Effect of Cold-rolling on Passivation of Pure Iron in pH8.4 Borate Solution

Takatoshi Yamamoto, Koji Fushimi, Hidetaka Konno and Seiji Miura
Graduate School of Engineering, Hokkaido University

The corrosion resistance of metals is strongly affected by the formation of a passive film on the metal surface. The metallic texture of the surface, which is changed by segregation of contents and/or phase transformation of substrate in the vicinity of surface, conceivably contributes to the formation and properties of the passive film. However, there are few reports about the effects of the dislocation and/or strain in the substrate to the passivation. In this work, the passive film formed on the cold-rolled iron substrate was investigated using electrochemical impedance spectroscopy.

An iron plate (5 mm thickness) with a purity of 99.99% was vacuum-annealed and cold-rolled down to 4–1 mm thickness (reduction ratio $Red = 20\text{ to } 80\%$) after electropolishing. The rolled plates as well as the annealed one were used as specimens. The specimen surface was passivated at 0.7 V (SHE) for 7.2 ks in deaerated pH8.4 borate buffer solution after cathodic polarization at 30 $\mu$A cm$^{-2}$ for 500 s to remove the air formed oxide. The impedance measurement was conducted by superimposing an ac voltage of 5 mV with the frequency ranging from $10^5$–$10^{-2}$ Hz on a dc bias 0.7–-0.1 V (SHE). From Mott-Schottky plots, flat band potential $E_{fb}$ and donor density $N_d$ in the passive film were calculated.

Immediately after the passivation, anodic current flowing through each specimen was independent of $Red$. The all specimens tend to decrease the current exponentially with time. However, after 10 s, highly reduced specimens ($Red \geq 60\%$) allowed to flow the large current compared with the lowly reduced ones (Fig. 1). It means that the passive film formed on the high $Red$ specimen is more conductive, probably due to formation of defects in the film. Fig. 1 also shows $E_{fb}$ and $N_D$ as a function of $Red$ when dielectric constant of 40$^1$ is assumed. The $E_{fb}$ is independent of $Red$, being -0.06 V (SHE), while the $N_D$ depends on $Red$, markedly increasing at $Red \geq 60\%$. This explains that the $i_{pass}$ becomes larger owing to reducing of substrate. The donors in the passive film should be defects of the oxide instead of impurity in this experiment. It is suggested that dislocation and/or strain of substrate in the vicinity of the surface induces the defects in the passive film during the formation.

Name: Takatoshi YAMAOTO

Position and Affiliation: Master of Engineering, Hokkaido University
Postal Address: North 13, West 8, Kita-ku, Sapporo 060-8628, Japan
Phone/Facsimile: +81-11-706-6577/+81-11-706-6577
Email: t-yama@eng.hokudai.ac.jp
Web Page URL: http://am2-me.eng.hokudai.ac.jp/

Research Interest and Keywords: Corrosion, Micro-indentation, Passivation, Depassivation, Repassivation, Metal texture, Dislocation, Plastic deformation, Elastic deformation, Stainless Steel

Recent Publications:

Biographical Sketch:
A research work on corrosion by Yamamoto started in 2005 when he belonged to the Interfacial Electrochemistry Laboratory in Department of Applied Chemistry, Faculty of Engineering, Hokkaido University. He went abroad to study at Rice University in 2008 for researching metallic properties of carbon nanotube. He has been JSPS Research Fellowships for Young Scientists since 2008 in Hokkaido University.