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Fe(O,OH)$_6$ Network Nanostructure of Rusts Formed on Weathering Steel (IV)

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Introduction

Improvement of corrosion resistance of steels without coating is important from the viewpoint of life-cycle assessments of structures. Weathering steel (WS) has been developed for such applications especially to bridges. WS, containing a 0.3-0.7 mass% Cr and Cu, forms a protective rust after a few years of exposure to atmosphere to show good corrosion resistance [1,2].

However, a conventional WS shows a good corrosion resistance only when it is exposed to atmosphere containing little air born salt. Thus advanced WS was developed; the addition of 3 mass% Ni increases the corrosion resistance to a large extent [3]. The mechanism has been investigated by *in situ* observation techniques using synchrotron radiation [4-6]. In this study, effects of copper addition on the formation of rust on WS is studied.

Experiments

Conventional WS (0.3Ni-0.3Cu-0.5Cr-Fe in mass%) and advanced WS (3.0Ni-0.4Cu-Fe in mass%) were exposed to atmosphere in a rural area for 5 years and in a costal area for 9 years, respectively. The rusts on both steels were investigated by X-ray absorption fine structure (XAFS) in the florescence geometry using a 19-element SSD [7] and Bent Crystal Laue Analyzer. Cu-K edge XAFS measurements were carried out at BL-9A and 12C at PF, KEK, Tsukuba, Japan.

Results and Discussion

Before corrosion begins, Cu atoms are in a solid solution in an alloy. As corrosion progressed, XAFS spectra showed significant change. Figure1 shows XAFS spectra of rusts formed after atmospheric corrosion. Edge energies of the rusts are higher than that of mother metal, showing formation of oxide. However near-edge-structures of the rusts are different from those of Cu$_2$O or CuO. Microstructure analysis with TEM showed no clear indication of formation of copper oxides. These results show that copper atoms in the rusts form Cu-O bonding which is different from Cu$_2$O and CuO. These spectra indicate that copper atoms are expected to occupy a unique sites in the Fe(O,OH)$_6$ [1,2] in the rust. This may alter the evolution of the atomic scale network of rust (Fig. 2), resulting in formation of fine grain rust, which can be attributed to the good corrosion resistance of WS.
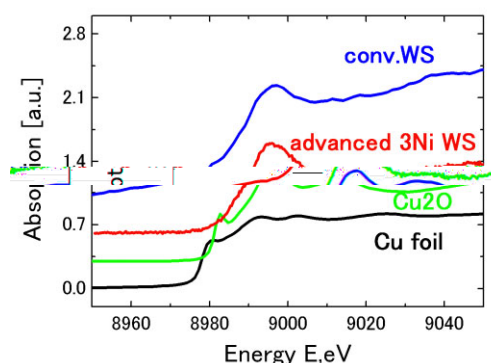

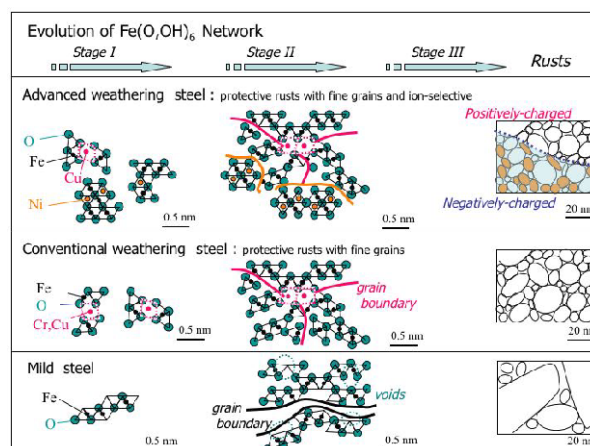Fig.1 XAFS spectra of rusts and reference materials.

Fig. 2 Schematic diagram of the evolution of the Fe(O,OH)$_6$ nano-network of the rust formed on the advanced weathering steel in an atmosphere containing relatively high air-born salinity (top), conventional weathering steel in milder condition (middle), and mild steel in milder condition (bottom) [1,2,5].

References

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