ANALYSIS OF RESIDUAL STRESS IN POLYCRYSTALLINE COATINGS – FROM SCIENTIFIC TECHNIQUE TO INDUSTRIAL METHOD

Arnold C. Vermeulen
PANalytical, Lelyweg 1, 7602 EA Almelo, The Netherlands

The presence of residual stresses in polycrystalline specimens is an important issue in both science and industry. X-ray diffraction is the most versatile tool for analyzing stresses, but to obtain reliable results the technique has to be applied with great care. Normalization is essential to promote stress measurements from science to industry. The current standardization literature covers the procedures for the classical stress analysis based on single-{*hkl*} measurements on homogeneous ‘bulk’ specimens.

However, in materials research there is a need for a reliable and robust method to analyze residual stresses in less ideal specimens like thin films, coatings and surface layers. The classical residual stress measurement technique is not sufficient for such specimens. Hence another approach is required that may involve techniques like the use of multiple {*hkl*} reflections, grazing incidence beam, combined tilts and/or low diffraction angles. These techniques are already applied in dedicated scientific research, but more knowledge about the possibilities and limitations is required for a wider application in materials research in science and industry.

In this paper we will discuss the set-up of the measurements and the analysis of residual stress in polycrystalline coatings.

With respect to the X-ray diffraction measurements the influence of alignment errors will be discussed. In principle all alignment errors are relevant when using focusing optics. However for the parallel beam geometry certain errors become irrelevant.

For multiple {*hkl*} stress measurements an accurate calibration of the zero 2theta angle is important. Especially for grazing incidence measurements and despite the use of parallel beam optics the zero beam shift error introduces a systematic error in the final stress result. Direct measurement of the zero beam will not give sufficient accuracy, so that additional measurements on a stress-free reference specimen are advised.

With respect to data analysis of multiple {*hkl*} reflections a proper indexing of the measured peaks is essential. Since the peaks are shifted due to the presence of residual stresses indexing is not straightforward. Even in the case of cubic phases wrong indices can be assigned. Hence a modified indexing algorithm is required.