Characterization of Electric Conduction of Passive Films and Oxide Films Formed on Fe-Cr Alloys

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In order to understand electronic structure of oxide film, the electric resistance / conductivity of passive film and also oxide films formed on Fe-Cr alloys and stainless steels have been studied using direct contact method without immersion in aqueous solution. Conventionally, electric feature of passive films has been characterized using electrochemical impedance spectroscopy, which provide electric structure of passive films in aqueous environment. Recently, the contact resistance between stainless steels and other conductive materials has been extensively interested in relation to the application of stainless steels to electric contact materials, such as casing of batteries, separator of fuel cells, etc. In these studies, contact resistance is measured by pressing counter material on the surface of stainless steel. It is reported that contact resistance highly depends on contact pressure, humidity, counter materials, and etc. The part and area of contact is usually not defined. Moreover, the electric resistance of passive film itself has not necessarily been characterized. In the present work, the electric resistance/conductivity of oxidized films or passive film formed on stainless steels and Fe-Cr alloys was measured as a contact resistance with liquid mercury

A coupon specimens of pure Fe, pure Cr, Fe-Cr alloys and some commercial stainless steel were mirror finished then polarized in aqueous solution or oxidized in air at elevated temperature up to 400 °C. The specimen was directly contacted with liquid mercury, then electric resistance was measured by a four-probe method applying direct current of approximately 36 μA / cm2. The thickness and chemical content of passive films were also evaluated using X-ray photoelectron spectroscopy.

It is confirmed that electric resistance of passive film formed in aqueous solutions increased in proportion to its thickness and proportionally decreased with increasing Cr content in the passive film up to approximately 90 % (cationic fraction), then increase with increasing Cr content. The electronic resistance is not necessarily depends on the aqueous solution in which passive film formed.

Oxide films formed in elevated temperature showed rectifier and conductor character depending on oxidizing temperature and Cr content. Basically, the oxide films which is formed at higher than a critical temperature exhibited n-type rectifier. The critical temperature tends to increase with increasing Cr content in the alloy. However, pure Fe and pure Cr did not exhibit such rectifier function in the condition examined in the present work.

The resistivity / conductivity of passive films and oxidized films on stainless films are compared with the results obtained by impedance measured in non-aqueous solution and discussed semiconductor characteristic of oxide films.