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Identification of the metallurgical parameters explaining the corrosion susceptibility in a 2050 aluminium alloy

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ABSTRACT

The corrosion behaviour of a 2050 aluminium alloy was studied in a NaCl solution. The structure of precipitation did not fully explain the susceptibility to intergranular (in the -T34 state) and intragranular corrosion for the aged state (the -T8 state). A relationship between the nature of interfaces, the grains characteristics (size, internal misorientation and orientation according to the plane exposed to the electrolyte) on one hand and the corrosion susceptibility of the alloy on the other hand was clearly established. Galvanic coupling between grains with different internal misorientations helped to explain the intergranular corrosion susceptibility of the -T34 state.

1. Introduction

New generation of Al–Cu–Li–X alloys shows remarkable combination of density, mechanical properties and corrosion resistance. Although other phases can be observed in these alloys, the precipitation of T_1–Al_2CuLi phase is commonly considered as a major parameter to explain the corrosion behaviour of these alloys [1–9]. This intermetallic phase possesses a more negative corrosion potential than the matrix [2,6]. When the material is exposed to an aggressive medium, a galvanic coupling between the T_1 phase and the matrix occurs in favour of the matrix. In the -T34 metallurgical state, because of the presence of T_1 particles only at the grain boundaries, galvanic coupling leads to the dissolution of the grain boundaries with a more negative corrosion potential than for the grains. To desensitise the alloy to intergranular corrosion, an aging treatment is applied to the material. This leads to the precipitation of T_1 particles both in the grains and at the grain boundaries, leaving the aged state (-T8). For a -T8 sample, because of this structure of precipitation, the corrosion potentials of the matrix and the grain boundaries are quite similar. Consequently, galvanic coupling does not occur between the grain and the grain boundaries and the material is susceptible to intragranular corrosion [2–4].

Our results from previous work confirmed the susceptibility of an AA 2050 alloy to intragranular corrosion after an ageing treatment at 155 °C for 30 h and correlated this to the homogeneous distribution of T_1 phase particles in the grains and at the grain boundaries [9]. For the AA 2050-T34 alloy, susceptible to intergranular corrosion, a major part of corroded grain boundaries did not evidence the presence of T_1 precipitates. This result suggested that the presence of the T_1 phase was not necessary to induce a susceptibility to intergranular corrosion in an AA 2050-T34 alloy. Furthermore, for both -T8 and -T34 alloys, preferential dissolution of some grains and grain boundaries was respectively observed while, for -T8 alloy for example, homogeneous distribution of T_1 precipitates was observed both in the grains and at the grain boundaries. These results suggested that parameters different than the structure of precipitation should contribute to explain the corrosion behaviour of the AA 2050 alloy. This should be in agreement with results found in literature. For example, Luo et al. showed that a relationship exists between the dislocation density in a grain and the ability of the grain boundary to be corroded [10]. Kim et al. showed that the grain boundary character distribution (GBCD) has a great effect on intergranular corrosion susceptibility of aluminum in HCl [11]. Ralston et al. worked on the influence of the grain size on

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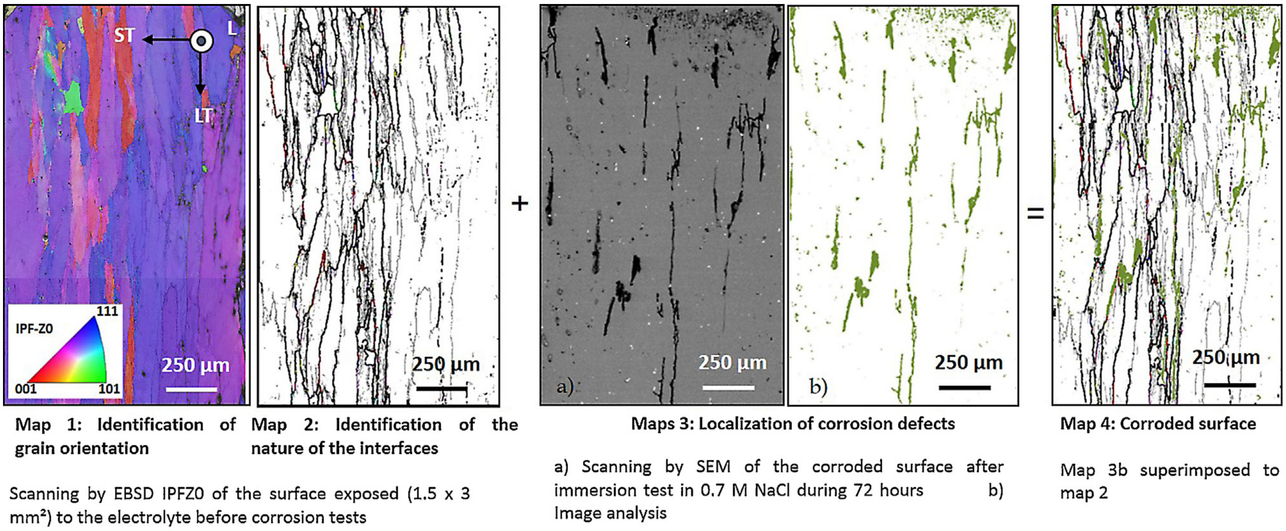

Fig. 1. Methodology used for studying the impact of different metallurgical parameters at the polycrystal scale on the corrosion behaviour of AA 2050.

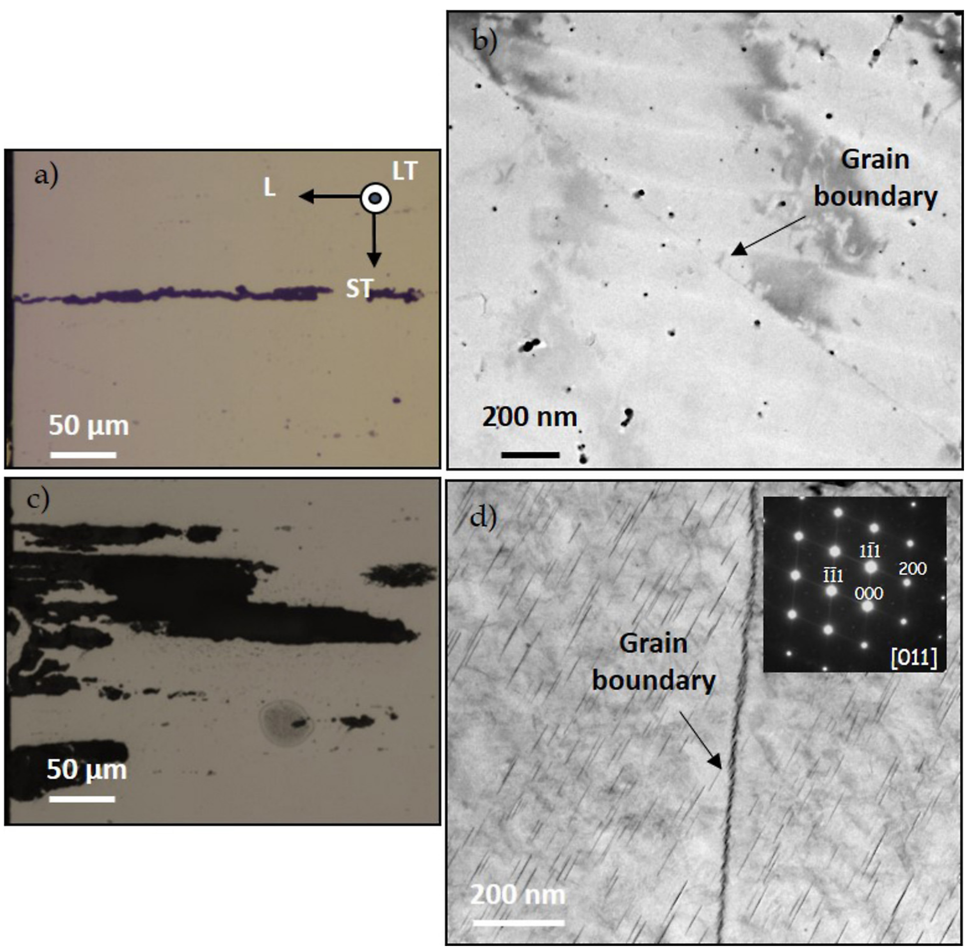

Fig. 2. Optical microscope observations of (a) intergranular corrosion in the -T34 sample and (c) intragranular corrosion in the -T8 sample. Bright-field TEM images of (b) the -T34 sample and (d) the -T8 sample.

the corrosion susceptibility of a material and noticed that the 'grain size—corrosion resistance' relationship is complex. They suggested that this complexity could be increased due to the heterogeneity of the grain size in a sample [12].

The aim of this study was to determine the origin of the susceptibility to intergranular and intragranular corrosion for AA 2050-T34 and AA 2050-T8 alloys respectively. The structure of precipitation was considered. However, attention was also paid to microstructural parameters at the polycrystal scale: this means that the nature of the interfaces (either grain boundaries or subgrain boundaries corresponding to the level of misorientation at the interfaces), the internal misorientation and size of the grains, and their orientation