HYDROGEN-MICROSTRUCTURE INTERACTIONS IN BCC FeCr ALLOYS BY *IN-SITU* NANOINDENTATION

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Environment sensitive failure, such as hydrogen embrittlement, of metallic alloys and particularly steels is a longstanding problem causing large annual economical loses. A deeper understanding of the individual mechanisms leading to the final material breakdown is highly demanded. Hydrogen can be incorporated into the material from different liquid or gas sources, during material processing or in operation conditions; the mechanisms leading to the material failure depend on the absorbed hydrogen interaction with trap binding sites or defects, as it is the case of dislocations.

We focus on bcc Fe-Cr alloys as the base components of ferritic stainless steels, and use nanoindentation to evaluate the hydrogen effect on homogeneous nucleation of dislocations. Pure bcc Fe can incorporate only a small fraction of hydrogen in the ppm range at room temperature and pressure, mainly in interstitial sites; however its mobility is high due to a low diffusion barrier. *Ex-situ* analyses often lead to hydrogen desorption and formation of concentration gradients prior and during testing. Under these conditions, it is compulsory to study *in-situ* the changes on the mechanical response while charging the material with hydrogen. An electrochemical cell for in-situ nanomechanical testing was developed in-house for this purpose, combining the existing ideas for in-situ nanoindentation and atomic force microscopy, together with a new approach for hydrogen charging to avoid surface damage. FeCr alloys were cast using pure elements, cold rolled and further annealed to obtain large ferritic grains (>400 micrometers). Nanoindentation tests were performed on individual grains for three different grain orientations prior, during and after hydrogen charging. A reduction in the pop-in load indicating the yield point with the increase of hydrogen content and formation of multiple pop-ins during nanoindentation provided evidence for the decrease in the resolved shear stress and enhanced dislocations nucleation. Further analysis on the dislocation density and plasticity development is provided by electron channeling contrast imaging and electron backscatter diffraction analyses around low depth indents for the three studied grain orientations.

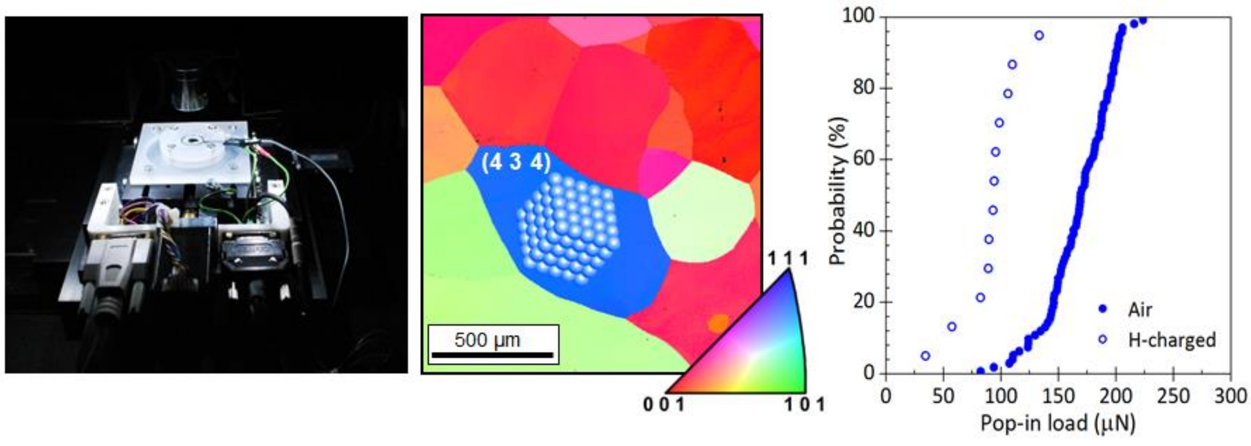

Figure 1 – (from left to right) Set-up used for in-situ nanoindentation during electrochemical H-charging; EBSD map of the ferritic microstructure and selected (4 3 4) grain orientation; example of a cumulative plot of the pop-in load for the (4 3 4) grain orientation showing a decrease in the pop-in load related to hydrogen charging.