8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

FAILURE ANALYSIS OF POLYSILICON MEMS ALLOWING FOR RANDOMNESS AT THE MICRO-SCALE

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Key Words: *polysilicon MEMS, failure analysis, multi-scale FE approach, micro-mechanics, Monte Carlo simulations.*

ABSTRACT

Because of polysilicon brittleness, micro electro-mechanical systems (MEMS) can suddenly fail when exposed to shock loadings.

To accurately capture the link between shocks and MEMS failure, at least three length-scales need to be explored: a macro-scale (or package length-scale), characterized by stress waves propagating inside the package and eventually impinging upon sensor anchors; a meso-scale (or sensor length-scale), characterized by forced vibrations of the sensor as a whole; a micro-scale (or polycrystal length-scale), characterized by the nucleation and propagation up to percolation of trans- as well as inter-granular cracks in the highly stressed sensor regions.

Former research works have shown that crystal topology and randomness of strength and toughness at grain boundaries can strongly influence the micro-cracking pattern of polysilicon at the micro-scale [1-2]. In this work we investigate, through a Monte Carlo approach, the effects on MEMS failure mode and time to failure of: the mis-match between the orientations of the axes of elastic symmetry of contiguous silicon grain; the shape and size of silicon grains; the fluctuations of grain boundary strength and toughness.

Moreover, links to deterministic reliability assessments based on a meso-mechanics Rankine criterion [3-4], and insights into the actual failure mechanism are discussed.

REFERENCES

[1] R. L. Mullen, R. Ballarini, Y. Yin and H.Heuer. “Monte Carlo simulation of effective elastic constants of polycristalline thin films”. *Acta Materialia*, Vol. **45**, 2247-2255, 1997.

[2] S. Mariani, A. Ghisi, F. Fachin, F. Cacchione, A. Corigliano and S. Zerbini. “A three-scale FE approach to reliability analysis of MEMS sensors subject to drop impacts”. *To be submitted*, 2007.

[3] A. Ghisi, S. Mariani, F. Fachin and S. Zerbini. “Reliability analysis of polysilicon MEMS sensors subject to accidental drops: effect of packaging”. *Submitted for publication*, 2007.

[4] S. Mariani, A. Ghisi, A. Corigliano, S. Zerbini. “Multi-scale analysis of MEMS sensors subject to drop impacts”. *Sensors*, Vol. **7**, 1817-1833, 2007.