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Characterization of Hydrogen Effect on Mechanical Properties of Metals at Different Length Scales

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Due to its small size, hydrogen has high mobility at room temperature in metals. The hydrogen mobility is also affected by the local stress field in the crystal. On the other hand, hydrogen can be trapped at different defects in the crystal differently, resulting in the non-uniform distribution of the hydrogen in the microstructure and its local enrichments. All these effects occur during the mechanical loading of metallic components that have been in contact with hydrogen or are in contact with a hydrogen source. Consequently, depending on the stress distribution and presence of the defects and their type, hydrogen will dynamically redistribute within the microstructure and locally enriches at specific locations. These hot spots with high hydrogen concentrations are developing within the microstructure spatiotemporally. Cracks form once the hydrogen concentration and stress level are high enough in these hot spots. Conventional macroscopic mechanical tests cannot resolve these spatiotemporally distributed cracks and hot spots and give us enough information to develop predictive models for the hydrogen effect on mechanical properties. They typically measure an integration of these incidents over time, which manifests itself in loss of ductility. Therefore, it is necessary to isolate these hotspots and study them separately. To realize it, we develop mechanical testing approaches at different length scales to look at the interaction of the hydrogen with different types of defects and how they behave in the presence of hydrogen. This talk will give an overview of the work that has been done in the past 20 years to get an insight into the hydrogen effect on mechanical properties at different length scales.