Technology and applications of microdosing systems

M. Richter, Fraunhofer Institution of Solid State Technololgies (EMFT), Hansastr. 27 d, 80686 München

Introduction

Micro devices especially for microfluidic applications can be applied to a wide variety of industrial solutions. Key components are micro pumps [1], microdosing systems, micromixers, microvalves, microreactors and flow sensors and their combination for the use in biotechnology, chemistry and medicine. Furthermore, applications in the field of lab technology and fuel cells can be addressed. Challenges in that field are addressing the improvement of the reliability, dosing accuracy and user safety by the integration of free flow protection, bubble point free filters and improved dosing accuracy to the micropump modules. Another trend is the development of complete systems, including electronics, sensors and system control.

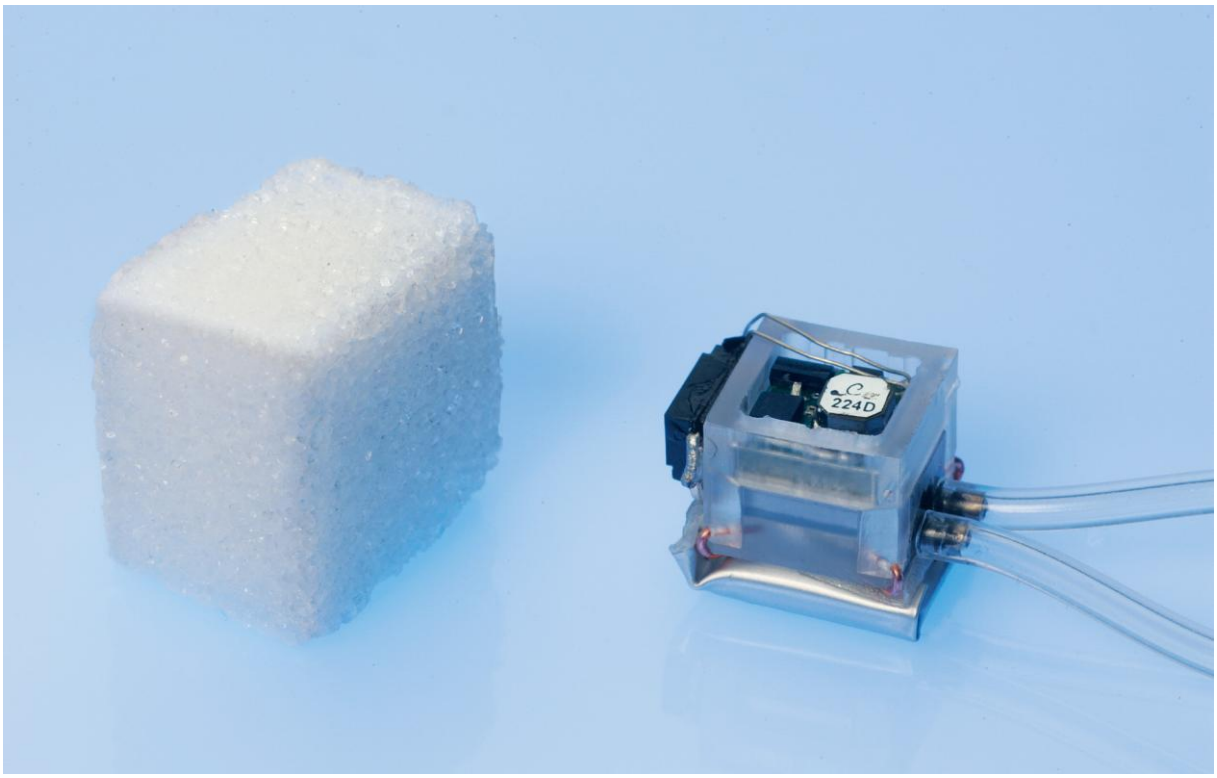

Fig.1: PumpCube compared to a sugar cube. The system comprising a silicon micropump chip, driver electronics together with micro controller, silicone gasket, fluidic carrier, and battery. The PumpCube is the smallest pump system worldwide.

Black Box strategy

Piezoelectrically driven microfluidic actuators like micropumps can be used in many applications. Requirements like dosing accuracy, back pressure independence, small size, low energy consumption, particle resistence and free flow protection are leading to new technolocical solutions to develop the micropump from a demonstrator to a industrial product. The user of the micropump is expecting a complete solution from the developer solving all of these requirements. This “black box”approach will be realised solving the requirements above helping the customer to launch new products.

Description of the „black box“

Dosing accuracy:

- Currently, a micropump will be realised with a very high compression ratio not known from other micropumps on the market. With that, the dosing accuracy will be independent to the presence on gas bubble in the pump chamber, which is one of the main reason limiting dosing accuracy of state of the art micropumps.

Dr. Martin Richter, Fraunhofer EMFT, eMail: martin.richter@emft.fraunhofer.de, Tel.: 089/54759-455

Back pressure independence:

- Micro diaphragm pumps are back pressure dependent. The pump mentioned above has additionally to the high compression ratio a stiff actuation diaphragm, with a stall pressure of several bar, for that this pump is nearly back pressure independent at low pressures.

Small size:

- The silicon micropump with a size of 7x7x1 mm^3 is one of the smallest pump of the world. Together with a very small driver electronic a „pumpcube“ system was developed, with a total size of less than 1 cm^3 including Battery and fluidic carrier.

Small energy consumption:

- The driver unit was optimised, the energy consumption is between 30 mW (standard pump) and 800 mW (high performance pump), dependent on piezo capacitance, driving voltage and pump frequency. These systems are ideal for battery driven systems.

Particle resistance:

- Particles pumped into the micropump by the pump itself can block valve flaps or actuation diaphragms, leading to a pump failure. Regulary, a hydrophilic filter with small pore size is needed. However, this filter will have a high bubble point, a large gas bubble can block the filter stopping the pump working. This problem was solved by a new patented filter without bubble point, which has no blocking pressure even if a large bubble is entering the filter.

Free flow protection

- In many applications, especially medical application, “free flow” must be prevented, if the reservoir is pressurised, no flow through the pump is allowed. At Fraunhofer EMFT several solutions were developed and patented, a “normally double closed (DNC)” micro valve, and a new safety valve. Both valves are passive and self blocking, the over pressure at the inlet is closing the valve

Flow sensors

- At EMFT several different flow sensor principles were investigated and developed. The most recent one is ideal for small flow rates was patented in 2010 and will be integrated currently into a drug delivery system. Here, volumes of 20 µl must be delivered with an accuracy of 3%.

Conclusion

Over all, considering these key issues for microdosing systems, reliable and accurate operation of microdosing systems can be realised, enabling many new industrial, consumer and medical applications.

[1] M. Richter, Micropumps – from the Lab to the fab, Actuator 2008, 11th International Conference on New Actuators, Bremen, Germany, 9-11 June 2008, pp. 204- 209

Dr. Martin Richter, Fraunhofer EMFT, eMail: martin.richter@emft.fraunhofer.de, Tel.: 089/54759-455