Rotary Planar Peristaltic Micropump (RPPM) and Rotary Planar Valve (RPV) for Microfluidic Systems

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Summary

A Vanderbilt University research team led by Professor John Wikswo has developed low-cost, small-volume, metering peristaltic micropumps and microvalves. These pumps and valves can be used either as stand-alone devices incorporated into microfluidic subsystems, or as readily customized components for research or miniaturized point-of-care instruments, Lab-on-a-Chip devices, and disposable fluid delivery cartridges.

Addressed Need

A major challenge when translating microfluidic and Lab-on-a-Chip technologies into marketable devices is the controlled movement of small volumes of fluids. The present RPPM and RPV technologies provide a low-cost solution to this problem. These technologies have minimal hardware needs, reduce dead space in the device design, minimize microfluidic interfaces, have low time lag, and can be made at low cost.

Technology Description

While most peristaltic pumps squeeze a tube by driving rollers around a bent piece of flexible tubing, the Vanderbilt RPPM rolls caged balls over a microfluidic channel the same way one would roll an apple in a circle between one's hands. Traveling peristaltic compression of a fluid-filled channel is created by the rotational translation of steel balls (4) guided by a floating, circular plastic cage (3) to form a simple thrust bearing. The motor-driven disk (1) has an elastomer washer (2) matched to the elastomer layer (5) that seals the microfluidic channel (6) in the microfluidic device (7). The low-cost pump motor and drive head (1-4) can be fabricated independent from the disposable, sterilizable microfluidic cartridge (5-7). Configuration of the channels radially rather than circumferentially converts the device into a Rotary Planar Valve (RPV) that can be used to select between different on-chip flow paths at a much lower cost than competing technologies.

Unique Properties and Applications

- RPPMs can deliver flow rates as low as a few hundred nL/min to tens of µL/min against pressure heads as high as 20 psi, at ~1/10th the cost of standard commercial peristaltic microfluidic systems
- The microfluidic design, pump dimensions and rates, and valve configurations can be easily customized for specific applications
- RPPMs and RPVs can be easily incorporated directly into a disposable microfluidic chip
- Motors in the devices can be powered by a small rechargeable battery without the need for bulky pneumatic controllers
- Rollers can be used for higher flow-rate pumps

Technology Development Status

Prototype devices have been manufactured using multiple different stepper motors and DC motors. Furthermore, RPPMs have been cycle tested without failure for over 2.5 million revolutions.

Intellectual Property Status

- Awarded: US 9,618,129
- Application: US 20130287613
- Video Demo: https://youtu.be/N_jb4OrEeFM

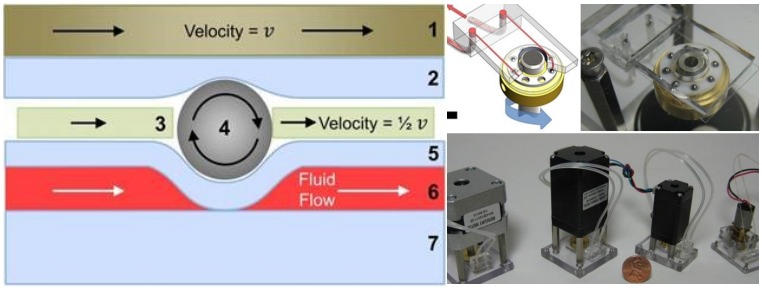

Figure 1: (Left) A cross-sectional schematic of the RPPM ball-drive concept is shown. (Right) various prototypes of RPPMs and RPVs are shown with a penny for scale.

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