Final Report Summary

MEMS Device Concept Feasibility Study

Oligon Ltd
www.oligon.com

Institute for System Level Integration
www.sli-institute.com

WORK INTRODUCTION

This work covers the evolution of analytical and FMEA models to support a range of MEMS based devices. The work was undertaken in co-operation between Oligon Ltd and the Institute for System Level Integration, both in Livingston, Scotland. Outline requirements were defined by Oligon and enhancements to its analytical models were undertaken to define FMEA start parameters.

ISLI has carried out finite element analysis (FEA) of possible design implementations applicable to a membrane based MEMS device for monolithic integration alongside CMOS control and signal extraction circuitry. Based on the design space identified by Oligon, ISLI modelled a first design exemplar, resulting in the identification of a number of areas where design improvements could be made. As a result of this, a second design based on a refined process flow was investigated. With the revised design implementation, the FEA model was progressively refined to ensure that the model output was independent of the mesh employed. More extensive use was made of rotational symmetry to reduce the computational expense of the model and hence speed up result generation.

Detailed analysis of the membrane as a function of various environmental parameters was carried out with extraction of device performance parameters from the FEA results matrix. Some parameters, such as stress, were available for direct extraction from the results matrix. Other performance information was extracted via more detailed analysis through the extraction of relevant parameters from the result set and subsequent numerical processing to provide higher order data, such as capacitance.

OUTLINE OF RESULTS

The first proposed design implementation was shown, through FEA modelling, to have certain undesirable characteristics of the mechanical structure. These characteristics led to the membrane suffering significant distortion immediately after fabrication and release, brought about purely by relaxation of internal material stresses after the removal of the stringent mechanical restraints in place during fabrication. Two routes to improving this aspect of the device performance which were compatible with the manufacturing process were identified; through modification of the device geometry and change to the intrinsic material properties.

Modelling of the revised device showed improvement both in the level of stress induced deformation seen after sacrificial release and in the relative stiffness of different components within the device. Both of these improvements deliver a device with a higher resistance to damage and a greater sensitivity to the measurand.

Further modelling of the revised device structure provided information on the detailed performance being obtained. Data was provided to the client covering sensitivity to the measurand together with information on linearity and symmetry of response.

ADDITIONAL OUTCOMES

During the course of the work, it became apparent that there was a fine line in modifying material characteristics between improving device performance and reaching a point where the device ceases to operate correctly. This in turn lead to the realisation that a novel design approach could be used to deliver a similar improvement in performance, without the associated risk of causing device failure. Some preliminary modelling confirmed that the design development could yield the desired outcome. This has directly resulted in a patent filing which is now in progress.

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