HRXRD Strain Analysis on DRIE Etched Silicon

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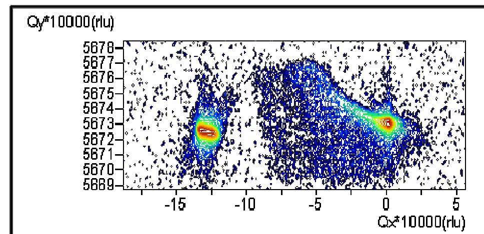
Microsystem engineering involves design, manufacturing, and packaging of microelectromechanical systems (MEMS). Applications of microsystems in aerospace, automotive, watch industry or sensors create a strong demand in quality control and failure analysis [1].

Monocrystalline material, and especially single crystal silicon (SCSi), is preferentially used due to its potential resistance against aging. However, quantified results on this assertion are rarely published. The reasons are manifold, and among others are related to surface roughness and defects, as for instance introduced by the ion bombardment in dry reactive ion etching (DRIE). In single crystals, such perturbances of the perfect lattice are recognized to favor failure. This makes it necessary to treat structural and material influences as inseparable parts of the problem.

Mechanical tests may be used to assess the resistance of SCSi structures to loading [2]. However, for the understanding of failure it is essential to obtain further going information about the stressed material on the atomic scale. This makes it necessary to conduct detailed investigations, which may include the comparison of experimental methods as well as numerical simulations. Experimental measurements of local deformations and an analysis of defects may be approached by High Resolution Diffraction Methods (HRXRD) and the simulation of deformations by the well-established Finite Element Method (FEM).

A methodic approach in the above sense will be demonstrated on the example of a loaded DRIE etched SCSi device. The strain field in the critical regions of the structure was investigated by HRXRD and compared with the results of a FEM analysis. The X-ray rocking curve method and Reciprocal Space Mapping (RSM, Fig. 1) were used to determine the strain in the crystal as well as the defect concentration.



References:

[1] A. Dommann, G. Kotrotsios and A. Neels, MEMS Reliability and Testing, *MST News*, (2007).

[2] E. Mazza and J. Dual, Mechanical behavior of a µm-sized single crystal silicon structure with sharp notches. *J. Mechanics and Physics of Solids* 47 (1999) 1795-1821.