Nanoscale deformation patterns in fibre-reinforced polymer composite and thin film systems based on digital image correlation

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In digital image correlation (DIC), the resolution of the deformation patterns is conditioned by the scale and quality of the pattern used to extract the displacement field. In the case of fibre-reinforced polymer composites, classical deposition methods create patterns that allow strain mapping down to the microscale [1], which is not fine enough to study very local strain localisation details at the fibre-matrix interface nor in micron-sized matrix pockets.

In this work, we propose a modified nanoscale DIC pattern deposition technique based on the work of Hoefnagels et al. [2], for the in-situ observation within a scanning electron microscope (SEM) of composites and metallic thin film specimens. After optimisation of the deposition parameters, a discontinuous layer of indium particles with an average diameter of 10 to 20 nm can be generated by e-beam evaporation. Compressive testing of unidirectional (UD) fibre-reinforced polymer composites and tensile testing of free-standing aluminium thin films were performed in a SEM. The nanoscale strain fields were successfully extracted by DIC. Finite element modelling (FEM) was used to confirm the spatial and quantitative accuracy of the experimental DIC results for composite materials, as illustrated in Figure 1.a. For aluminium free-standing thin films, shear bands less than 50 nm in width were observed, see Figure 1.b, revealing the local processes involved in intensive strain delocalisation within these materials.

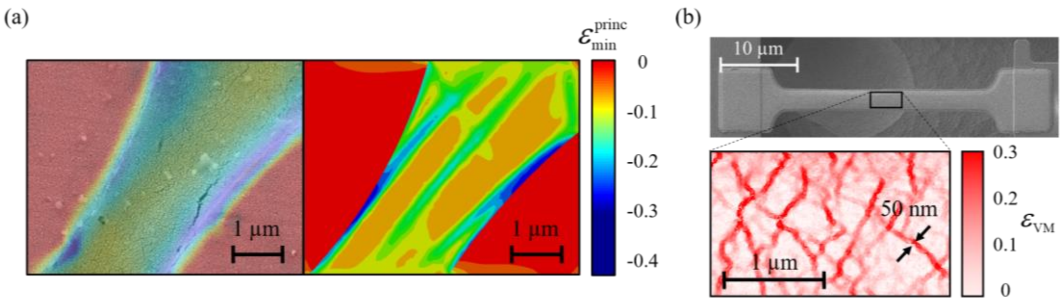

Fig. 1: (a) Minimum principal strains $\varepsilon_{\mathrm{min}}^{\mathrm{princ}}$ obtained by DIC (left) and FEM (right) in a methacrylic composite under compression, and (b) Von Mises strain $\varepsilon_{\mathrm{VM}}$ obtained by DIC in an aluminium thin film under tension

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