Effect of Surface Roughness, Thickness and Current Density on Surface Resistance of Electro-deposited Copper Layer

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Abstract
Surface resistance of electro-deposited copper with its thickness, current density and surface roughness was determined by using a 4-point probe analyzer. The copper was prepared electrochemically on 316 stainless steel substrate in copper sulfate solution at the condition of 1 A/dm^2, 298 K, and 6.5 cm-electrode distance. The surface resistance of the copper sheet in the range of 0.93-0.97 Ω increased with the copper thickness in the range of 21-70 ㎛. The surface resistance in the range of 0.963-1.009 Ω also increased with current density in the range of 0.5-2 A/dm^2. The increased surface resistances corresponded to 11% for thickness and 25% for current density, respectively.

1. Introduction
Since electromagnetic properties of an electro-deposited copper for EMI components significantly depend on surface morphology and microstructure [1, 2], surface roughness, thickness and current density on the surface resistance of the electro-deposited copper layer were systematically studied to give an optimum fabrication condition for a cellular phone antenna with a high performance.

2. Experimental Methods
Copper was electro-deposited on 316 stainless steel substrates with 2.6-23 ㎛-surface roughness for 0.5-2 hour with the current density of 0.5-2 A/dm^2 at 298 K in copper sulfate solution. Surface resistance of the electro-deposited copper was determined by using a 4-point probe analyzer.

3. Results and Discussion
The copper thicknesses prepared in this study were in the range of 21-70㎛. The surface resistances of the copper layers were in the range of 0.93-0.97 Ω, which increased about 11 % with the copper thickness. For the copper layers with the surface resistances in the range of 0.963-1.009 Ω, their surface resistances were in the range of 0.5-2 A/dm^2, which also increased about 25% by current density to produce the copper layers. Since lower current density tended to form smaller copper cluster, the surface resistance change seemed to be related to microstructures near and at the surface that influenced the current behavior.

3. Conclusions
(1) Surface resistance of electro-deposited copper depended on the surface roughness of the 316 stainless steel substrate.
(2) Surface resistance of the copper sheet increased 11% for the copper thickness and 25% for current density to produce the copper layers, respectively.

References
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