

# Micro Calorimeter

Calorimeter

가 가

Micro Calorimeter

Physikalische Hochtechnologie

Micro

Calorimeter

Fig.1

Micro

Calorimeter

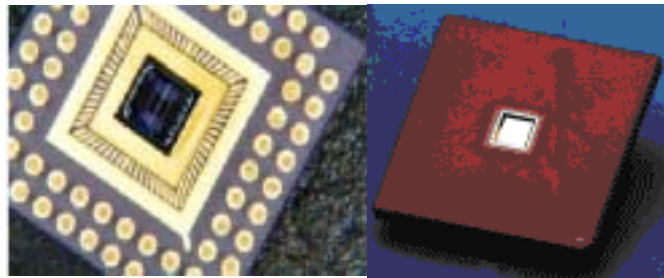


Fig. 1 Micro Calorimeter

Micro Calorimeter (100) silicon chip PMMA  
 (polymethylmetacrylate) chip 가 epoxy glue  
 Silicon chip Silicon nitride 1  $\mu\text{m}$  NaOH  
 22 mm x 2.5 mm free-standing 가 Free-standing  
 magnetron sputtering 0.1  $\mu\text{m}$  0.8  $\mu\text{m}$

가 .

$\text{Bi}_{0.87}\text{Sb}_{0.13}$  Sb 가 electron beam evaporation 0.4  $\mu\text{m}$

0.28  $\mu\text{m}$  0.135 mV/K . Micro

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thermocouple .

25.5 mm x 4 mm x 1 mm PMMA chip 24.5 mm x 1 mm x 0.5 mm

channel 가 3

. Silicon chip PMMA chip

Fig. 1 Micro Calorimeter .

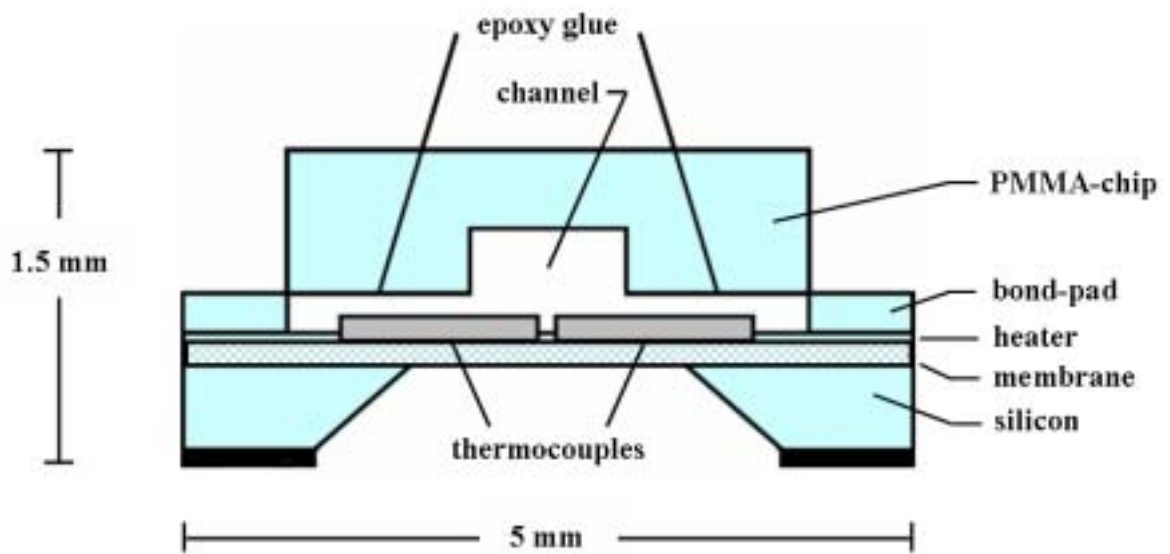


Fig. 1. Schematic cross-sectional view of glue-bonded silicon and PMMA chip.

## Experimental

Micro Calorimeter 가 table

nanovoltmeter .

Yokokawa 7651 . Syringe 4-way-  
 90°-valve .

1 μW 100 mW square-wave heat pulse

. Fig. 2 responsivity .

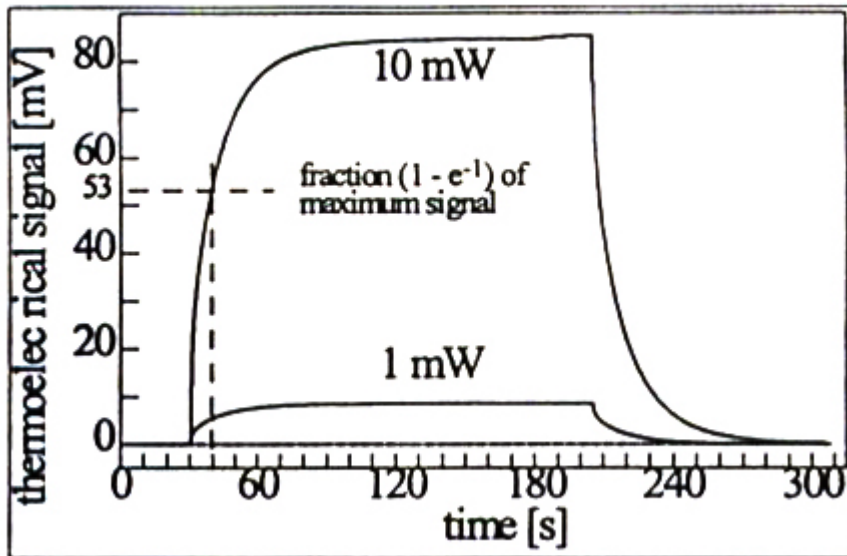


Fig. 2. Thermoelectrical response of MFK472-P on square-wave heat pulses of 1 and 10 mW

## Results

Joule heating

$$P_{\text{Joule}} = P_{\text{cond}} + P_{\text{conv}} = \Delta T / R_{\text{th}} + \rho C_p \Delta T V$$

$\rho$  : density

$C_p$ : specific heat capacity of the fluid

$\Delta T$ : the rise in temperature due to heating

$R_{\text{th}}$ : the effective thermal resistance

$V$ : the volume flow

Responsivity

$$S = n\alpha\Delta T/P_{\text{Joule}}$$

$$S^{-1} = (\rho C_p/n\alpha)V + 1/n\alpha R_{\text{th}}$$

n : number of thermocouples

$\alpha$ : thermopower per thermocouple

Fig. 3 Responsivity y x  
 total thermal power ( $n\alpha$ )=63.7 mV/K, thermal resistance( $R_{\text{th}}$ )= 135 K/W,  
 0 responsivity (S) = 8.56 V/W, ( $\tau$ )= 9.8 s

Table 1 glass Calorimeter

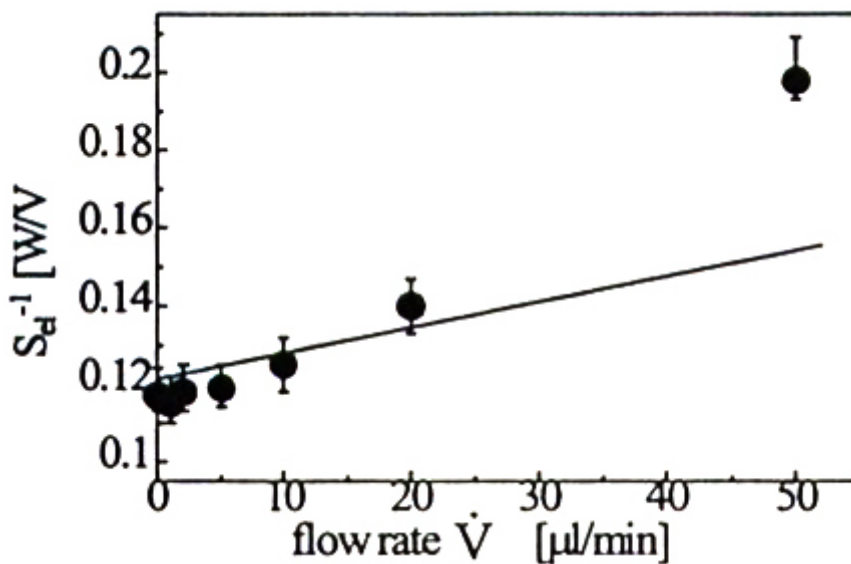


Fig. 3. Reciprocal responsivity vs. flow rate

Table 1. Data comparison of chip calorimeter

	<b>presented calorimeter</b>	<b>earlier calorimeter</b>
<b>cover chip</b>	PMMA	glass
<b>reactor dimensions [mm<sup>3</sup>]</b>	21 × 1 × 0.5	10 × 2 × 0.1
<b>reactor volume [μl]</b>	10	2
<b>number of thermocouples</b>	4 × 10	3 × 48
<b>total thermo- power [mV/K]</b>	63.7	19.44
<b>thermal resistance [K/W]</b>	135	150
<b>exp. responsivity at zero flow [V/W]</b>	8.56	4.3
<b>Time constant [s]</b>	9.8	2

Micro Calorimeter

2 μl

가 . Micro Calorimeter

10 μl

thermopower가 64 mV/K .