Strain mapping by non destructive method : Laue microdiffraction

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Scanning X-ray microdiffraction [1] combines the use of high brilliance synchrotron sources with state-of-the-art achromatic X-ray focusing optics and large area detector technology. Using either white or monochromatic beams, it allows for orientation and strain/stress mapping of polycrystalline materials with large grain size (bulk materials) using white beam and small grain size using monochromatic beam (ion beam sputtered thin films) with submicron spatial resolution.

Evolution of strain fields in materials conducted by external loading conditions (tensile or compressive testing) can be studied by performing in situ testing. White microdiffraction can then be used to study metallurgical alloys with grain size greater than the beam spot (typically 1x1 micron).

Evolution of the stress field in shape memory alloys has been characterized using white beam Laue diffraction. It allows following the evolution of the strain/stress field in a grain, surrounded by other grains and subject to external loading. When the internal load reaches a critical value, the austenitic phase transforms to martensite in order to accommodate the stress field and reduce internal load in the primary phase. With the sub-micron resolution of the microdiffraction, we are able to follow the stress field evolution in a single grain and also between the martensite variants during the whole transformation of the grain due to the external loading.

Due to the experimental, Laue microdiffraction beamlines allows changing from white to monochromatic beam without position change on the sample. So it is possible to use both techniques to characterize samples with grain size lower than the beam spot, as thin film on substrate:

Delamination mechanisms of a thin metallic film (such as gold) adherent to a substrate can be analysed in situ by applying compressive stress to the substrate covered by the thin metallic film (500nm thick) during white beam and monochromatic microdiffraction scanning. White beam diffraction is used to characterise the substrate which is a LiF single crystal. Monochromatic diffraction is used to analyse the thin film, the grain constituting the film having a nanometric size. With the large two dimensional detector available at the beamline, partial powder rings are collected. The thin film diffraction patterns are analysed using the classical powder diffraction technique and $\sin^2\psi$ method.

[1] A.A.MacDowell, R.S.Celestre, N.Tamura, R.Spolenak, B.C. Valek, W.L.Brown, J.C.Bravman, H.A.Padmore, B.W.Batterman & J.R.Patel, *Nuclear Instruments and Methods in Physics Research A* 2001, 936-943, 467

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