A μsensor array in a fluidic system for space applications

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0. ABSTRACT
The development of a hybrid integration method for a multi μsensor array unit in a fluid channel on a breadboard is presented. The method is illustrated by means of the fabrication of a demonstrator micro fluid analysis system, also called a Micro Total Analysis System (μTAS), containing a pressure-, temperature-, pH-, pO_2 and pCO_2-sensor. This system is designed for a multi-user and multi-purpose application in life science, biotechnology research, and life support systems according to the technical requirements for space.

1. INTRODUCTION

Over the past few years there has been an increasing interest in the development and realisation of miniaturised total analysis systems (μTAS) [1-3]. This growth is partly due to the rapid developments in fluid handling devices such as micropumps, -valves, -filters and -mixers [4], but is also explained by the need for complex (bio)chemical sensor systems with integrated self-test and calibration features. This has led to attempts to fabricate miniaturised flow systems [2,3] and microfabricated parts for separation systems. However, since such systems typically would comprise a variety of components, materials and technologies, considerable attention should be paid to the integration-concept of such systems. The two extreme forms of integration are hybrid and monolithic. An example of a completely hybrid analysis systems is the stacked phosphate analyser, as developed by Van der Schoot *et al.* [2], whereas the liquid dosing system of Lammerink *et al.* [5] is an example of a monolithic system. In practice, most systems will consist of a combination of these two forms. In [6], Lammerink *et al.* showed a concept that enables a modular mixed integration of different system components or subsystems on a planar backplane: the Mixed Circuit Board. This MCB serves at the time as mechanical support for the system components (modules), it has the necessary electrical connections (Printed Circuit Board) and contains the microchannels for fluid transport connecting the different modules (Channel Circuit Board).

Standardization of components, materials and technology is important to make the modular concept successful. One of these issues is a general connection technology from components to the planar backplane or carrier. In this project the development of such technology that enables with fluid tight sealing, mechanical support and electrical contact of sensors, is presented and illustrated by means of a demonstrator μTAS.

2. SYSTEM

An overview of the system layout is given in figure 1. The system has (on a flow system board) a conventional miniature pump and valves together with the sensor array carrier containing the micro channels and micro sensors. Analog electronics for sensor read-out are located on a separate printed circuit board which can be stacked under the flow system board. Control is done with a PC and belonging AD control electronics.

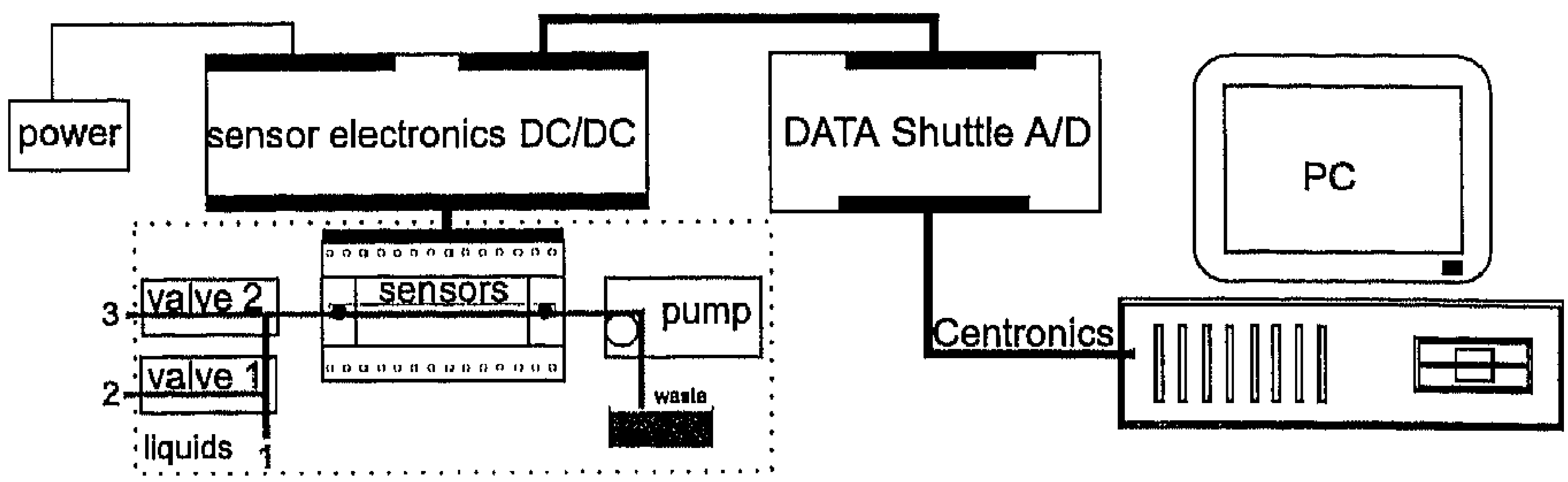


Fig. 1 System configuration.

2.1 sensors

The sensors used to demonstrate the technology are a capacitive pressure sensor, a temperature sensor, a pH ISFET and a chip containing the pO_2 sensor together with a pCO_2 sensor. Figure 2 shows a chip (4.8 x 6 mm) containing two ISFETs. The ISFETs contain a Ta_2O_5 layer on the gate for maximum sensitivity and minimum drift. On one of the two ISFETs, polymers are deposited and patterned to create a longer diffusion time [7]. During this time, the pH is measured differentially between the fast and slow response ISFET [8].

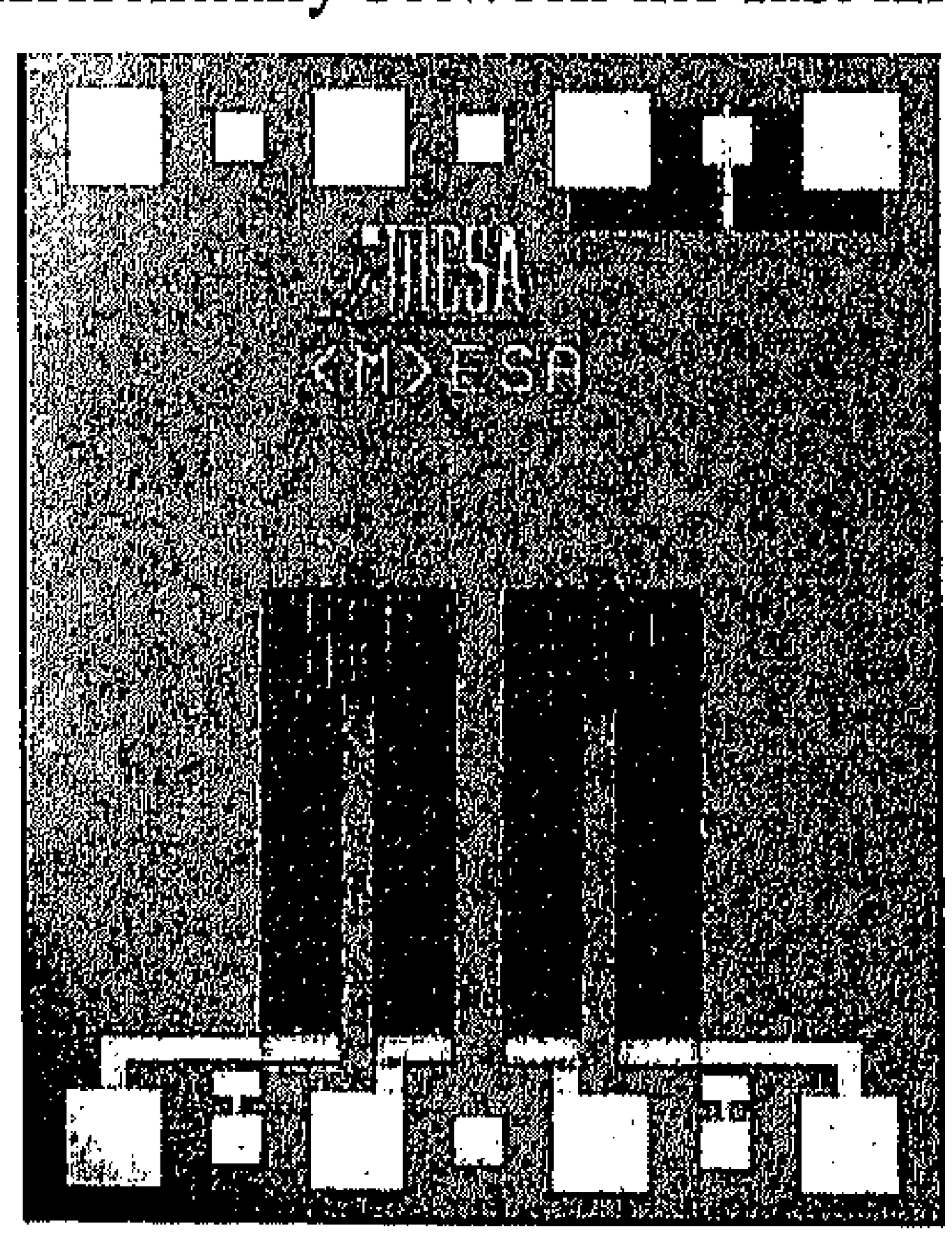


Fig. 2 Photograph of dual ISFET chip.

2.2 sensor carrier

The sensor carrier contains the sensor chips (pH, pO_2, pCO_2, P and T) on top and *fluid channels* inside (see fig. 3). It consists of a silicon layer with etched holes anodically bonded on a glass layer with machined channels. The channels have a minimum of sharp corners to prevent places with low-velocity of the fluid.

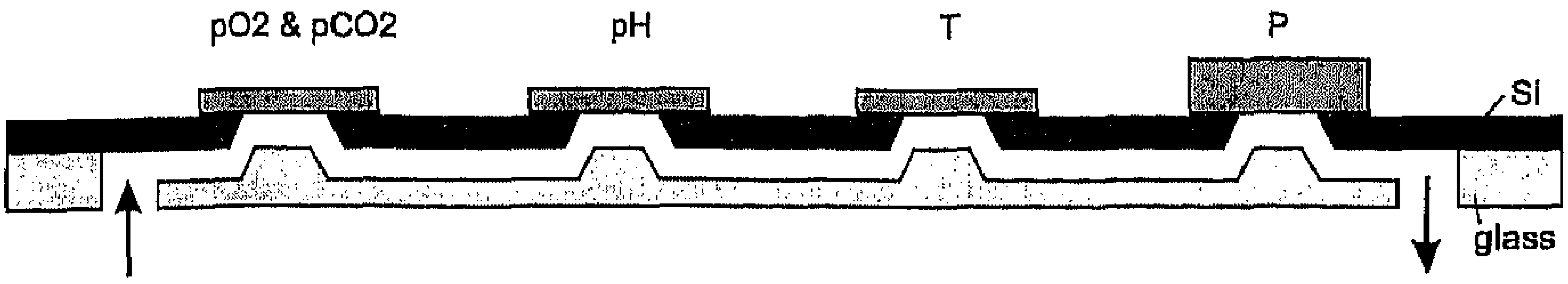
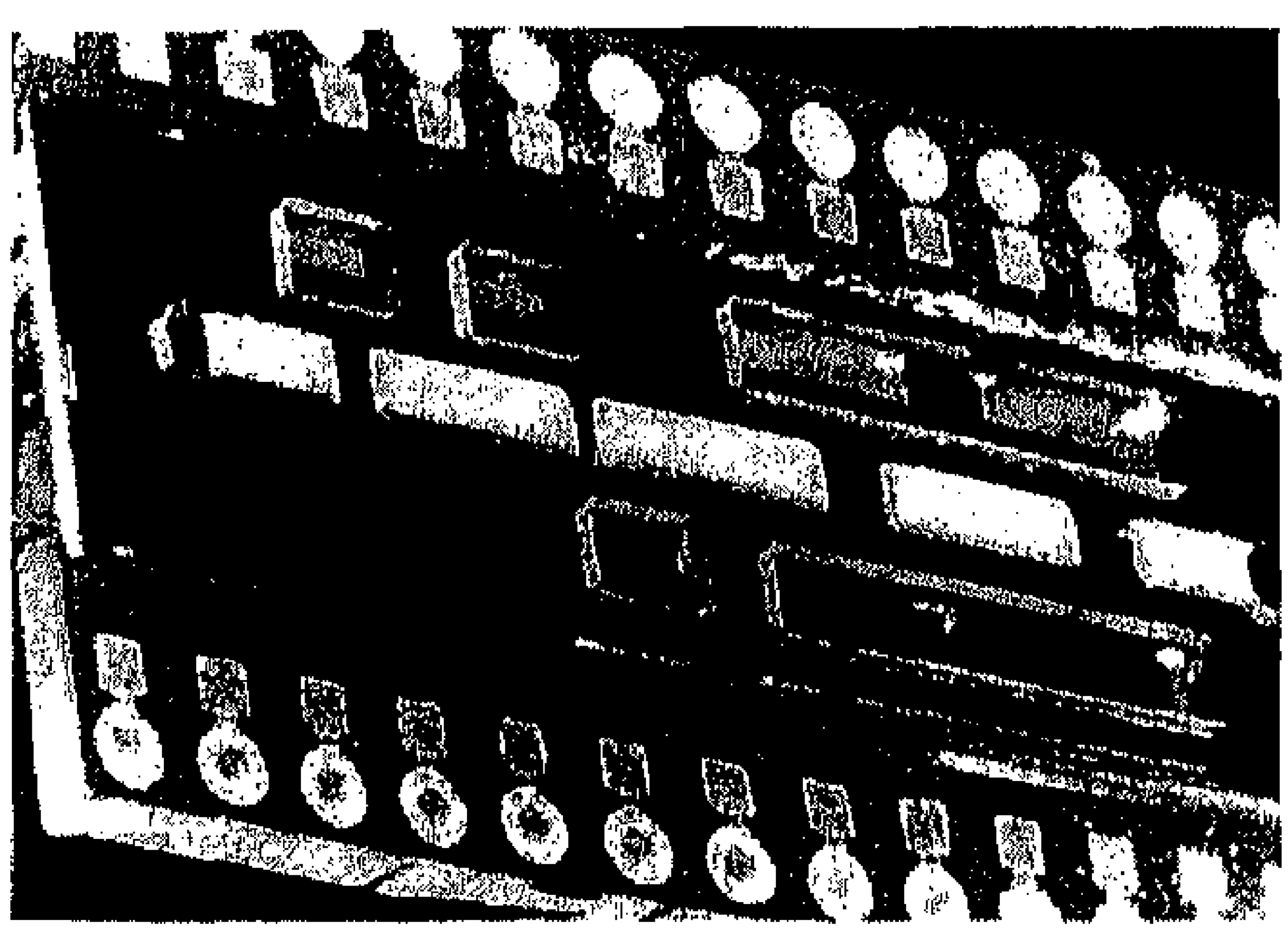


Fig. 3 Cross section of sensor carrier.

The sensors are sealed with epoxy to the glass/silicon substrate, while holes in the carrier allow wire bond connections (fig. 4 and 5). The epoxy is deposited by a programmable dispenser, after which the sensors are placed by a pick and place machine. The bio-compatible epoxy is room-temperature curable.
In a next generation the electrical contacts will be made by a kind of flipchip bonding technique, and this technology is then integrated with the sealing technology in one contact step. The holes in the carrier are not required anymore in that case.



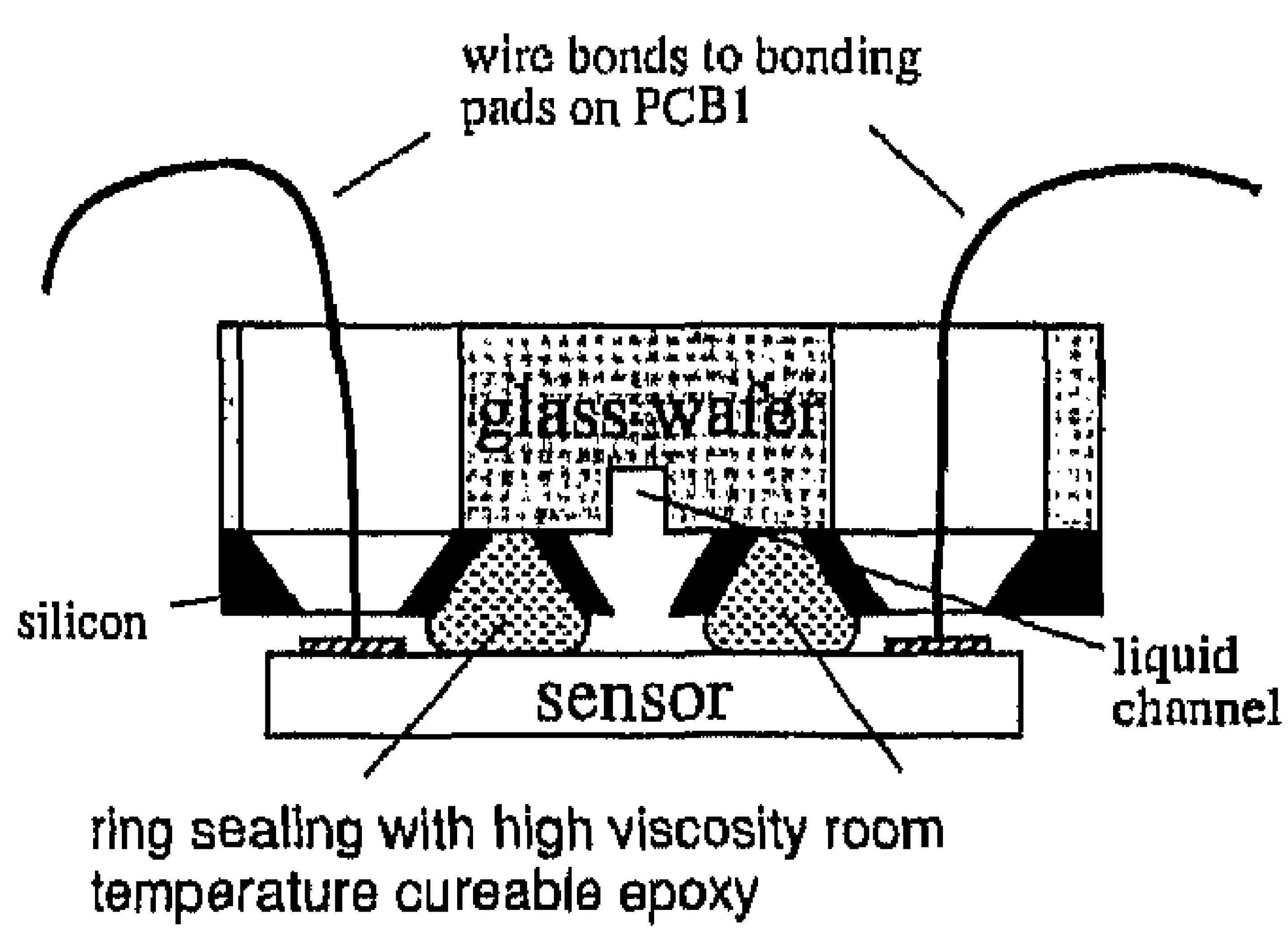


Fig. 4 Photograph of Si-glass sensor carrier. *Fig. 5 Sensor to carrier connection technology.*

2.3 flow system board (credit card size)

The flow system consists beside the carrier of 2 valves and a pump, connected by tubes (fig. 6). By switching the valves, sample-peaks can be injected in a (calibrant) carrier fluidic. Pump and valves are (semi-)commercial miniatures.

2.4 analog electronics; AD control electronics and PC

A printed circuit board with the *analog electronics* for sensor read-out is connected to the flow sensor board. The electronics and flowsystem can be stacked, or connected via a flatcable to separate electronics and fluids.
Control and read-out is done with the software package MS Visual Basic under windows.

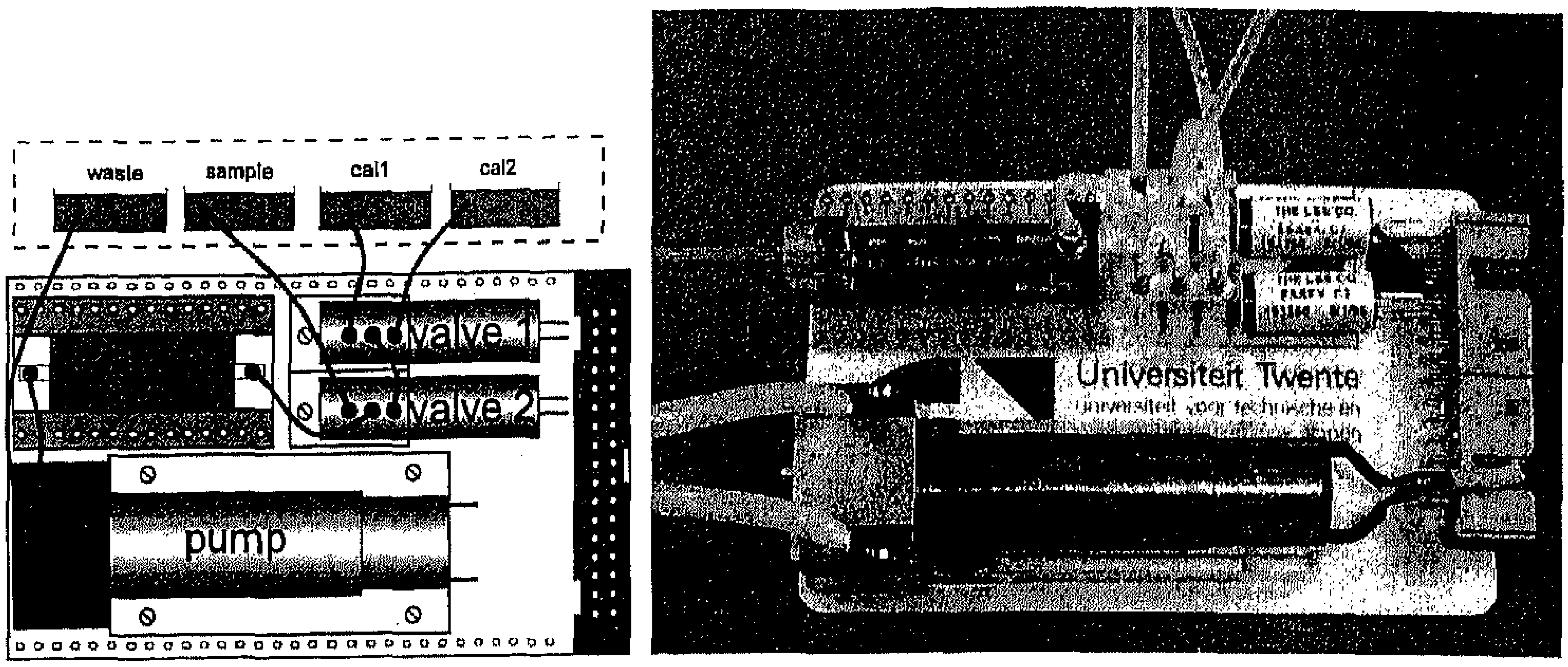


Fig. 6 Layout and mock-up of flow system board with components (credit card size).

3. CONCLUSIONS

The development of a hybrid integration method for a multi μsensor array unit in a fluid channel on a breadboard is presented. A demonstrator micro fluid analysis system is designed and fabricated according to the technical requirements for space. The biotechnological experiments are carried out in the direct future.

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