DETERMINATION OF MECHANICAL PROPERTIES OF DIFFERENT SIZED SILICON AND SILICA NANOWIRES TESTED IN SEM

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To push miniaturization in electronics forward, integration of silicon or silica nanowires into microelectromechanical based sensors (MEMS) becomes essential, because they were found to enhance the overall sensitivity and noise immunity. With respect to mechanical stress may develop in nanowires in operation of the MEMS system, their stability need to be checked to ensure long-term reliability.

The monolithic fabrication includes a controlled two-step chip-on-wafer etching technique resulting in double-anchored wires with the minimum width of 35 nm, the maximum width of 74 nm and a height of 168 nm with clamped wire endings for silicon [1,2]. Based on this idea clamped silica wires with widths between 150 to 200 nm and heights of 50 nm and 372 nm were created due to prior coating of a silicon bulk with a silsesquioxane precursor in addition to subsequent e-beam irradiation [3]. Dimensions and shape of the wire cross-sections were exemplary investigated using transmission electron microscopy, while the determination of the respective wire´s length between the clamped endings of 2 to 12µm and the *in-situ* three-point-bending tests were carried out within a scanning electron microscope. A micromanipulator equipped with a piezo-resistive force sensor, shaped like a cantilever conventionally used for atomic force microscopes was loaded and unloaded at the wires mid-span and forces were detected. Simultaneously the systematic tests were recorded in scanning electron micrographs taken each second to extract force-displacement (f-d) curves of the different sized nano-objects.

As expected for brittle material, silicon nanowires showed well-known f-d behavior. Considering a modulus of elasticity of 169 GPa for bulk [100] silicon and the influence of the native oxide finite element simulation (FEM) exactly fit to the experimental data leading to the conclusion that no size dependence for elastic properties was identified [4]. Same observations were made with silica wires until a stress level of about 0.1 to 0.4 GPa is reached and a superplastic deformation without fracture of the wires takes place.

The validation of the f-d results from the systematic study of the fracture behavior of silicon wire is in progress. Due to the special wire geometry (small width in relation to height) buckling occurs during loading, implemented within a finite-element simulation, which needs still further refinement. Finally, this study will help to predict mechanical behavior (or *vice versa* the dimensions) of MEMS integrated silicon nanowires.

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