

ADVANCES IN NEAR SURFACE RESIDUAL STRESS GRADIENT ANALYSIS OF POLYCRYSTALLINE MATERIALS BY MEANS OF ENERGY DISPERSIVE DIFFRACTION

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Residual stress analysis by energy dispersive (ED) diffraction using a white beam of up to 100 keV allows the determination of near surface residual stress distributions within the first tens to hundreds of micrometers [1]. However, the methods currently applied - LAPLACE- and real-space-methods – only deliver limited information.

Applying LAPLACE-methods the integral information from the surface region is detected and the in-plane stress distribution $\sigma(\tau)$ obtained represents the stresses relative to the mathematical abstract LAPLACE-space. The calculation of the real space distributions $\sigma(z)$ from the $\sigma(\tau)$ -profiles is complicated since it requires the application of the inverse Laplace transform (ILT) on scattering experimental data.

The alternative method is to determine the out-of-plane depth distributions $\varepsilon(z)$ by applying the strain-scanning method and calculating the in plane residual stresses $\sigma(z)$ by means of the transversal contraction requiring the precise knowledge of the lattice parameter d_0 . Apart from the presumptions made, the main problem rises from the fact that the gauge volumes are usually large in respect to the depth region of interest requiring complex correction terms and deconvolution procedures.

Considering the problems, a real space “stress-scanning” method has been developed allowing the direct determination of stress distributions $\sigma(z)$ by means of ED diffraction. The high spatial resolution within the micrometer range is realized by detecting the diffraction signal in different orientations ψ from the identical flat gauge volume being aligned parallel to the sample surface.

Both the stress-scanning method and the LAPLACE-method were applied to samples with complex stress states using ED diffraction. The experimentally obtained stress distributions $\sigma(z)$ and $\sigma(\tau)$ of the same depth region give access to the problems involved with the currently applied procedure of the ILT. The results obtained on a multilayer system containing several layers of identical composition demonstrate the uniqueness of the stress-scanning method allowing the direct access to buried layers.

- [1] Ch. Genzel, I. A. Denks, J. Gibmeier, M. Klaus, G. Wagener, Nucl. Instr. Meth. A578 (2007), 23.