DYNAMIC MICROSCOPY IN SUBORBITAL FLIGHT. P. Todd[1], M. A. Kurk[1], J. C. Vellinger[1] and R.E. Boling, II.[1]
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Introduction: Suborbital low-gravity flights to the "edge of space" open new opportunities for laboratory research in low gravity utilizing the capabilities of the forthcoming generation of crewed space ships. There is an expected demand for rapid execution of low-gravity experiments, especially those in which fluids, biological cells or model organisms are involved. A portable, robust microscope will be a vital component of a wide variety of research designs. Two configurations of light microscopy systems are presented here as potential tools for crew members aboard suborbital space ships.

Discussion: The technology described herein had its origins in a completed Phase II SBIR project conducted by Techshot , Inc. for NASA Glenn Research Center. The project culminated in two deliverable models of the product, which was named "Dynascope". One of the instruments consists of a platen equipped with four reservoirs and valves, two piezo pumps, a hollow slide for samples, and three selectable dynamic elements: electric field, magnetic field and heater (Figure 1).

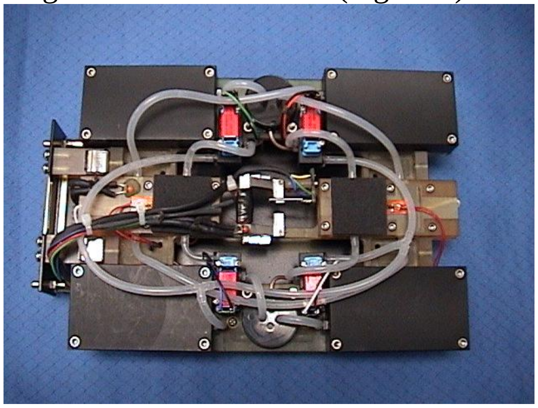

Figure 1. Dynamic microscope platen designed to fit the geometry of standard microscopes. It can be used to apply electric and magnetic fields to samples, thermal control and real-time fluid changes. The platen is 176 mm x 127 mm (6.9" x 5.0").

This device includes a controller for the platen components that controls hardware and software interfaces (Figure 2).

Figure 2. Electronics interface for fluidics controls and image acquisition. The dynamic microscopy platen is seen on the far right. The software environment provides users with opportunities to design, optimize and operate their experiments.

The other instrument (Figure 3) is a self-contained microscopy unit capable of recording time-lapse images of particles or cells or interfaces under dynamic investigations, such as applied magnetic or electric fields, moving interfaces, self-assembling systems or living cells.

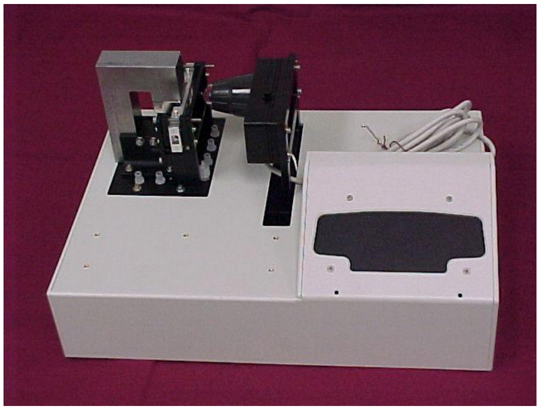

Figure 3. Self-contained version of dynamic microscope for video recording of hydrodynamic, gravitational, magnetic, electrokinetic, interfacial and swimming motion, built into a small-footprint housing.

The mounted USB video microscope is focused and scanned by computer-controlled stepper motors. Fluidics and control circuits are located in the housing.

Hollow slide. At the heart of the technology is a hollow glass slide. Commercial rectangular extruded glass (borosilicate or fused silica) with a 4.0 x 0.4 mm cross section is ideally suited for most anticipated applications. Figure 4 shows an exploded view of a version of a holder for hollow slides. Considering their composition and their shatter characteristics, the hollow slides are embedded in a protective holder that still allows the close approach of a high-magnification microscope objective. The hollow slide is an exchangeable, disposable element of the platform. Its own reservoirs are fed from the four reservoirs on the platen (Figure 1) or within the self-contained unit using two micro pumps and four microvalves.

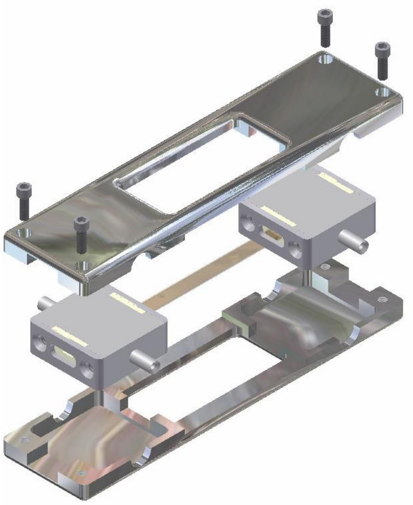

Figure 4. Hollow slide holder. Exploded view of components showing fluid reservoirs "headers" at each end of the hollow slide and embedded into stabilizing holder. Each header has an inlet and an outlet.

Application example. Figure 5 is a photo taken with the device. It shows the interface between two immiscible liquid phases and suspended particles undergoing extraction from the right phase into the left phase. Interfacial experiments represent one category of microgravity science served by microscopy.

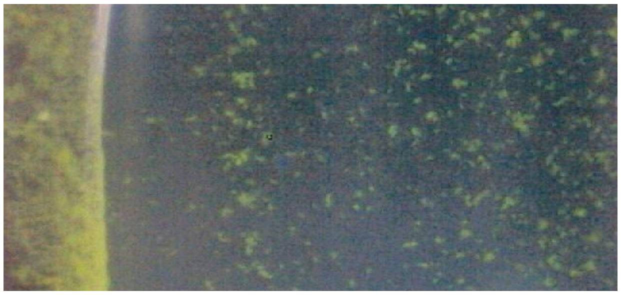

Figure 5. Video micrograph of a two-phase system in the hollow slide showing dynamics of extraction of particles from the right phase into the left phase.

Summary Comments: The technology is especially applicable to life sciences experiments in brief low-gravity episodes. The ability to change fluids in cultures of living cells under the microscope, suitably enough, originated with Charles Lindbergh [1, 2], and today, low-cost, temperature-controlled perfusion units for observing living cultures by microscopy are readily available commercially for ground-based observations (for example: Bioscience Tools, San Diego, CA). Typically such systems are observed using an automated camera and time-lapse microscopy, which we prefer to call "dynamic microscopy" because in most experiments the experimental system is subjected to temporal modifications by the investigator (robotically) and not just passively observed by the microscope, and a suitable name for the instrumentation would be "Dynascope".

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References: [1] Carrel, A. and Lindbergh, C. A. *The Culture of Organs.* Paul B. Hoeber, Inc., New York (1938). [2] Lindbergh, C. A. 1939. J. Exper. Med. 70, 231 (1939).