Effect of deviation from basal texture on polycristalline simulations of ZnAlMg coatings under multiaxial loading

Mikel Bengoetxea Aristondo*[1], Ahmed Zouari[1], Fabrice Gaslain[1], Kais Ammar[1], Samuel Forest[1], Vincent Maurel[1], Houssem Eddine Chaieb[2], Joost De Strycker[2], and Jean-Michel Mataigne[3]

[1]Centre des Matériaux, CNRS UMR 7633, Evry, BP 87 91003, France – Mines Paris-PSL University – France

[2]OCAS NV, President John F. Kennedylaan 3, 9060, Zelzate, Belgium – Belgium

[3]ArcelorMittal Global RD, Voie Romaine, 57280, Maizières-lès-Metz, France – ARCELORMITTAL – France

Abstract

In this study, crystal plasticity finite element simulations of a ZnAlMg coating deposited on a steel sheet were carried out to assess the effect of texture on its deformation behaviour. In fact, the microstructure of most ZnAlMg coatings consists of multiphase grains, where dendrites are surrounded by binary and ternary eutectics, and both microstructure and texture condition the formability and the subsequent corrosion resistance of the coating, due to the different mechanical properties of microconstituents and the highly anisotropic behaviour of zinc.

The aim of these simulations was to reproduce results from uniaxial tensile tests and equibiaxial Marciniak tests of a ZnAlMg coating (5 wt%Al and $<$ 1 wt%Mg) deposited on a sheet of S250GD grade structural steel. In addition, an in-situ scanning electron microscope (SEM) tensile test provided a better understanding of crack propagation and activation of plasticity. To model this coating/substrate system, a elastoviscoplastic substrate and a polycristalline coating with a single grain in the thickness direction were considered, and different behaviours were assigned to the zinc dendrites and to the mixture of eutectics. SEM analysis was used to characterise several features of the coating, such as grain size, dendrite/eutectic ratio and the strong (0001) basal texture. In order to assess the role of the latter, simulations with different degrees of deviation from basal texture were executed.

As for experimental results, SEM imaging and electron backscatter diffraction analyses showed that strain was mainly accommodated by twinning and slip in the zinc phase, leading to dynamic recrystallisation in some locations. Three main damage mechanisms were observed: cleavage in the zinc phase, decohesion at the interface of Al-Zn eutectoid globules and cracking in MgZn2 lamellae. These crack patterns and crystal orientation maps were compared with calculated local strain, stress, twinning and slip activity fields.

Keywords: cracking behaviour, crystal plasticity, EBSD, ZnAlMg coatings

*Speaker