HYDROGEN EMBRITTLEMENT OF HIGH-ENTROPY ALLOYS: CASES OF MONOTONIC TENSION AND FATIGUE

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Stable austenitic steels have been recognized as hydrogen-resistant materials. However, they also show hydrogen-assisted failure when exposed to a severe hydrogen atmosphere, e.g., 100-MPa hydrogen gas. In this regard, FCC-type equiatomic CrCoFeMnNi high-entropy alloy is an interesting material as a candidate of hydrogen-resistant and high-strength material. In this talk, we aim to share our results of hydrogen embrittlement behavior of the fcc-structured high-entropy alloy. In particular, we investigated the effect of hydrogen on resistance to tensile fracture and mechanically long fatigue crack growth in an equiatomic CrCoFeMnNi high-entropy alloy. The fatigue crack growth was evaluated using compact tension (CT) tests at the frequency of 1 Hz and room temperature (293 K). The CT test specimens were hydrogen-charged using 100 MPa hydrogen gas at 270 ˚C prior to testing. Both the monotonic tension and fatigue loading after hydrogen charging caused intergranular cracking. Specifically, the intergranular fatigue crack growth showed three times faster crack growth rate compared to that without hydrogen charging.

The intergranular fracture in the tensile test occurred after significant plastic deformation and the cracked region had a large local plasticity, which indicates the occurrence of plasticity-mediated grain boundary cracking. The intergranular fracture could be completely suppressed by grain refinement and removal of Mn. However, in terms of fatigue, grain refinement generally acts as a factor accelerating mechanically long crack growth owing to a reduction in crack closure effect. Therefore, to find another route to suppress the hydrogen-induced intergranular crack growth in fatigue, we must understand the details of the mechanism. As a key feature, striation-like marks were observed on the intergranular fracture surface, which indicated that intergranular crack growth occurred via plasticity-driven mechanism. Furthermore, the striation-like pattern showed a peak-to-valley morphology, implying occurrence of the alternating crack tip shear mechanism involving a crack blunting/re-sharpening process. This interpretation of the fractographic feature implies that hydrogen-assisted dislocation emission/motion from grain boundaries is a key phenomenon that accelerated the fatigue crack growth.