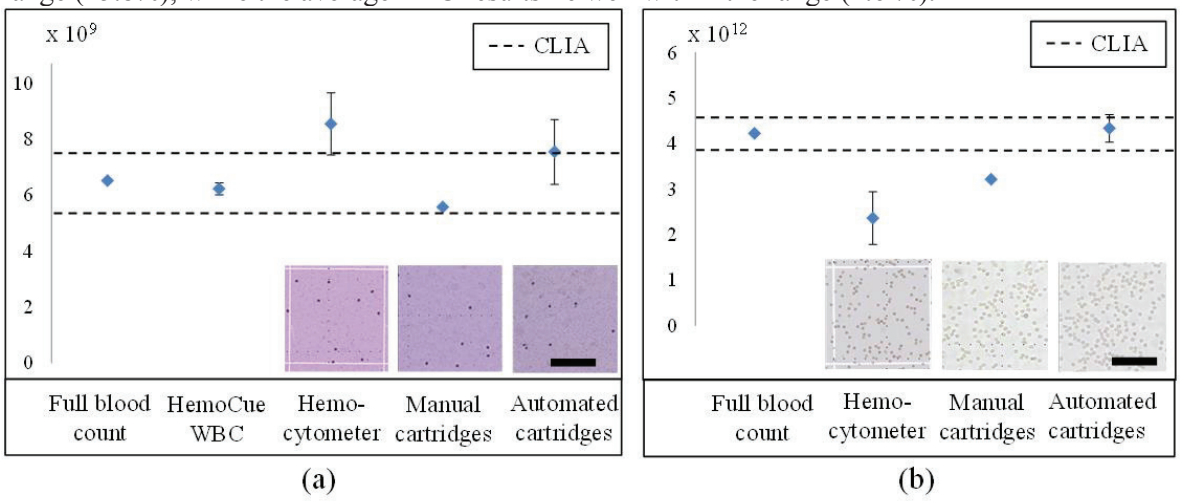

Figure 2: (a) WBC and (b) RBC results, with representative microscope images. Acceptable error ranges for cell counts/L are indicated for the CLIA standards. Scale bar = 0.5 mm.

CONCLUSION

Future work will include testing larger numbers of cartridges and further scale down of the actuation set-up. The functionality of the blood cell counting microfluidic cartridges can be extended to platelet counting and potentially hemoglobin analysis with few design changes, towards a POC FBC system, ultimately aimed at under-resourced settings where the need for such tests is greatest.

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CONTACT

* S. Smith; phone: +27-12-841-3101; ssmith@csir.co.za