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Thermal simulation of micromachined bridges for integrated pyroelectric sensor arrays

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Heat loss from the pyroelectric element to the silicon chip is the reason for the lower sensitivity of integrated pyroelectric sensors compared to discretely assembled single element sensors. A possible measure to overcome this drawback of the sensor performance is the fabrication of micromachined bridges on the top surface of an integrated circuit as the support for a pyroelectric film. A relaxation procedure is given as a tool for a detailed thermal modelling, which allows to estimate the sensor performance and to optimize the thermal parameters. Examples for the thermal sensor design are presented. The performance of pyroelectric sensors, which can be achieved by means of appropriate micromachined bridges, is discussed.

1. INTRODUCTION

Several methods for the integration of pyroelectric materials with silicon chips containing amplifiers and multiplexers have been proposed in literature [1–3]. Compared to discretely assembled single element sensors, the high thermal conductivity of the silicon chip causes a significant decline of the sensor performance. One method to reduce the heat loss from the pyroelectric element to the silicon chip is the use of thermal insulation layers [4]. A promising way for a further increase of the performance of integrated pyroelectric sensors arises from the introduction of surface micromachining technologies to the sensor fabrication.

The fabrication of micromachined bridge structures on the top surface of the chip as carriers for the pyroelectric element, as illustrated in Fig. 1, is a way to reduce the heat loss from the pyroelectric element.

The design of appropriate bridge structures covers the selection of size and shape and the choice of the materials. A detailed quantitative thermal modelling is required to estimate the sensor performance and to optimize the thermal parameters. In the following we present a formalism for the simulation of the temperature distribution on a bridge structure, which is based on an iterative solution of the heat conduction equation following a relaxation method.

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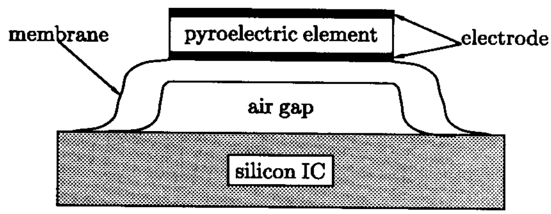

Figure 1. Schematic diagram of an integrated pyroelectric sensor. A micromachined bridge supports the pyroelectric element.

2. THERMAL MODELLING

The sensor structures considered consist of a support membrane in the form of a bridge on a silicon substrate. The support membrane acts as a carrier for a pyroelectric film covered by electrodes, as schematically shown in Fig. 1. Infrared radiation with the sinusoidally modulated intensity j is incident on the surface of the sensor: $j = j_s + j_\sim e^{-i\omega t}$. j_s is the stationary part and $j_\sim$ the amplitude of the incident intensity.

We assume that the thickness d of the bridge structure is small compared to the decay length of a thermal wave with the circular frequency

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