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SCIENCE CASE STUDY

Investigation into the corrosion mechanisms of next generation protective metallic coatings (ZMAs) for steel

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Industrial Sponsor – Tata Steel

International Collaborator – The French Corrosion Institute

Tom has been investigating the metallurgy and corrosion behaviour of a new generation of functional coatings designed to sacrificially protect steel products. The new alloys (ZMA1 -3) are composed of Zinc with alloying additions of Magnesium and Aluminium ranging from 1 – 3 weight % of each element and offer improved corrosion performance and cost benefits over coatings based on Zinc alone. Tom's work has focussed on the application of novel techniques to assess the fundamental corrosion mechanisms at a microstructural level and rates of material degradation related to alloy content. A new time lapse microscopy technique developed at Swansea University permits corrosion to be imaged at a microscopic level whilst a sample is immersed in electrolyte (1% NaCl). Using this technique, it has been observed that corrosion preferentially occurs in the eutectic phases of the alloys' microstructure in regions that are rich in Magnesium intermetallics ($MgZn_2$) as shown in figure 1.

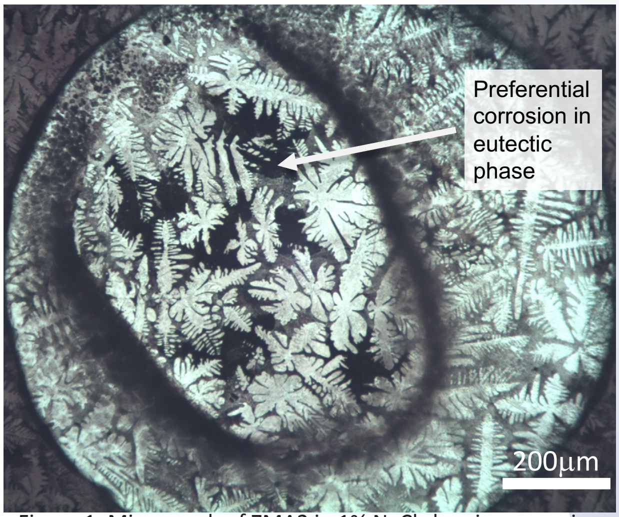

Figure 1. Micrograph of ZMA2 in 1% NaCl showing corrosion preferentially occurring in areas of the coating microstructure rich in Mg.

Through image analysis the corrosion rates have been determined for samples with increasing Mg and Al levels between 1 - 3 weight % and it was observed that the corrosion rate decreased as the alloying levels were increased as shown in figure 2.

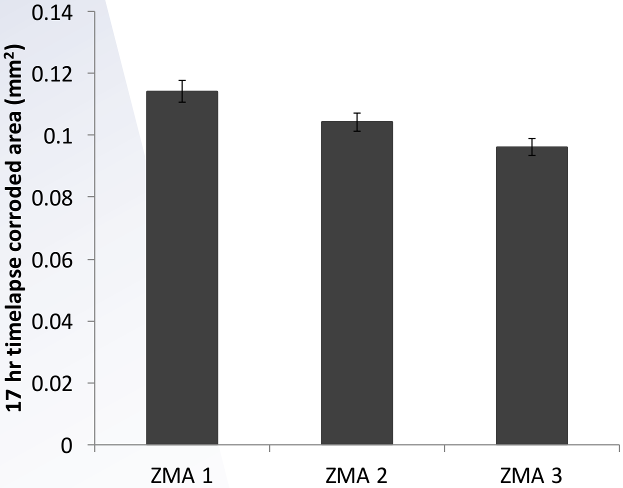

Figure 2. Graph showing that corrosion rate of the ZMA coatings decreasing with increasing Mg and Al alloying levels (ZMA 1 -3).

Scanning vibrating electrode technique (SVET) experiments were also carried out on the samples, a technique that maps corrosion spatially and in a time resolved fashion and this data confirmed the change in corrosion rate observed from the novel microscopy experiments. This data has been published in RSC Faraday Discussions[1] and formed the topic of a talk to the Corrosion Chemistry meeting of Faraday Discussions in April 2015. This investigation has also been presented at the largest electrochemistry conference in the world (PRiME 2016, Honolulu, Hawaii) and the research has formed the foundation of a funded Research for Coal and Steel European Consortium project (Microcorr) involving three steel companies and Academic groups from across Europe.

[1] Faraday Discussions, 2015, 180, 361-379, James Sullivan, Tom Lewis, Nathan Cooze, Callum Gallagher, Tomas Prosek and Dominique Thierry, DOI: 10.1039/C4FD00251B

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