Microstructure for the Determination of the Seebeck Coefficients of Doped Poly-Si Thin Films

D. Moser[1,*], A. Steffen[1] and O. Paul[1]

[(1)]Microsystem Materials Laboratory, Department of Microsystems Engineering (IMTEK), University of Freiburg, Germany.

*Corresponding Author: E-mail: moserd@imtek.de

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Abstract:
For commercial, integrated thermoelectric sensors and transducers, poly-silicon (poly-Si) thin films are of particular interest due to their availability in standard microfabrication processes. Methods for the local determination of material properties are needed, e.g., in view of the homogeneity over the substrate or the self-calibration of integrated microsystems [1]. We report a simple planar microstructure for the determination of the Seebeck coefficients of doped poly-Si thin films against aluminum (Al).

The test structures are fabricated from a phosphorous (n) or boron (p) doped LPCVD poly-Si and an Al metal layer separated by a dielectric layer of Si_3N_4 on Si substrates. The structures consist of single poly-Si/Al-thermoelements used for the measurement of the thermopower while a temperature gradient is applied by an integrated poly-Si heater. The temperatures of the hot and cold contact of the thermoelement are monitored by integrated resistive poly-Si temperature sensors adjacent to the contacts.

Finite element (FE) simulations are used for the modeling of the temperature distribution in the contact area of the thermoelement and within the temperature sensors. Based on the simulations, an appropriate design of the device was identified. The design is capable of compensating temperature differences between the contacts of the thermoelements and the temperature sensors. The FE simulations show a temperature difference between the sensor and the contact of less than 0.1 K.

The thermopower of n- and p-doped poly-Si is measured in a temperature range from 300 K to 350 K which is typical for room temperature applications. Thermopowers of −78 μV/K and 186 μV/K were determined for n- and p-doped poly-Si at 300 K. The results are in good agreement with the Seebeck coefficients reported for similar thin films [2, 3].

Furthermore, an alternative type of the test structure is fabricated using additional bulk micromachining by anisotropic KOH-etching of silicon. The alternative type enables the application of higher temperature gradients along the thermoelement and thus provides a higher output voltage.

References:

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