

# HANDLING OF SOLID SAMPLES WITH MICROFLUIDIC TECHNOLOGY FOR END-TO-END ANALYSIS IN A SINGLE DEVICE. M. F. Mora<sup>1</sup>, A. M. Stockton<sup>1</sup>, and P. A. Willis<sup>1</sup>, <sup>1</sup>Jet Propulsion Laboratory, California Institute of Technology.

**Introduction:** Despite multiple orbiter and landed missions to extraterrestrial bodies in the solar system, including Mars and Titan, we still know very little about the detailed chemical composition and quantity of organics and biomolecules present. For *in situ* chemical analysis on astrobiological targets, instrumentation must be extremely sensitive and capable of analyzing a broad range of organic molecules. Microchip capillary electrophoresis ( $\mu$ CE) coupled to laser-induced fluorescence (LIF) detection provides the required sensitivity and targets a wide range of relevant organics while offering low mass, volume, and power requirements. One of the key aspects essential for *in situ* analysis is automation. On-chip handling of liquids is uniquely solved by integration of pneumatically-actuated monolithic membrane valves in microdevices. These microvalves are fabricated in glass/polymer hybrid wafer stacks and coupled to  $\mu$ CE-LIF. We demonstrated automated end-to-end analysis of amino acids in a liquid sample employing a microdevice designed in our laboratory. The device performs automated sample processing (labeling, dilution, standard spiking) and electrophoretic analysis by routing sample and buffer to a microchannel. The entire process was exclusively controlled via computer and the only intervention of the operator was to place the solutions in the reservoirs prior to beginning the experiment. To our knowledge, this is the first demonstration of a completely automated end-to-end  $\mu$ CE analysis of amino acids on a single fully-integrated microfluidic device.

Although these capabilities offer unique possibilities for handling of fluids by *in situ* instruments, the analysis of solid samples would currently require the integration of a separate system to handle the sample and perform liquid extraction. This addition of a separate system for extraction of solid samples would increase the size of the instrument and also its power requirements. Conversely, by integrating the manipulation of solid samples into the same microdevice employed for the chemical analysis, end-to-end analysis can be performed by a much simpler and smaller instrument. This is the goal of the work described here. We have conducted proof of concept demonstrations for storage, manipulation and extraction of solid samples on chip. In order to manipulate fluids, microdevices were designed with the pneumatic and fluidic features etched in different layers of the device so fluid could only move through one of the layers (fluidic). In order to introduce solid sam-

ples into the microchip and to create an extraction chamber, we have modified the traditional architecture such that there are some pneumatic connections on both layers of glass and also liquid can now move from one layer to the other one (Figure 1). The extraction chamber is also a valve itself, such that the actuation of the membrane would allow rapid mixing and agitation of the solid sample with the extraction solvent. In this new configuration, two holes are punched in the PDMS layer where there are overlapping channels in the bottom and top layers. This way fluid can move from the top layer to the bottom layer and up back to the top again by passing through the PDMS hole. A frit is placed on one of the PDMS holes between the two layers so that solid sample can be trapped in the bottom layer while fluid can pass through the sample and the frit to the top layer after the extraction is performed. The solid sample is pulled into the microchannel simply by the suction force produced by actuating three valves (pneumatic pump) in the same way used to pump liquid.

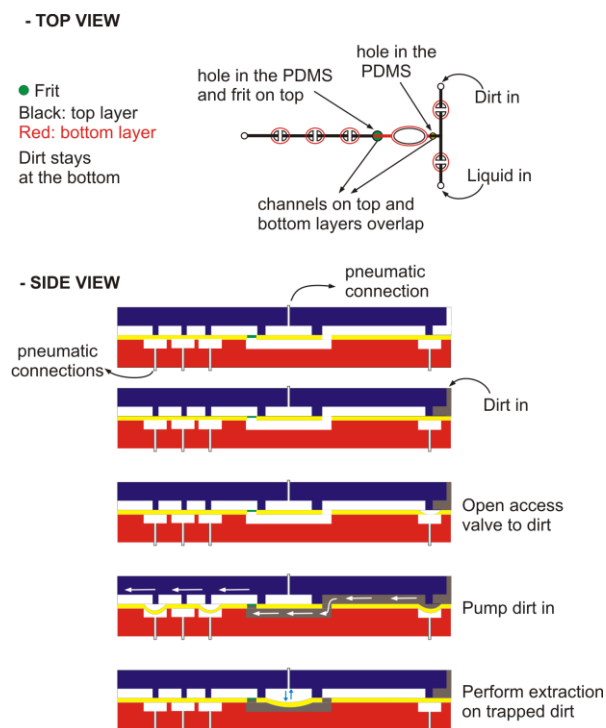


Figure 1: *Upper* - Top view of the architecture employed for trapping solid samples on chip to perform extraction and *Lower*- side view of the mechanism for trapping solid samples on-chip.

In order to demonstrate this approach we performed an experiment in which a solid sample was mixed with methylene blue powder before being introduced into the microchip. Following the trapping of the sample into the chip we pumped water through the system to demonstrate operation.

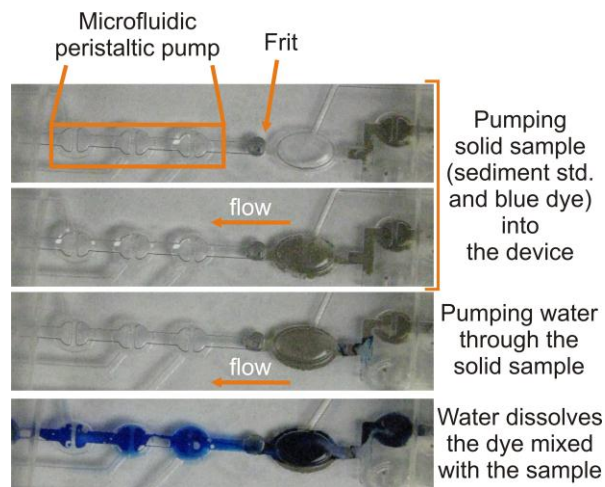


Figure 2: First demonstration of handling of a solid sample inside a microfluidic device.

Figure 2 shows the successful introduction of a solid sample and the following extraction of the blue dye from the sample by flushing water through.

In this presentation, the approach employed for integrating solid sample handling into microfluidic devices will be discussed as well as the most recent results on this project.