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The Effect of Coating Thickness on the Microstructure and Performance of Zn-Al-Mg Alloy Coatings

INTRODUCTION

Zinc-Aluminium-Magnesium (ZAM) coatings have been used since the mid-2000s as a more effective alternative to traditional zinc galvanizing, showing increased corrosion protection [1] and beneficial manufacturing properties [2]. However, ZAM coatings produce a complex microstructure which can be easily influenced by a large range of processing parameters, making consistent coatings very difficult to produce. This work concentrates specifically on the effect of coating weight on microstructure composition and in turn, the performance of corrosion protection.

EXPERIMENTAL

Multiple ZAM-coated steel samples were produced at the TATA Steel ZODIAC production line whilst systematically varying the coating weight and cooling rate at a fixed pot composition of 1.4-1.8wt.% Al & Mg, remainder Zn. Optical and scanning electron microscopy were both used to characterise sample microstructure (Table 1). Scanning Vibrating Electrode Technique (SVET), Linear Polarisation Resistance (LPR) and Time Lapse Microscopy (TLM) were used to analyse corrosion behaviour, as shown in Figures 1, 2 and 3.

RESULTS

Corrosion metal loss and rate has been shown to decrease steadily as coating weight is increased. Use of sequential polishing also found that the average volume of zinc dendrites in the coating declined as coating weight rose, providing greater protection through an increased proportion of the binary and ternary eutectics. However, a lesser anode spread, as shown in a coating weight of 310g/m^2, Figure 3, may encourage through-coating penetration as anodic attack is localised.

FUTURE WORK

The effect of cooling rate on ZAM coatings will be investigated using microstructure analysis, corrosion testing and corrosion behaviour under organic coatings. Samples will be produced on a Hot Dip Simulator (HDS).

Table 1 – Microstructure data for each sample

Sample	Average zinc dendrites volume (%)	Average primary Zn size (µm^2)	Zn surface area fraction	Metal Loss (g/m^2)
ZMA80	84.24	17	70.1	6.69 ± 1.75
ZMA200	73.53	35	55.0	4.74 ± 1.87
ZMA310	67.88	45	50.0	2.40 ± 1.15

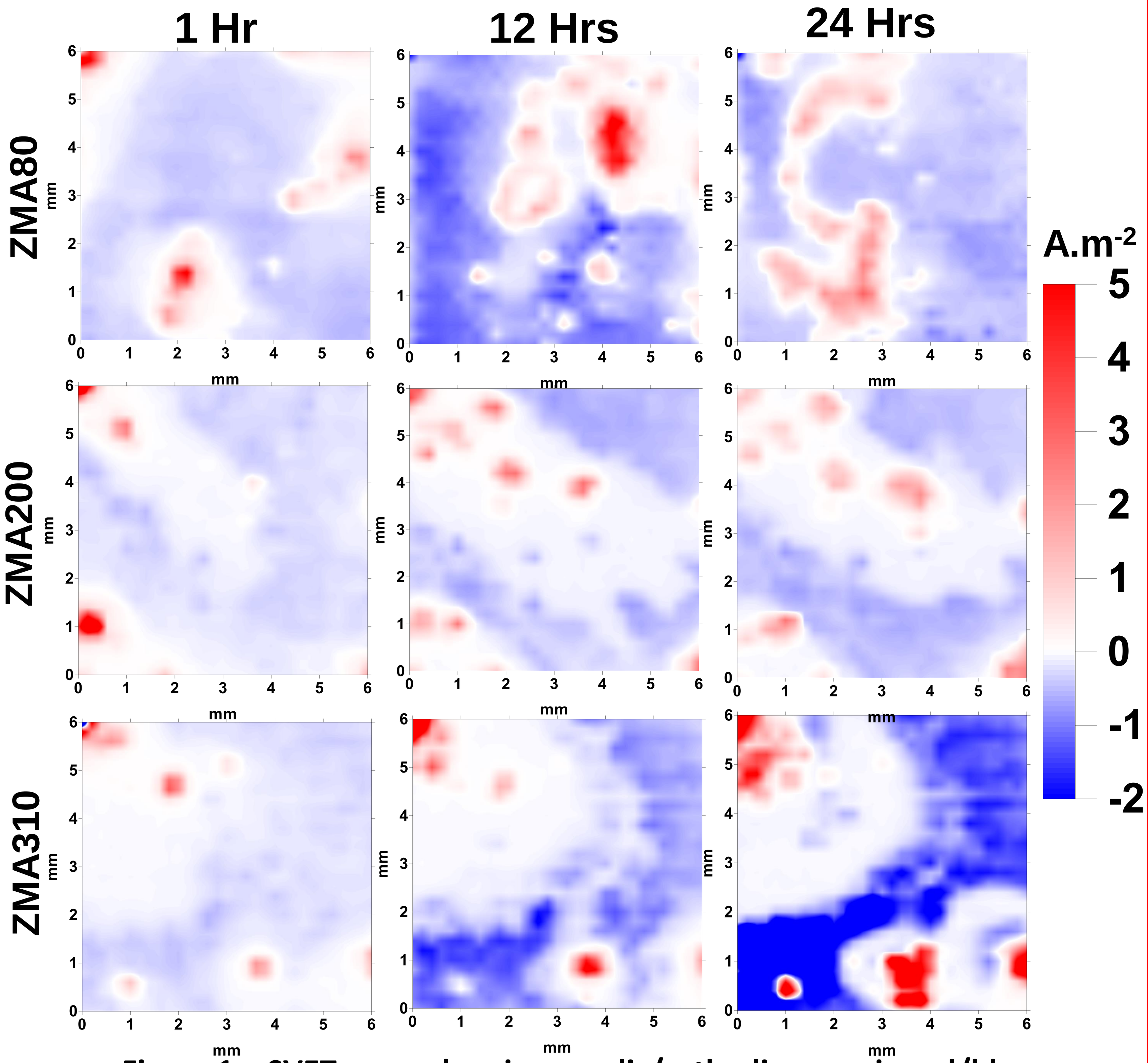

Figure 1 – SVET maps showing anodic/cathodic areas in red/blue for each sample at multiple time intervals

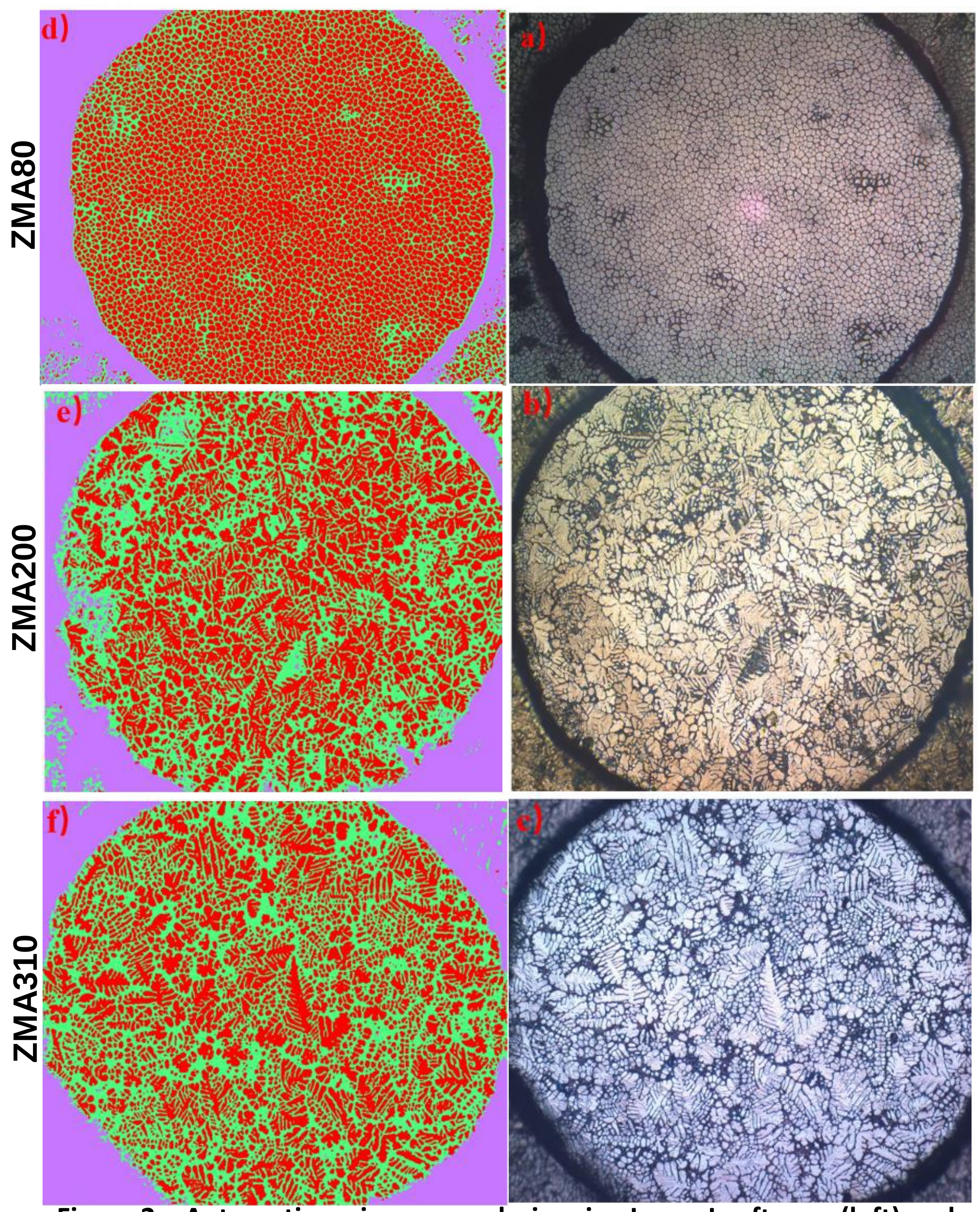

Figure 2 – Automatic grain area analysis using ImageJ software (left) and original micrographs (right)

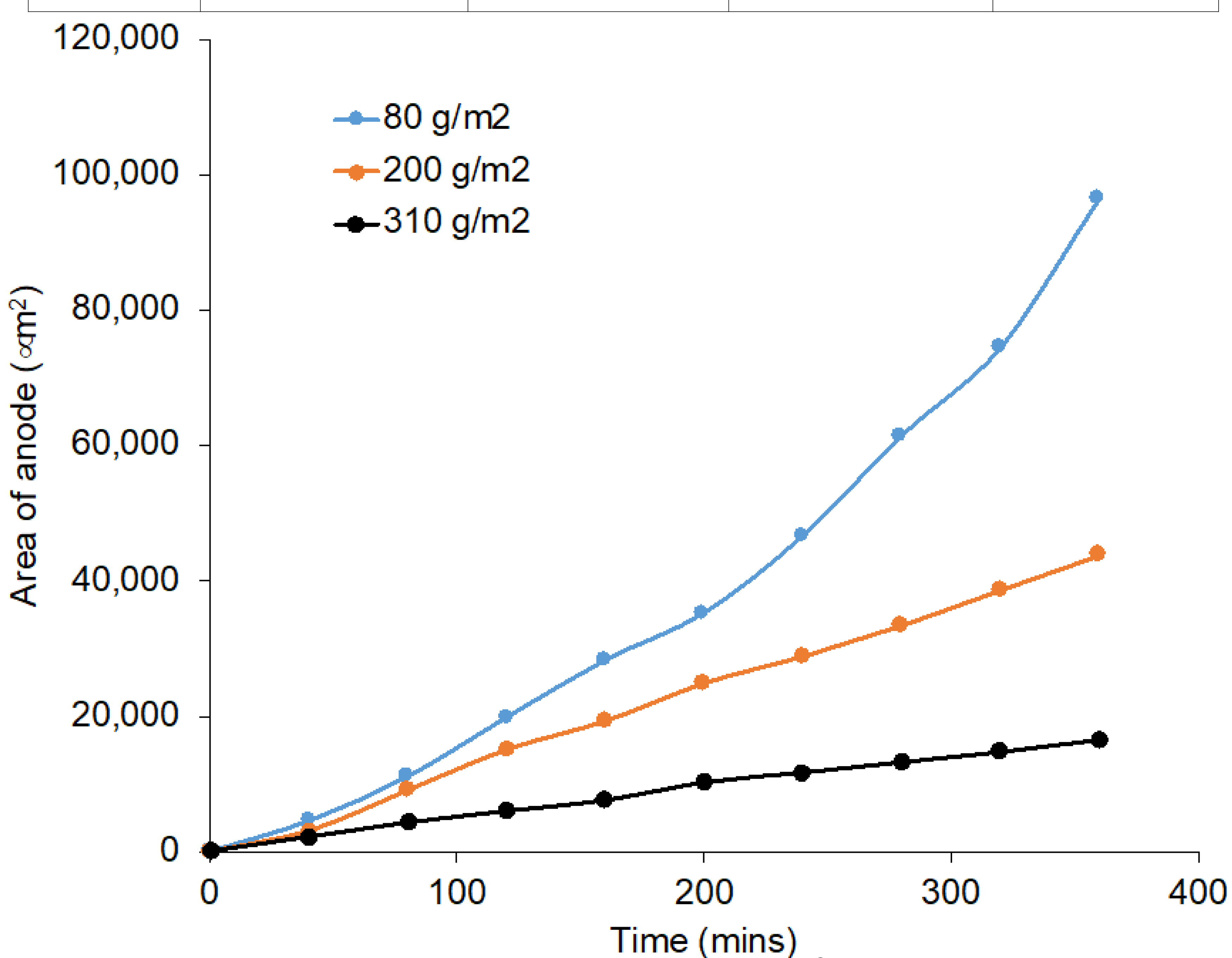

Figure 3 – Variation of anode area (µm^2) against time (minutes)

References

[1] Prosek, T. Hagstrom, J. Persson, D. Fuertes, N. Effect of the microstructure of Zn-Al and Zn-Al-Mg model alloys on corrosion stability. Corrosion Science 110(2016) 71-81.

[2] Lin, KL. Yang, CF. Lee, JT. Correlation of Microstructure with Corrosion and Electrochemical Behavior of the Batch-Type Hot-Dip Al-Zn Coatings: Part 1. Zn and 5%Al-Zn Coatings. Corrosion 47-1(1991) 9-17