MICRO-MECHANISMS OF FRACTURE IN METALS

LABORATORY : Institut Lumiere Matiere

LEVEL : M2

TEAM(S) : MMCI
LIQ@INT

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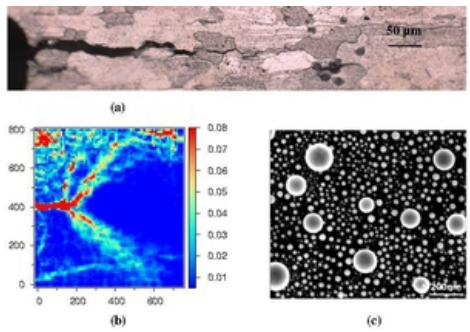
KEYWORD(S) :

SCIENTIFIC CONTEXT :



Deformation field around a crack obtained by digital image correlation (resolution 1 µm)

Fracture of metals in severe environments is an important topic which concerns many applications (aqueous corrosion and hydrogen embrittlement in transport represented in Fig. 1a and nuclear industry, irradiation) and future applications such as the storage of hydrogen for a clean supply of energy (fuel cell technology). It is important to understand the mechanisms of such damage in order to design more resistant metallic materials or to predict the crack initiation and the propagation velocity in the ones that are already in service. A first goal is to be able to observe the elementary mechanisms at the scale of the microstructure (i.e. at a scale at least one order of magnitude smaller than the grain size). Of particular interest is the intermittency of crack propagation, which is essential to the current models [Katz]. Recently, it has been shown [Richeton] that plasticity is intermittent because of plastic avalanches. It is therefore possible that acoustic emission (AE) signals, that were attributed to rupture events [Lii], stem from plastic avalanches. As a consequence, a fine characterisation of the plasticity occurring during crack propagation is required.

MISSIONS :

In order to study plasticity, several tools will be used: (i) a micro-traction machine enabling in situ observations within a scanning electron microscope (SEM), (ii) digital image correlation (DIC) giving access to the displacement field on the surface, (iii) discrete dislocation dynamics simulations to understand the origin of localized plasticity and the stresses at a small scale which are responsible for fracture.

For DIC, the key element is the characteristic size of the surface pattern. In this internship, we want to produce gold nanoparticles by laser dewetting, at low temperature (i.e. without thermal treatment of the surface), to reach a spatial resolution that reveals plastic slip bands. They are typically of a few 100 nm thickness. This small scale pattern (Fig. 1c) will be used during tensile tests within a scanning electron microscope with a special attention paid to the distortion of the image of the surface due to the movement of the sample under the beam. In parallel, it is also interesting to develop a coarser pattern that could be used under an optical microscope (Fig. 1b). In the case of further lockdowns, there also exists the possibility to perform simulations.

OUTLOOKS :

577 euros/month will be given. Possibility to apply for a PhD grant at the University.

BIBLIOGRAPHY :

[Katz] Y. Katz, N. Tymiak, and W.W. Gerberich. Nanomechanical probes as new approaches to hydrogen deformation interaction studies, Eng. Frac. Mech., 68 :619–646, 2001.

[Bourcier] Bourcier, J. Geophys. Res. Solid Earth 118, 511-526, 2013).

[Lii] M.-J. Lii et al. Dislocation modeling and acoustic emission observation of alternating ductile/brittle events in Fe-wt%Si crystals. acta metall. mater., 12 :2435, 1990.