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Response of Resonating Microbridge Mass Flow Sensor

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This paper describes the response of a prototype resonating microbridge mass flow sensor. The flow channel is formed by the bonding of two (110) silicon wafers with facing V-grooves. The microbridge is suspended across the V-groove in the bottom wafer. It consists of two silicon nitride thin films embedded with polysilicon resistors, which serve for thermal excitation and piezoresistive detection of the bending mode vibration of the microbridge. The steady-state average temperature elevation of the microbridge depends on the cooling effect of the mass flow. The accompanying thermal stress affects the resonance frequency of the microbridge, which is then a measure for the mass flow. Structures with a variety of resistor patterns are investigated. This paper presents analytical models for the average temperature elevation as a function of mass flow, and for the resonance frequency as a function of average temperature elevation. Experimental results are compared with the predicted behaviour. Measured resonance frequencies range from 25 to 135 kHz, at calculated average temperature elevations ranging from 25 to 105°C. Frequency shifts range from −6.9 to +3.8 kHz per sccm nitrogen mass flow. The coefficient of heat transfer is linear with mass flow in the range from 0 to 10 sccm, with a proportionality factor ranging from 7.7 to 9.4 μW/°C per sccm. Predicted and measured results agree reasonably well. The concept of this sensor offers the opportunity for high-performance mass flow measurements at small temperature elevations, with high resolution, fast response and quasi-digital output.

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