A Silicon chip based flow-through calorimeter for bio-chemical and screening applications

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Because of the universal nature of the heat power production of chemical reactions the measurement of the evolved heat opens up an elegant way to study directly elementary biochemical processes. However, highly sensitive calorimetric devices are necessary to obtain reasonable information from such kind of processes. For numerous applications classical calorimeters are not suitable for the study of biochemical processes because of their high materials and time consumption. The solution of the problem is to apply micro-sized calorimeters based on thermopile silicon chips. They are called chip or IC calorimeters [1]. The application of chip calorimeters is very promising: The investigation of very small samples is possible and the operation is much faster in comparison with classical calorimeters. Up to now different devices were used especially by the Freiberg group for the construction of chip calorimeters. A new chip device, which was developed at the IPHT [2], offers some advantages as for example higher sensitivity, lower time constants and improved mixing conditions for the fluidic reactants.

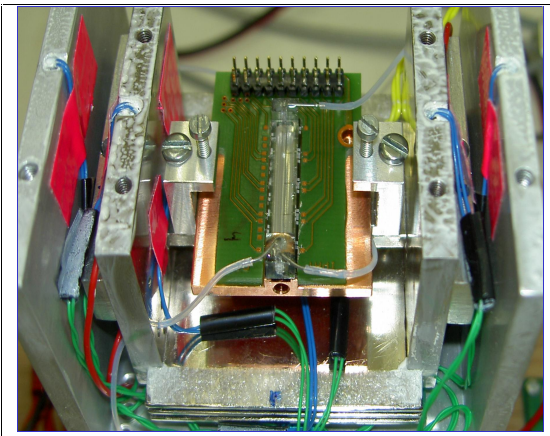

Fig. 1: Thermopile chip module inside the thermostat

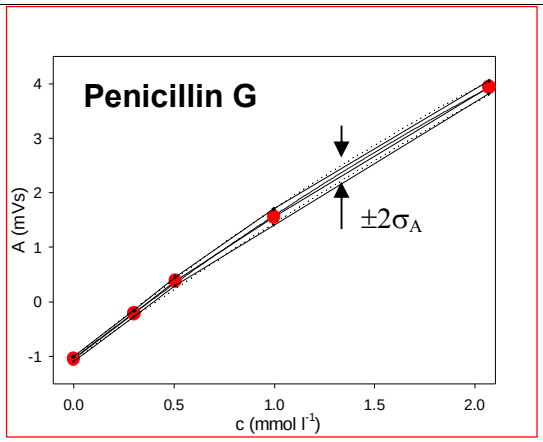

Fig. 2: Characteristic for the determination of penicillin applying an enzyme catalyzed reaction by impulse injection (A- area of the signal peaks).

The thermopile chip module is placed inside a two-stage thermostat with an temperature stability better than 100 µK (Fig.1). This extreme temperature stability is necessary if an heat power resolution lower than 100 nW has to be achieved. For the temperature control of the fluid flows micromachined heat exchanger are mounted at the inner stage of the µK thermostate. Typical volume flow rates are in the range of 10 – 30 µl min^{-1}. The calorimeter can be operated in continuous and impulse injection mode, respectively. Applying impulse injection mode, a minimum volume of only 15 µl is necessary for one measurement. The injection of the liquid reactants is performed by miniaturized piston pumps (LEE). Under laboratory conditions a base line stability of 70 nV could be achieved. This relates with an heat power detection limit of 20 nW assuming a sensitivity of approximately 3 VW^{-1}.

References

[1] J. Lerchner, A. Wolf, G. Wolf; *J. Therm. Anal. Cal.* 57 (1999), pp. 241-251.

[2] M. Zieren, R. Willnauer, J. M. Köhler; *4th International Symposium on Micro Total Analysis μTAS 2000,* May 14-18, 2000 Enschede, Netherlands.