A Study of Stress Corrosion Cracking by High-Speed Atomic Force Microscopy

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Stainless steels are widely used in the nuclear industry for their well-known behaviour, favourable mechanical properties, and resistance to corrosion. However, under certain conditions stainless steels are susceptible to forms of corrosion that can result in failure. Forms of localised corrosion, such as stress corrosion cracking (SCC), are particularly detrimental as they can occur without any obvious visual cues such as tarnishing. This can lead to sudden and unexpected failure. There are many safety and economic incentives to prevent failure events due to corrosion, motivating considerable research.

SCC occurs due to the synergistic interactions of three factors: a susceptible material, a corrosive environment, and sufficient stress. There are currently a multitude of techniques employed for the detection and observation of SCC. However, the key to understanding the mechanisms behind SCC, is to be able to observe such an event as it initiates at the nanoscale. This can only be achieved by a handful of techniques.

Contact mode high-speed atomic force microscopy (HS-AFM) produces topographic maps of a surface with nanometre lateral resolution and sub-nanometre height resolution, at a rate of multiple frames per second [1]. Material surfaces can be imaged within aqueous or gaseous environments allowing for in-situ observations of dynamic events, such as corrosion [2-4].

Within the work presented here, SCC and the factors leading to SCC, were analysed using HS-AFM in combination with scanning electron and ion beam microscopy techniques. SCC was initiated in thermally sensitised 300 series stainless steel within a solution of sodium thiosulfate, with measurements being performed as cracking progressed. HS-AFM was also used to observe localised dissolution events and pitting corrosion in-situ, both of which can lead to SCC, as well as perform analysis of the sensitised microstructure and how such a surface responds to applied stress and corrosive environments.

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