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## **PERIDYNAMIC MECHANO-CHEMICAL MODELING OF STRESS CORROSION CRACKING**

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### **ABSTRACT**

In this work, we extend the peridynamic model of corrosion damage to consider mechanical damage produced not only by the corrosion process, via anodic dissolution, but also by mechanical strains. We include a dependence of the metal-ion diffusivity (which determines the corrosion rate) on the peridynamic bond strain. The mechanical model is solved together with the diffusion model. We calibrate and validate the mechanochemical model against the experimental results on corrosion of copper under tension stress. We then apply the model to study stress-corrosion cracking of stainless steel. The coupled model is capable of simulating the transient corrosion process and the dynamic crack growth seamlessly.

**Keywords:** corrosion, stress-corrosion cracking, peridynamic, damage.

### **INTRODUCTION**

Corrosion can lead to accelerated failure of structural components by pitting and perforation, or by acting as an initiation site for cracking. Most models for the evolution of pitting corrosion consider that the corrosion reaction only affects the metal surface and, because of that, they cannot capture changes in the mechanical properties in the layer immediately below the solid/liquid interface. These changes, such as embrittlement induced by corrosion or stress-dependence of the diffusion processes in corrosion, are determining factors in explaining how Stress Corrosion Cracking (SCC) is triggered and how it progresses in time. We apply a novel peridynamic model for the evolution of damage from corrosion [1, 2]. In this model, the anodic reaction in corrosion processes is treated as an effective diffusion process in the electrolyte/solid system combined with a phase change mechanism; mechanical damage is induced based on local concentration drop and this damage enhances corrosion rate.

Here, we extend the model to consider mechanical damage produced not only by the corrosion process, via anodic dissolution, but also by mechanical strains. We include a dependence of the metal-ion diffusivity (which determines the corrosion rate) on the peridynamic bond strain. The mechanical model (that gives the stresses/strains and the damage produced by reaching the critical fracture strain in the material) is solved together with the diffusion model (which gives the metal-ion concentration and computes the damage induced by the material dissolution due to corrosion processes). We apply the mechanochemical model to study corrosion of stainless steel under tension stress.

## RESULTS AND CONCLUSIONS

Figure 1 shows the simulation setup for the corrosion of stainless steel under tension stress.

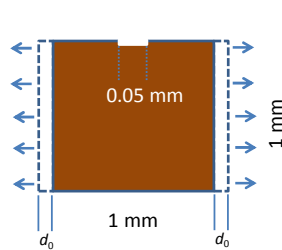


Fig. 1 - The simulation setup: geometry and boundary conditions. The metal is protected by the passive film except the upper-central region.

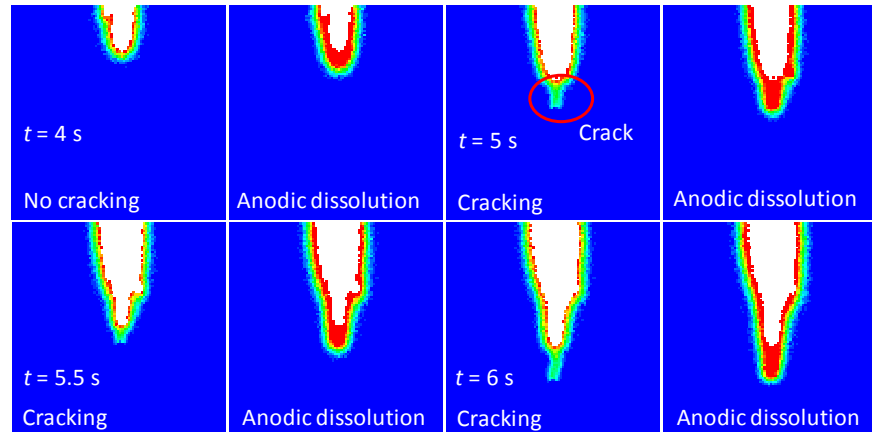


Fig. 2 - Snapshots of damage evolution.

The results (see Figure 2) show that once corrosion damage creates regions of high stress concentration, the corrosion rate, which in our model depends on local strain, starts to increase, giving the notch a more elongated shape, which further increases the stress concentration factor at such locations. When the stress intensity factor becomes critical, a dynamic crack starts to propagate. Diffusion of the corrosive solution advances along the new path and the corrosion front shape becomes elongated in the direction of the crack.

The coupled model is capable of simulating the transient corrosion process and the dynamic crack growth seamlessly. The flexibility of the peridynamic model for describing arbitrary damage configurations, ranging from diffuse to localized damage, is seen as an important advantage for the proposed approach. Future work will concern modeling of fatigue crack growth in corrosive environments.

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