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AN IMPROVED MICROMECHANICAL METHOD FOR INVESTIGATING THE MECHANICAL PROPERTIES OF POLY-SILICON MEMBRANES

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Freestanding poly-silicon membranes are of increasing importance for designing MEMS devices such as pressure sensors, microphones and gyroscopes. It is crucial to accurately determine the mechanical properties of such membranes not only to access parameters for designing new devices but also for assuring proper performance and quality in service. Classically, microscopic tensile tests [1-3] or bulge tests [4] were conducted to obtain Young's modulus and strength of the membrane material. These methods however are prone to artifacts due to crack initiation at edge defects (e.g. predefined notches in tensile specimens [3] or slits in bulge test samples [4]). In search of a method more sensitive to the membrane surface rather than specimen geometries, a novel approach has been introduced more recently. By loading the center region of a circumferentially clamped membrane with a spherical probe, the membrane is stretched all the way up to rupture while precisely recording the load-deflection data. Complementary FEA simulations allow for determining the failure stresses of individual membranes, based on the mechanical test data. In a subsequent step the tests are analyzed via a two-parameter Weibull approach to statistically evaluate the characteristic fracture strength.

The membranes tested in the given project had a thickness of only 330 nm over a diameter of 1 mm. The necessity to apply minute forces while testing the compliant membranes at quite large deflections with high precision proves to be challenging. Additionally the need for statistical verification requires conducting multiple tests in a reasonable time frame. In the presented work a commercial nanoindenter has been used to match the aforementioned requirements. Lately some methodological improvements have been implemented to maximize throughput by automation and improve accuracy by refining the data analysis to capture the experimental conditions most realistically. Some of these approaches will be illustrated by recent data and explained in detail.

References

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