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IDENTIFICATION OF CRYSTAL PLASTICITY LAW PARAMETERS USING KINEMATIC MEASUREMENTS IN POLYCRYSTALS

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The use of 316L(N) austenitic stainless steel in pressurized water reactor internals requires a good knowledge of its mechanical behavior. In particular, predictive constitutive models are established in micromechanical frameworks and take into account material ageing, for example due to irradiation. Crystal plasticity laws allow for accurate descriptions of intragranular plastic strains by considering the activity of slip systems [1]. However the identification of their parameters remains challenging [2]. In this paper, an identification procedure based on kinematic measurements in polycrystals during *in situ* tests performed in an Scanning Electron Microscope (SEM) is presented.

To get experimental values of kinematic fields in a polycrystal, a sequence of SEM images has been acquired during an *in situ* tensile test. The displacement fields are measured between two consecutive images with a continuous Galerkin based Digital Image Correlation (DIC) procedure [3, 4]. The size of the region of interest is 400 µm in width that corresponds to 1500 pixels. Thanks to electron backscatter diffraction acquisitions, the displacement discretization is performed using an unstructured mesh taking as support the grain boundaries, and built from 3-noded triangular elements (about 20 pixel / 5 µm mean size). Digital image correlation provides spatially dense kinematic measurements at the polycrystal scale (Figure 1(a) and 1(b)). This approach allows consistent comparisons to be performed with finite element calculations to identify material parameters by an inverse method.

Simulations of the experimental tensile test are performed using the finite element software Code_Aster and using the same mesh as that used in DIC calculations. Experimentally measured boundary conditions are prescribed with their time evolution. The applied load is also accounted for. Three parameters associated with isotropic hardening of the crystal plasticity law [1] are chosen to be identified. For that purpose, a weighted finite element model updating procedure is used, an inverse method already applied by Meuwissen *et al.* [5] to J2 plasticity. The cost function to be minimized is built from nodal in-plane displacements at each time step, the load level, the measurement uncertainties and specific developments are proposed to regularize the sometimes ill-posed identification problem [6, 7]. Several numerical and experimental examples will demonstrate the performance of the method. Figure 1(c) shows the change of the cost function with one of the three parameters to be identified in a numerical test case.

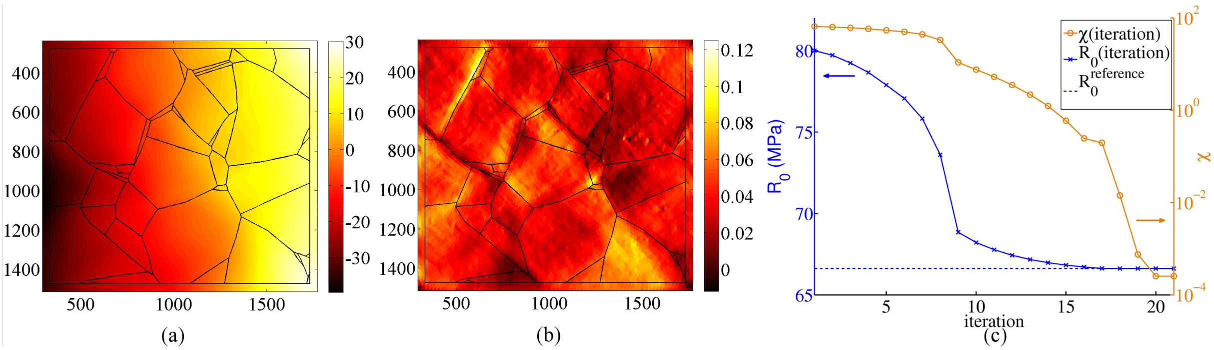

Figure 1: Longitudinal displacement field in pixels (a) and longitudinal strain field (b) measured experimentally for a macroscopic strain of 5%. The physical size of one pixel is 150 nm. The grain boundaries are shown as black lines on these fields. Change of the cost function χ and of the critical resolved shear stress R_0 as functions of the iteration of the identification procedure (c). In this test case, a set of reference values of parameters is to be identified.

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