Journal of ELECTRONIC MATERIALS, Vol. 42, No. 2, 2013
DOI: 10.1007/s11664-012-2185-4
© 2012 TMS

Micro- and Nanostructure of Zn Whiskers and Their Coating

A. ETIENNE,[1,5] E. CADEL,[1] A. LINA,[2] L. CRETINON,[3,4] and P. PAREIGE[1,6]

1.—Groupe de Physique des Matériaux, Université et INSA de Rouen, UMR CNRS 6634, Avenue de l'Université BP 12, 76801 Saint Etienne du Rouvray Cedex, France. 2.—Department Material and Mechanic Components, Corrosion Studies Laboratory, EDF R&D, 77818 Moret sur Loing Cedex, France. 3.—Department Electrical Equipment Laboratory, EDF R&D, 77818 Moret sur Loing Cedex, France. 4.—EDF SEPTEN, 69628 Villeurbanne Cedex, France. 5.—e-mail: auriane.etienne@gmail.com. 6.—e-mail: philippe.pareige@univ-rouen.fr

To understand the mechanisms at the origin of whisker formation and growth, a Zn-electroplated steel prone to whiskering was studied. Several samples were prepared from different locations of the electroplated plate. Care was taken to extract samples at the root, in the nodule, or away from whiskers. Samples were characterized using electron backscattered diffraction (EBSD). Crystallographic data from EBSD show that recrystallized regions are present at the root of whiskers and in their nodules. These observations support whisker growth models based on recrystallization. In addition, atom probe tomography samples were prepared in the center of whiskers. The distribution of Zn atoms is almost homogeneous and no impurities are present in the whiskers.

Key words: Electroplating, whiskers, electron scattering diffraction, recrystallization, focused ion beam, atom probe tomography

INTRODUCTION

Since the 1940s and the discovery of short circuits caused by cadmium whiskers,[1] a large number of studies have been focused on whiskering in metals. Indeed, the only way to minimize whisker growth, so that induced electrical or electronic disturbances are avoided, is to understand in detail the mechanisms at the origin of whiskering. It is known that whiskers grow spontaneously, at room temperature, from electroplates such as tin,[2–7] zinc,[8–11] or cadmium coatings. Metallic whiskers show different morphologies: (i) whisker needles whose length can reach several millimeters,[2] (ii) kinked whiskers that have sudden change in growth direction, and (iii) whiskers in the form of nodules from which needles can grow. Although whiskers have been studied for several decades, the mechanism of whisker growth is still not well understood.

As far as Zn is concerned, electroplated zinc coatings are usually used as an anticorrosive layer for low-alloy steels. These Zn-coated steels are used for electronic components in automotive, aerospace, and energy industries, but also for support structures or raised-floor tiles in computer data centers.[8,10] The risk of electrical or electronic disturbances caused by Zn whiskers is significant, as shown, for example, by a National Aeronautics and Space Administration (NASA) data center report.[8]

The most recent study on Zn whiskers[10] presents x-ray diffraction (XRD) and transmission electron microscopy (TEM) with energy-dispersive x-ray spectroscopy results. The authors show that the presence of Fe-Zn intermetallics and Zn oxides plays a significant role in the presence of Zn whiskers by increasing the compressive stress on the Zn coating. Although their results are important for comprehension of whisker growth, the authors do not show any crystallographic information about whiskers and their coatings. To understand whisker formation and growth clearly, the micro- and nanostructure of the whiskers and their coatings must be characterized.

In the present work, an electroplated Zn coating prone to whiskers has been investigated using dual-beam scanning electron microscope–focused ion beam (SEM–FIB), electron backscattered diffraction (EBSD) and, for the first time, atom probe tomography (APT). The originality of this work lies in the

(Received April 8, 2012; accepted June 19, 2012; published online August 2, 2012)