On the use of an Oscillation-based Test Methodology for CMOS Micro-Electro-Mechanical Systems

V. Beroulle, Y. Bertrand, L. Latorre and P. Nouet
LIRMM – UMR CNRS / University of Montpellier
161 Rue Ada – 34392 Montpellier Cedex 5
Tel: +33 467 418 527 – Fax: +33 467 418 500 – Email: nouet@lirmm.fr

Abstract

This paper introduces the use of the oscillation test technique for MEMS testing. This well-known test technique is here adapted to MEMS. Its efficiency is evaluated based on a case study: A CMOS electro-mechanical magnetometer

1. Introduction

The development of testing methodologies for MEMS is extensively making use of results obtained in the standard IC's test field. This study investigates the application to MEMS testing of the Oscillation-based Test Methodology (OTM) previously introduced for analogue circuits [1].

2. The Device Under Test

The Device Under Test (DUT) is a U-shaped cantilever beam carrying a known current (figure 1). In presence of a magnetic field, the cantilever beam is deflected under the action of the Lorentz force. Polysilicon strain gauges are embedded into the mechanical structure in order to detect subsequent deflections. A readout circuitry including a Wheatstone bridge and amplification stages is used to process the sensor signal.

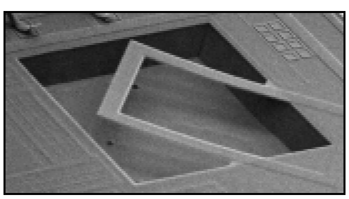

Figure 1. CMOS micromachined U-shaped cantilever used for magnetic field sensing.

The first task was to make the simulation model of this mechanical device suitable for realistic fault injection. Theoretical relations between high level parameters (mass, stiffness, damping…) and low-level physical parameters, such as design dimensions and material properties, have been established [2].

3. Oscillation-based Test methodology (OTM)

OTM is based (i) on the reconfiguration of the Device Under Test (DUT) into an oscillating system and (ii) on the measurement of indirect parameters that are easier to observe: the amplitude and the frequency of the output signal. In order to implement OTM, the MEMS is then turned into an oscillator using a simple first-order derivation feedback circuit.

It is commonly admitted that tolerance ranges must be handled using single fault assumption. These tolerance ranges apply on low-level parameters (e.g. material density, layer thickness...) and are defined according to sensor specifications. Then, it is necessary to relate these tolerance ranges to the indirect parameters to be actually observed (frequency, amplitude). After these individual tolerance ranges have been determined it is possible to fix an overall tolerance on each indirect parameter. At this point, two different test strategies can be considered:

- A yield based approach guaranteeing that no fault-free devices will be declared faulty.
- A fault coverage based approach guaranteeing that all faulty devices will be detected.

Using these strategies, two sets of detection ranges are obtained. The distance between these ranges and tolerance ranges on low-level parameters establishes the OTM efficiency.

4. Conclusion

We have introduced the use of an Oscillation-based Test Methodology for MEMS testing using a monolithic magnetometer as a case study. A first qualitative evaluation method demonstrates OTM efficiency. Further works, using low parameters statistical distribution, should conduct to quantitative evaluation methods.

References

[1] K. Arabi, B. Kaminska, "Parametric and Catastrophic Fault Coverage of Analog Circuit in Oscillation-Test Methodology", Proc. VTS'97, pp. 166-171.

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