

6. Electrochemistry

On the use of the dielectric bi-layer model to characterize passive film properties grown on stainless steel

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Abstract

Since the properties of oxide films are crucial for designing new corrosion and oxidation-resistant alloys, numerous studies have focused on their enhanced characterization. Among the various techniques available, electrochemical impedance spectroscopy (EIS) is commonly used to obtain *in-situ* physical information about passive layers. For passive materials, the electrochemical impedance response often deviates from ideal capacitive behavior due to resistivity distribution within the oxide layer. This distribution follows either a power law (as proposed in Power Law Model (PLM)) [1] or an exponential law based on the Young model [2].

Surface analysis has shown that passive films grown on stainless steels may consist of two distinct layers with different properties and compositions. Therefore, models used to analyze the electrochemical impedance response must consider this duplex structure.

In the present work, two models were applied: the PLM, which assumes a homogeneous oxide film with a power-law distribution of resistivity, and the recently proposed Dielectric Bi-Layer Model (DBLM), which accounts for an inner layer with a constant resistivity (ρ_0) resulting in an impedance resembling a pure capacitance in parallel with a resistance, and an outer layer with an exponential resistivity distribution according to Young's theory [3].

In the presented work, passive films grown on 316L stainless steel with different physicochemical conditions (applied potentials, solution chemistry, temperature...) were tested. Resistivity profiles and regressed physical parameters were discussed concerning oxide thickness. X-ray photoelectron spectroscopy further described the

oxide film's nature and structure. The applicability of the hypotheses in the DBLM could be then discussed regarding the passive film features.

Keywords Electrochemical Impedance Spectroscopy, X-ray photoelectron spectroscopy, Passive film

Reference

- [1] B. Hirschorn *et al.*, *J. Electrochem. Soc.*, 157 (12), C458 (2010)
- [2] L. Young, *Trans. Faraday Soc.*, 51, 1250 (1955)
- [3] B. Ter-Ovanessian *et al.*, *Electrochimica Acta*, 492, 144307 (2024)