

## Influence of Copper on the Anodizing of Binary Aluminum-Copper Alloys

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In copper-containing aluminum alloys, copper is present in solid solution in the matrix, as fine strengthening phases and as relatively coarse intermetallic particles. In appropriate media, localized corrosion can occur due to galvanic coupling between the matrix, the particles and the bordering region. In order to understand further the electrochemical behavior of the different phases, examination of Al-Cu model alloys allows separation of the individual effects. Here, the influence of copper (up to 7 at%) on the anodic processes during anodizing are considered.

Binary Al-Cu alloys were deposited on an aluminum substrate by magnetron sputtering. The alloys were anodized up to 150 V at 5 mA cm<sup>-2</sup> in a 0.1 M ammonium pentaborate solution at 293 K. They were then observed by TEM and analyzed by Rutherford backscattering spectroscopy (RBS) and Glow Discharge Optical Emission Spectroscopy (GDOES).

Figure 1 shows a linear increase of the anodizing voltage with time for alloys containing up to 2 at% Cu. For higher copper contents, contrasting anodizing behavior was evident, with deviations from the linear behavior with time of anodizing. TEM observations and RBS analysis [Fig. 2] showed copper enrichment just below oxide film in the model alloy [1]. The variation in the anodizing behavior with copper content is related to the extent of copper enrichment, which is also related to the copper content in the bulk material. Thus, during anodizing, copper in the alloy enriched layer to a limiting level. From TEM, the thickness of the enriched layer is about 2.0 nm [Fig 3].

Oxygen generation within the alumina also occurred during the anodizing process [2], coinciding with the oxidation of copper from the enriched layer. Figure 4 confirms that the O to Al atomic ratio in the oxide film increased during anodizing, and reached a limiting value of about 4 after 150 s. This value, greater than 3/2 for amorphous, anodic alumina, shows that oxygen bubbles are formed in the oxide film; these lead to film rupture, local repair and further enrichment. The influence of such copper enrichment on the electrochemical behavior is the subject of further study.

[1]. X. Zhou, G.E. Thompson, H. Habazaki, K. Shimizu, P. Skeldon and G.C. Wood, *Thin Solid Films* 293 (1997) 327

[2]. Y. Liu, E.A. Sultan, E.V. Koroleva, P. Skeldon, G.E. Thompson, X. Zhou, K. Shimizu, H. Habazaki, *Corros. Sci.* 45 (2003) 789

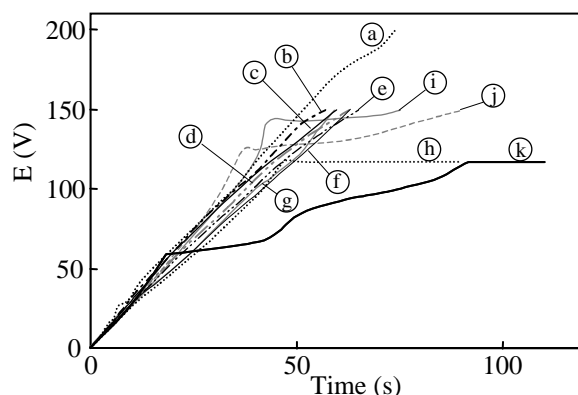


Fig 1: Potential vs time during anodization of Al-x%(at)Cu alloys at 5 mA cm<sup>-2</sup> in (NH<sub>4</sub>)<sub>2</sub>B<sub>10</sub>O<sub>16</sub> solution: x= (a) 0 (b) 0.1 (c) 0.2 (d) 0.3 (e) 0.8 (f) 1.1 (g) 1.8 (h) 2.5 (i) 3 (j) 3.5 (k) 7

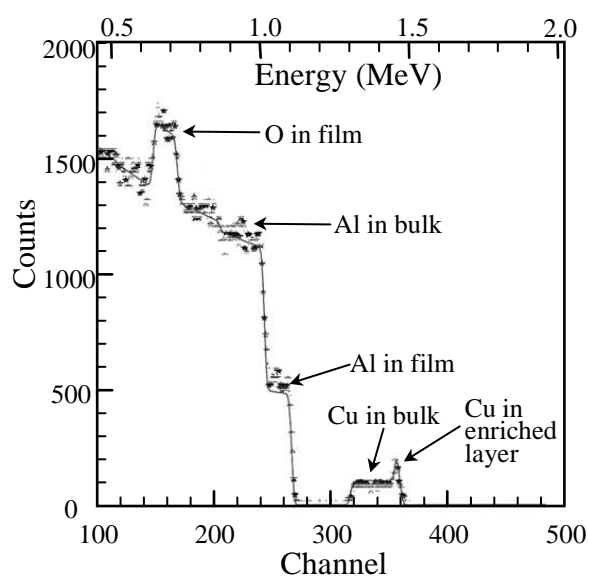


Fig 2: RBS spectra of a Al-1.8at%Cu alloy anodised at 5 mA cm<sup>-2</sup> in (NH<sub>4</sub>)<sub>2</sub>B<sub>10</sub>O<sub>16</sub> solution.

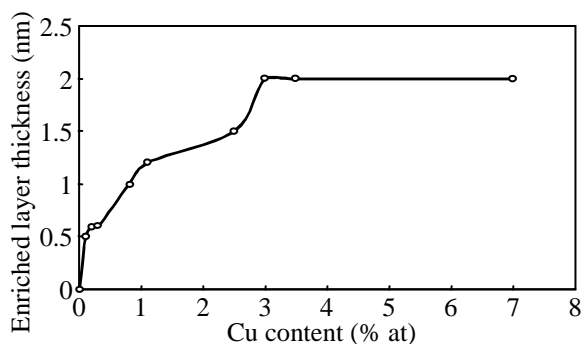


Fig 3. Copper enriched layer thickness versus copper content in bulk (RBS analysis)

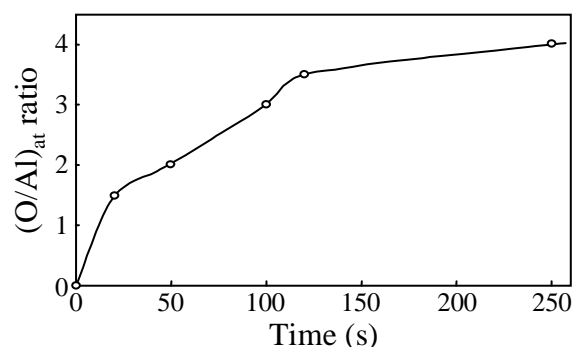


Fig 4. Oxygen generation during film growth. (O/Al)<sub>at</sub> ratio in porous anodic film on a Al-7 at% Cu alloy.