Measurement of Surface Resistivity and Surface Conductivity of Anodized Aluminium by Optical Interferometry Techniques

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Abstract

Optical interferometry techniques were used for the first time to measure the surface resistivity and surface conductivity of anodized aluminium samples in aqueous solution, without any physical contact. The anodization process (oxidation) of the aluminium samples was carried out in different sulphuric acid solutions (1.0-2.5 % H_2SO_4), by the technique of electrochemical impedance spectroscopy (EIS), at room temperature. In the mean time, the real-time holographic interferometric was carried out to measure the thickness of anodized (oxide) film of the aluminium samples during the anodization process. Then, the alternating current (AC) impedance (resistance) of the anodized aluminium samples was determined by the technique of electrochemical impedance spectroscopy (EIS) in different sulphuric acid solutions (1.0-2.5 % H_2SO_4) at room temperature. In addition, a mathematical model was derived in order to correlate between the AC impedance (resistance) and to the surface (orthogonal) displacement of the samples in solutions. In other words, a proportionality constant (surface resistivity or surface conductivity=1/ surface resistivity) between the determined AC impedance (by EIS technique) and the orthogonal displacement (by the optical interferometry techniques) was obtained. Consequently the surface resistivity (ρ) and surface conductivity (σ) of the aluminium samples in solutions were obtained (1). Also, electrical resistivity values (ρ) from other source were used for comparison sake with the calculated values of this investigation. This study

revealed that the measured values of the resistivity for the anodized aluminium samples were $2.8x10^{9}$, $7x10^{12}$, $2.5x10^{13}$, and $1.4\ x10^{12}$ Ohms-cm in 1.0%,1.5%, 2.0%, and 2.5 % H_2SO_4 solutions, respectively. In fact, the determined value range of the resistivity is in a good agreement with the one found in literature for the aluminium oxide,85% Al_2O_3 ($5x10^{10}$ Ohms-cm in air at temperature $30C^0$), 96% Al_2O_3 ($1x10^{14}$ Ohms-cm in air at temperature $30C^0$), and 99.7% Al_2O_3 ($>1x10^{14}$ Ohms-cm in air at temperature $30C^0$). The obtained data are given in Table 1.

Keywords: Electrical Resistivity, Electrical Conductivity, Alternating Current (AC) Impedance (Resistance), Holographic Interferometry, Aluminium, Oxide Aluminium (Al_2O_3), Room Temperature, and Sulphuric Acid Solution.

Table 1. Calculated Parameters of Anodzed Aluminium samples in different H_2SO_4 concentrations.

Solution Concentration (%H_2SO_4)	AC Impedance x Area(ZA) (Ohms-cm2)	Tolal Displacement (U) (μm)	Resistivity By OI (ρ) (Ohms-cm)	Conductivity by OI (σ) (Siemens/ cm)	Resistivity by other source[7] (ρ) (Ohms-cm)
1.0%	**$5.5x10^{6}$**	**19.91**	**$2.8x10^{9}$**	**$3.6x10^{-10}$**	**$5x10^{10}$**
1.5%	**$15.0x10^{9}$**	**21.72**	**$7x10^{12}$**	**$1.43x10^{-13}$**	**$5x10^{10}$ -$1X10^{14}$**
2.0%	**$62.5x10^{9}$**	**42.72**	**$2.5x10^{13}$**	**$4x10^{-14}$**	**$5x10^{10}$ -$1X10^{14}$**
2.5%	**$5.95x10^{9}$**	**43.1**	**$1.4\ x10^{12}$**	**$7.14x10^{-13}$**	**$5x10^{10}$ -$1X10^{14}$**

References

[1]-K.Habib," Measurement of surface resistivity/conductivity of Metallic Alloys in Aqueous Solutions by optical interferometry techniques", accepted in Optik (2011), in Press.