FIB-SEM Based Techniques for Residual Stress Evaluation at the Micro and Nanoscale

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Local quantitative evaluation of residual stress at the micro and nanoscale can provide useful information in materials design and failure analysis. Non-destructive techniques such as X-ray Diffraction (XRD), high resolution electron back-scattered diffraction (HR EBSD) or Raman spectroscopy can provide information on relative changes in residual stress with respect to a reference state. Apart from the material limitations of these techniques, the interpretation of these measurements in terms of absolute stress values depends on a strain-free sample, which is often difficult to obtain.

A new approach based on Focused Ion Beam (FIB) milling, developed as part of the European research project iSTRESS [1], uses Focused Ion Beam and Digital Image Correlation (FIB-DIC). Residual stress is released by milling a ring-core or other pre-determined geometry and the strain is mapped during the milling process using DIC of high resolution SEM images [2]. The main advantage of the technique is that it can be applied to a broad range of materials: crystalline and amorphous metallic alloys and ceramics, polymers, composites and biomaterials.

FIB milling for strain release has been also proved to provide a strain-free reference for other techniques for strain mapping like micro-Raman or HR EBSD. Results from an integrated FIB-SEM-Raman system are shown.

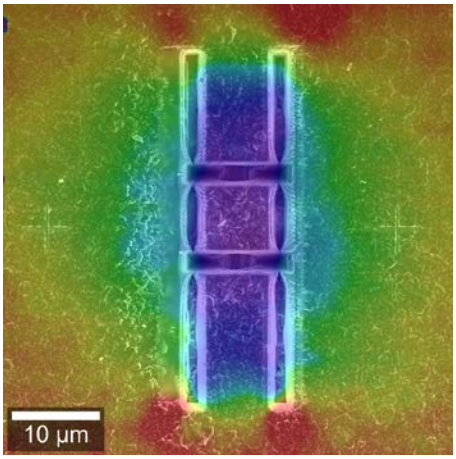

Figure 1 Strain release caused by FIB milling of a nanocrystalline diamond coating. Raman peak position map superimposed on the SEM image.

[1] www.istress.eu

[2] A.M. Korsunsky, M. Sebastiani, E. Bemporad, Residual stress evaluation at the micrometer scale: Analysis of thin coatings by FIB milling and digital image correlation. Surf Coat Tech, 205(2), p. 393-403, 20