

MATAS – An Inexpensive, Flexible and Modular Approach for MicroFluidic Systems

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Introduction

The possibilities promised by microfluidic systems have not only interested scientists, but also industries, especially in the areas of the Life Sciences (food, medical, biotech) and fine chemistry (pharma) [2]. Microfluidics is the MEMS-field in which minute quantities of liquids or gases are manipulated, monitored, analyzed, and even processed. Microfluidics based instruments are capable of synthesizing and analyzing (bio)chemical materials at very high throughputs and against reduced costs. These decisive benefits are enabled by the reduced consumption of reagents, shorter temperature cycling times, faster mixing, and the high degree of automation possible compared to conventional equipment. Referring to the size of microfluidics based systems, they are often called *Lab-on-a-Chip* systems.

Lab-on-a-chip systems

Roughly, one can distinguish two main areas in Lab-on-a-chip based systems. In the first place there are the so-called *biochips* of glass or polymer, which have passive fluidic functions and which are being applied in combination with bulky laboratory equipment providing functions such as sample and reagent supply, high voltage control for electro-osmotic pumping, and optical (fluorescence) detection. On the other hand, there is the emerging area of *true* lab-on-a-chip systems, in which all, or at least the main, functions are combined in a complete (sub)system (Fig. 1). Somewhere in-between are the so-called *micro-arrays* having an integrated detection function and which can be applied in combination with a desktop apparatus, having functions such as sample preparation and supply.

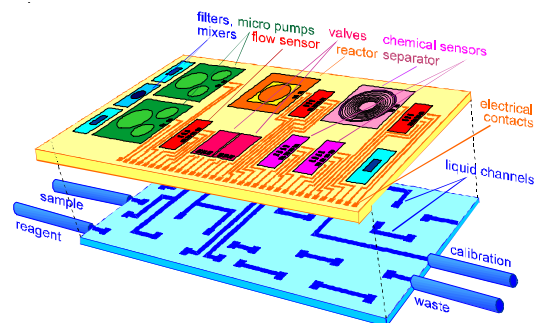


Fig.1 Artist impression of a hybrid μ TAS dating from the mid 90's.

Applications

This revolutionary Lab-on-a-chip equipment is being introduced rapidly. In pharmacy and genomics, for example, experiments can be performed by thousands in parallel resulting in more efficient discovery of new drugs and the accelerated unraveling of the human genome (*high throughput screening*) [1]. In fine chemistry, the optimization of process parameters and production of small quantities is performed in the very same system, bypassing the expensive up scaling stage (*process-on-a-chip*) [2]. Other emerging applications are in medical, clinical and other analysis instrumentation. The range of possible applications for a quick, cheap and portable analysis of any liquid or air sample is beyond imagination; it can give the information technology world electronic taste and smell, monitor water quality in-line everywhere, check for alcohol or drugs in blood or breath on the spot, and many more.

'True' Lab-on-a-chip systems

This article will focus on the emerging area of *true* lab-on-a-chips and a modular and hybrid approach, *MATAS*, with which complete systems can be realized in a flexible and economically feasible way. *MATAS* is based on established technology, procedures, and

materials and makes for a short *time-to-market* possible (Fig. 2).

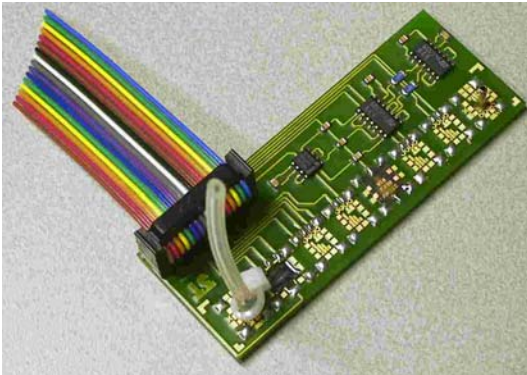


Fig.2 A top view of the entire circuit board, which is about 8 x 3 cm in size.

MATAS Technology

MATAS stands for Modular Assembly Technology for micro Analysis/synthesis Systems and is being developed in the framework of a series of projects [4, 5, 6, 7, 8]. The essence of the MATAS technology is a series of modules designed to fit a class of components (micro fluidic functions, sensors and actuators, etc.) that fit into recesses in a surface mounted technology (SMT) based printed circuit board. The board thus becomes a housing for both electrical and the fluidic circuits (Fig. 3 and 4). Figure 5 shows how the modules fit precisely into the circuit board.

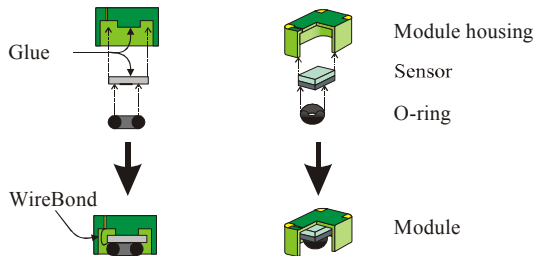


Fig. 3 Example of a module for a front sided contact sensor type [5].

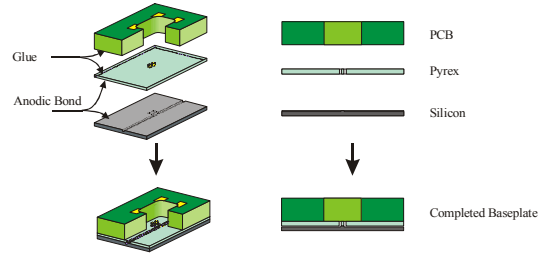


Fig 4 Example of a wet circuit board, where the modules will be mounted [5]

Assembling the board involves simply putting the modules in place, as if assembling a simple jigsaw puzzle. Electrical and mechanical connections are made by soldering. The integrity of the fluidic interconnections are assured by small O-rings. All dimensions in the modules are chosen to be easily within the tolerances of the technologies used. The O-rings provide the ability to correct for the different tolerances of the surface mounted technologies used for the layout and the microsystem technologies used for the components.

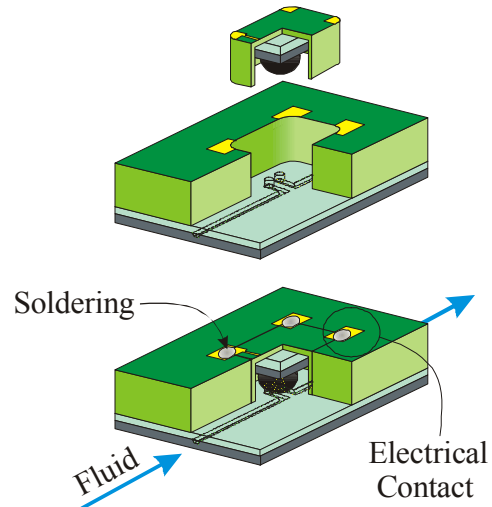


Fig. 5 Assembly drawing of the modules and the wet circuit board.

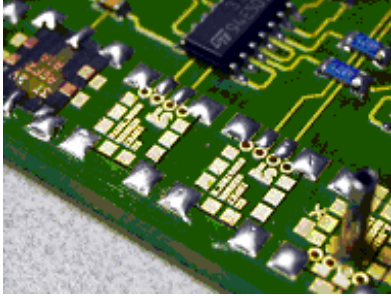


Fig. 6 Modules applied in a water hardness detector μ TAS [6]. The module on the left is a thick film reference electrode, the two in the middle are a sodium and a calcium module and the right module is an input/output module.

The electrical layout is situated on one side of the system (Fig 6 and 7). The technology used to interface the components electrically and to fix and align the modules mechanically is situated on this side of the board. The fluidic circuit is situated at the other side of the system, making the total system a planar system (Fig. 8). The fluid interconnection between the modules and the fluidic layout is done between the fluidic part and the electrical part; by O-rings inside the system. The fluidic part can be made in any technology of any material, as long as the SMT tolerances are kept.

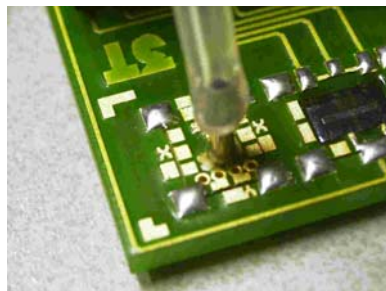


Fig. 7 Close up of an input/output module connected to a tube to interface the 'macro world'.

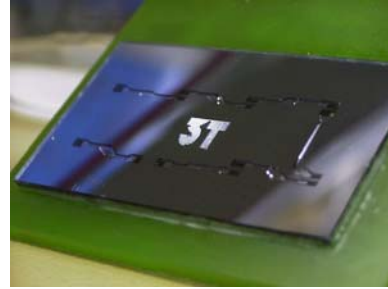


Fig. 8 Close up of the fluid side of the water hardness system. The fluidic part is realized in silicon, but it can also be plastic or polymer.

A demonstrator system is able to measure the electrical conductivity [8], pH [9], sodium and calcium concentrations [9] of a mineral water solution, while an integrated sensor controls the water flow (Fig. 9). Thanks to the very small volumes of solutions the system shows a very fast response on variations in e.g. pH and electrical conductivity reading (Fig. 10).



Fig. 9 The water test demonstrator. The different mineral waters enter the pinch valve board on the left, the liquid flows through the cell (attached on the valve board). The sensor signals are entered in the computer and processed on the screen (ACHEMA2000).

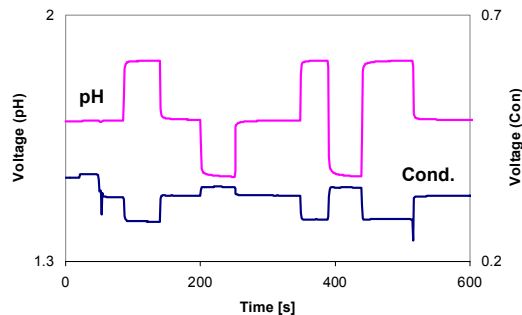


Fig. 10 pH and conductivity signals as a function of time for varying step inputs.

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