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Phase field modelling of hydrogen assisted fracture

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Hydrogen is ubiquitous and causes catastrophic failures in metallic components. However, the development of models capable of predicting cracking in hydrogen-sensitive environments remains an elusive challenge. In this work, we present a new phase field fracture formulation to predict hydrogen embrittlement. Our pioneering framework combines: (i) a coupled mechanical and hydrogen diffusion response, driven by chemical potential gradients [1], (ii) a (higher order) strain gradient plasticity description of crack tip deformation [2], and (iii) a hydrogen-dependent fracture energy degradation law grounded on first-principles calculations [3].

The potential of the proposed phase field modelling framework is demonstrated by means of representative case studies. Experimental trends are captured both qualitatively and quantitatively. Moreover, we show that the framework can deliver large-scale predictions for technologically-relevant applications, bringing the *Virtual Testing* paradigm to hydrogen-sensitive applications [4]. More recent extensions, such as the modelling of fatigue damage [5], will also be discussed.

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