MICRO-SHEAR OF SILICON: ELASTIC STRAIN ANALYSIS USING DIGITAL IMAGE CORRELATION

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Silicon is ubiquitous at small length scales. Small volumes of Silicon serve as both functional and structural components in microelectromechanical systems. In the latter, components often are subject to multiaxial loading; a simple case of which is shear. In microcompression, shear stresses are determined by calculating the critical resolved shear stress from the uniaxial applied stress. More direct shear measurement of small volumes subjected to two equal but opposing forces is desirable. Only a few micro-scale geometries have been described that induce shear stress states. Pfetzing-Micklich *et al.* [1] used a nominal double-shear specimen, which was initially developed for macroscopic creep experiments, and applied this to small scale testing of metals. This geometry is convenient, since the shear stress is induced by the application of a vertical load in the middle of the structure. Further, this geometry was already optimized to minimize bending components in the shear volumes. In the current work, we use this double-shear geometry to investigate the [-100](110) shear system in Silicon using *in situ* experiments in the SEM. The specimens are loaded in consecutive loading-unloading cycles to ever increasing maximum indenter displacements. Specimens are fabricated using a combined approach of lithographic etching and FIB milling. The superimposed bending of the structure appears to be more significant in materials with high elastic limits, such as Silicon, which makes strain assessment from load-displacement data challenging (*i.e.* global strain analysis). Since bending and deflection of the substrate material dominate the measured displacement, digital image correlation (DIC) was applied to determine the actual strain as well as the strain distribution in the shear volumes (*i.e.* local strain analysis). Of special interest is the degree to which strain and stress is transferred to the shear volumes of the geometry. Local strain analysis performed by digital image correlation revealed that a homogeneous strain of 5% is achieved in roughly 60% of the shear volume compared to the global strain of 25% obtained by the indenter system. Finite element (FE) modeling was used to calculate local and global strains of the double-shear geometry and compared to experimental results. Finally, the shear strength at failure is compared and discussed in terms of critical resolved shear stress values obtained from pillar compression experiments.

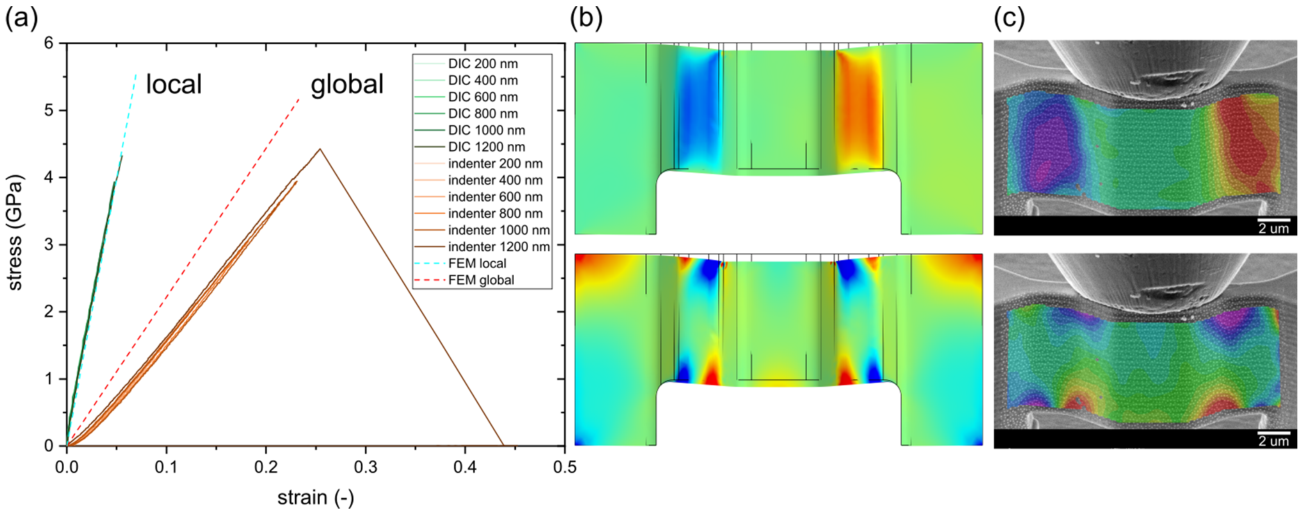

Figure 1 – (a) Stress-strain curves obtained by DIC (local) and indenter system (global) compared to FE modelling local and global results. Strain distribution obtained by FE modeling (b) and by DIC (c) at an average surface strain of 5.5 % shear strain in the shear constriction. The upper row represents shear strain, whereas the lower row represents normal strain (bending) – qualitative color code is rescaled for each image.