Abstract Title

Deformation measurements at the nanoscale

Symposium Track

Application (Track 5)

Authors' names

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Abstract body

The application of micro- and nanotechnological products in a variety of different market segments ranging from aerospace, medical engineering, automotive to consumer electronics will cause reliability problems with great effect on the success of the respective product. The ongoing miniaturization with the implementation of newly developed materials and processes results into increasing demand for deformation measurements at the nanoscale. To fulfil these needs new strategies for experimental assessment is essential.

It has been shown that Scanning Probe Microscopy (SPM) is a powerful method for the analysis of such nanoscale structures. In addition to the more or less static analysis of topography or material contrast by the phase signal the authors show that SPM images can be used for the measurement of deformations on the nano scale. The so-called nanoDAC method (nano Deformation Analysis by Correlation), allows the determination and evaluation of 2D displacement fields based on SPM data. In-situ SPM scans of the analyzed object are carried out at different states. These states can be induced by thermo-mechanical loading. The obtained topography-, phase- or error-images are compared utilizing gray scale cross correlation algorithms (DIC, Digital Image Correlation). This allows the tracking of local image patterns of the analyzed surface structure. The measurement results of the nanoDAC method are full-field displacement and strain fields (Fig. 1).

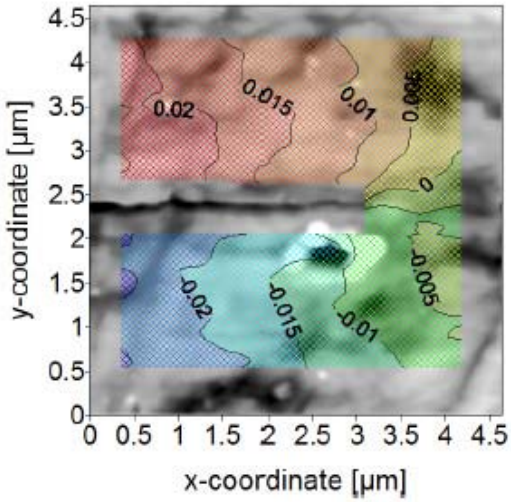

Figure 1: Crack opening displacement field in vertical (y)-direction [µm] determined by means of nanoDAC; in the background of the contour lines the AFM topography scan is illustrated.

The nanoDAC method is suited for measurement of mechanical properties such as fracture properties, Young's modulus, Coefficient of Thermal Expansion, Poisson's ratio. Furthermore the technique should be used for tracking of structures or particles driven by diffusion processes or nanomanipulators. Future generations of SPM equipment will provide modes for observation of dynamic processes. The nanoDAC method will be a useful tool for evaluation of time-dependent processes observed by in-situ SPM techniques.

In addition to the nanoDAC method the fibDAC method will be presented. With the fibDAC (Focused Ion Beam based Deformation Analysis by Correlation) method the classical hole drilling method for stress release measurement has been downscaled to the nanoscale. The ion beam of the FIB station is used as a milling tool which causes the stress release at silicon microstructures of MEMS devices. The analysis of the stress release is achieved by DIC applied to load state SEM images captured in cross beam equipment (combination of SEM and FIB). The results of the DIC analysis are deformation fields which are transferred to stress solution by application of finite element analysis. In another step the resolution of the method has been improved by the application of trench milling instead of milling of holes. Thereby deformation measurements in the nm range are established.

Keywords

nano deformation measurement, nanoDAC, fib DAC, digital image correlation

References

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