MICROCANTILEVER-BASED SENSOR ARRAY FOR AMINE DETECTION IN AGRO-FOOD APPLICATIONS

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Microcantilevers are MEMS-structures suitable for chemical sensing; sensitivity to specific analytes can be achieved by coating the beam surface with proper chemically sensitive films. Analyte adsorption onto the surface affects both resonance frequency and beam bending, leading to different read-out approach which can be also combined [1, 2].

This work presents the development of silicon microcantilever-based sensor arrays designed for integration in a chromatographic system for food quality monitoring applications. In particular the detection of amine with chemical destructive methods is already used to evaluate the freshness of fish in the food industry. The implementation of an integrated system can allow real time and on-field analyses of products during the whole production and delivering process.

The selected detection method for analyte adsorption is the resonant frequency shift; beam bending is monitored using integrated piezoresistors. In order to optimize the sensitivity properties and the read-out performances of the structure the investigation of the electro-mechanical behaviour of the system has been implemented by both finite element analysis, performed with ANSYS™ software, and analytical models. Multilayer beam structure has been evaluated in order to design devices with a target working frequency and to estimate structure stiffness and mass. Effect of residual stresses has also been investigated with regard to the resonance frequency and beam deflection. Furthermore the stress distribution on device has been calculated in order to optimize the piezoresistors configuration and their location along the silicon beam. Some issues related to the fabrication process have also been simulated in order to evaluate their effect on device properties.

A key-point for reducing the structure thickness is the definition of the fabrication parameters for the piezoresistors implantation, in order to obtain a very shallow p-doped layer. This process step has been simulated using ATHENA (Silvaco software).

Furthermore design and fabrication process outline are presented. Four-beam arrays have been designed with resonance frequency ranging from 10 to 60kHz, with piezoresistive Wheatstone bridge read-out in order to enhance deflection sensitivity and to reduce read-out temperature dependence.

The fabrication process is a CMOS-compatible process including bulk micromachining steps to define the mechanical structure. The starting material is a 4-inch, 500 um thick, 10 Ohm-cm, n-type, (100) oriented, double side polished silicon wafer. The piezoresistors are implemented with 3 different sets of process parameters in order to investigate the read-out efficiency. BF_2 and B implantation, with doses of $2\ 10^{13} \div 2\ 10^{15}$ at cm^{-2}, and energy of $70 \div 110$ keV, in order to have, after a proper activation step, a junction depth of $1.4 \div 1.8$ µm. The substrate contact is done with a phosphorus implantation, having a dose of 3×10^{15} and energy of 80 keV. The metal lines are a sputtered multilayer of Titanium/Titanium Nitride/Aluminium 1%Silicon alloy/Titanium. The 3-dimensional microcantilever structures are obtained through an appropriate sequence of back and front-side silicon anisotropic wet etchings, with TMAH solutions. The final beam thickness for these structures is about 10 µm.

Acknowledgements

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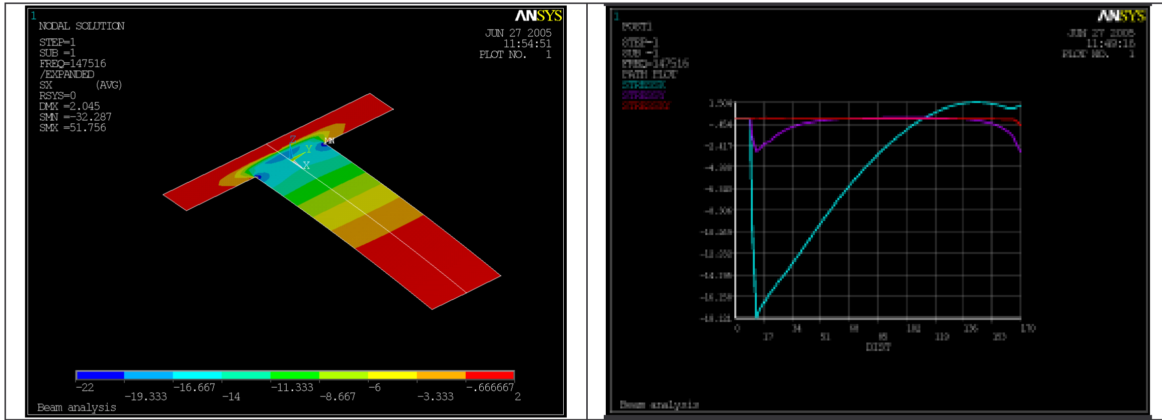

Figure1: Modal analysis, stress distribution on cantilever, with 20 μm underetch and 10 μm bulk.

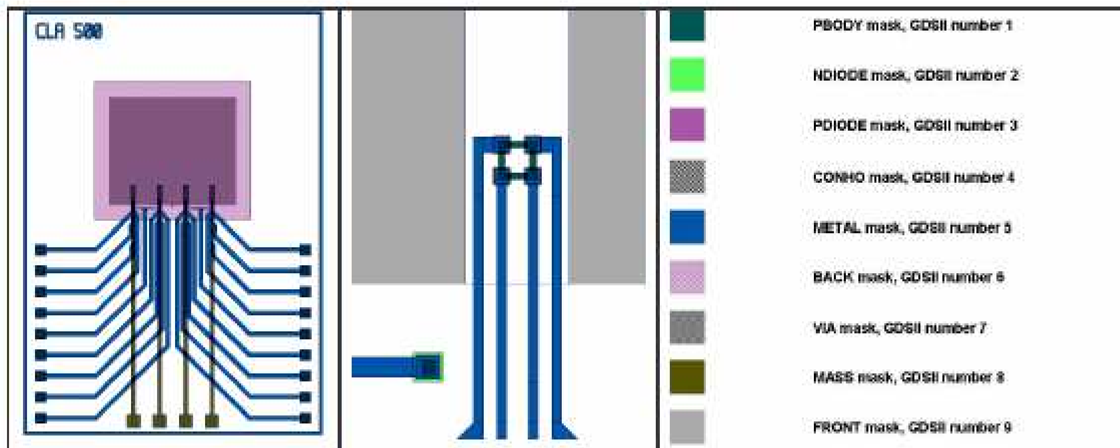

Figure 2: Cantilever array layout, beam length 500 μm. B) Detail of the piezoresistive bridge.