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A MEMS nanoindentation system for quantitative nanomechanical characterization of soft materials

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Soft materials, including polymers and bio-macromolecules, are widely used in various scientific and industrial fields. Especially, the quantitative nanomechanical characterization of soft materials plays an essential role in the design and development for the applications of these materials.
Although commercial nanoindentation instruments have proven to be effective for the measurement of commonly hard materials, they generally suffer from inadequate force resolution in the case of soft materials under test, whose elastic moduli tend to be generally in the MPa range. Atomic force microscopes (AFM) can also be used for soft material testing. However, the drawbacks of cantilever-based AFM nanomechanical measurements, e.g. limited indentation depth and force, prevent AFMs use for quantitative material testing. There is a need for something between Nanoindentation and AFM.
A MEMS-based nanomechanical measurement system for quantitative nanomechanical characterization of soft materials with low uncertainty is hereby presented with the aim of bridging the capabilities of nanoindentation instruments and those of AFMs. The MEMS nanoindenter is developed on basis of an electrostatic comb-drive actuator, featuring a force resolution better than sub-nN and a maximum indentation depth of up to 10 µm. For material testing, a Berkovich-like indenter tip directly is formed out of the end of the transducer's main shaft by means of focused ion beam (FIB) fabrication.
Quantitative approaches for the characterization of the MEMS nanoindenter are explained in detail. Nanomechanical measurements of typical soft materials using this MEMS nanoindenter are reported in the manuscript.

Keywords
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