ESRF	**Experiment title: Analysis of Residual Stresses with a Local Resolution in the Range of Micrometers**	**Experiment number: HS 294**
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Report:

The failure resistance of thin film aluminum- and gold-interconnects (lines) is an important factor governing the reliability of integrated circuits (ICs). It is known that several factors influence the initiation of voids and cracks in the circuit lines, which eventually lead to a complete failure of the IC. Among these factors thermal stresses are of special interest.

The aim of this experiment was to determine the residual stresses with a resolution on a scale of micrometers inside sputtered gold metal lines exhibiting a width of 4 and a thickness of 0.8 micrometers. Since the width of the lines corresponds to their typical grain size, it was necessary to use a single grain measurement technique. A channel-cut Si 111 monochromator was used to select a wavelength of λ = 0.78 16 A. The detector was a 110mm fluorescent screen coupled optically to a CCD. Mechanical imperfections of the κ-goniometer used at beamline ID13 required a collimation of the primary beam of about 30 micrometers to keep the crystallite under study exposed to the beam for any setting of the goniometer.

In a first step the orientation of the crystallite under study was evaluated. Since the sputtered lines showed a strong <Ill>-texture the search for three symmetrically equivalent reflections belonging to one crystallite was performed by rotating the sample around the φ_κ-axis in 120 degree intervalls and searching around these positions for reflections with similar intensities. Additionally it could be verified that the crystallite stayed exposed to the beam for all three φ_κ-settings and therefore for any other goniometer setting as well. Having evaluated the orientation matrix of the crystallite, the setting of the goniometer for every reflection (hkl) to be studied was calculated and then the precise position of the reflections were determined by centering to the aimed accuracy in κ and φ_κ. Subsequently a 2θ-ω scan was carried out for the determination of the precise interplanar lattice spacing d. Using the stress free do-value measured on gold powder, the strain values ε were obtained. Due to the low incident angles of the beam with respect to the surface of the sample adjacent gold lines were illuminated at the same time increasing the number of reflections along the Debye-cone. Hence it is not certain whether all reflections belong to the same crystallite. However, the comparison of the strain values of symmetrically equivalent {hkl} indicates an isotropic behaviour of the strain distribution inside the gold line (see table 1). Conventional X-ray diffraction measurements using the $\sin^2\psi$-method showed this isotropic behaviour as well.

Measurement 1:

h k l	strain [10^{-5}]
5 5 1	-18 ± 20
1 5 5	-33 ± 20
5 1 5	-18 ± 20
1 7 3	-21 ± 20
7 1 3	-20 ± 20
1 3 7	-36 ± 20
6 2 6	-43 ± 20
2 6 6	-43 ± 20
6 6 2	-38 ± 20

Measurement 2:

h k l	strain [10^{-5}]
5 5 1	-3 ± 20
1 5 5	-25 ± 20
5 1 5	-2 ± 20
1 7 3	-13 ± 20
7 1 3	-14 ± 20
1 3 7	-35 ± 20
6 2 6	-21 ± 20
2 6 6	-31 ± 20
6 6 2	-13 ± 20
6 4 2	-30 ± 20

Table 1: Measured strain inside a gold line along different crystallographic directions